GROUNDWATER ASSESSMENT TOOLBOX FOR SSD/SSI

Guidelines for Groundwater Documentation for SSD/SSI Projects. Technical guideline.

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Executive Summary

The Water Group of the New South Wales (NSW) Department of Planning and Environment has prepared updated guidelines specifically focused on the requirements of the NSW Government for the assessment of groundwater related matters and consideration of potential impacts of State significant development and State significant infrastructure projects in NSW.

The Guideline will assist proponents to demonstrate if an activity can operate and be compliant with the principles and objects of the NSW *Water Management Act 2000* and the requirements described within the NSW groundwater policy documents.

When used by proponents, the Guidelines will ensure consistency between proposals and ongoing compliance with their approvals, resulting in efficient assessment and provision of recommendations and advice from the Water Group of the NSW Department of Planning and Environment under the *Environmental Planning and Assessment Act 1979* process.

The main objective of this Guideline is to clarify and inform the requirements for groundwater assessment and documentation required for State significant development and State significant infrastructure projects in NSW. These projects can include activities located above the water table and below the water table. Those located above the water table are unlikely to have a major impact on groundwater systems and therefore the required groundwater impact assessment is less rigorous than those projects directly impacting groundwater. Those project activities located below the water table will impact one or more water sources and require a more rigorous impact assessment. Such projects include aquifer interference activities such as tunnelling, underground mining, open cut mining, dredge mining, quarrying and petroleum projects, and consumptive use activities such as town water supply borefields. The Guidelines are not specific to a particular project type and are applicable to all State significant development and State significant infrastructure projects in NSW.

Adaptive groundwater management relies on improvements to the understanding of system behaviour, such that monitoring, interpretation and prediction of system responses reduce the uncertainty that would otherwise impede the reliable design of management strategies at an earlier time (Thomann et al 2000). The combination of the adaptive management and “Plan, Do, Check, Act” approaches that underpin this Guideline provides an efficient and logical approach to the ongoing consideration of groundwater systems and potential impacts.

This Guideline provides an overview of the water regulatory and policy framework applying to major projects in NSW, and includes checklists and examples for aquifer interference activity projects where information, assessment requirements and examples of common challenges are provided.

The Guideline communicates the expectations of the NSW Government and requirements for the groundwater investigations conducted to inform a groundwater impact assessment, as well as the groundwater impact assessment itself. Following project approval, the role of the NSW Government continues, providing guidance on and review of post-approvals monitoring and management plans and compliance reporting. The overarching workflow of a project through pre-approval, impact assessment, monitoring and management and compliance reporting is presented in Figure 1.

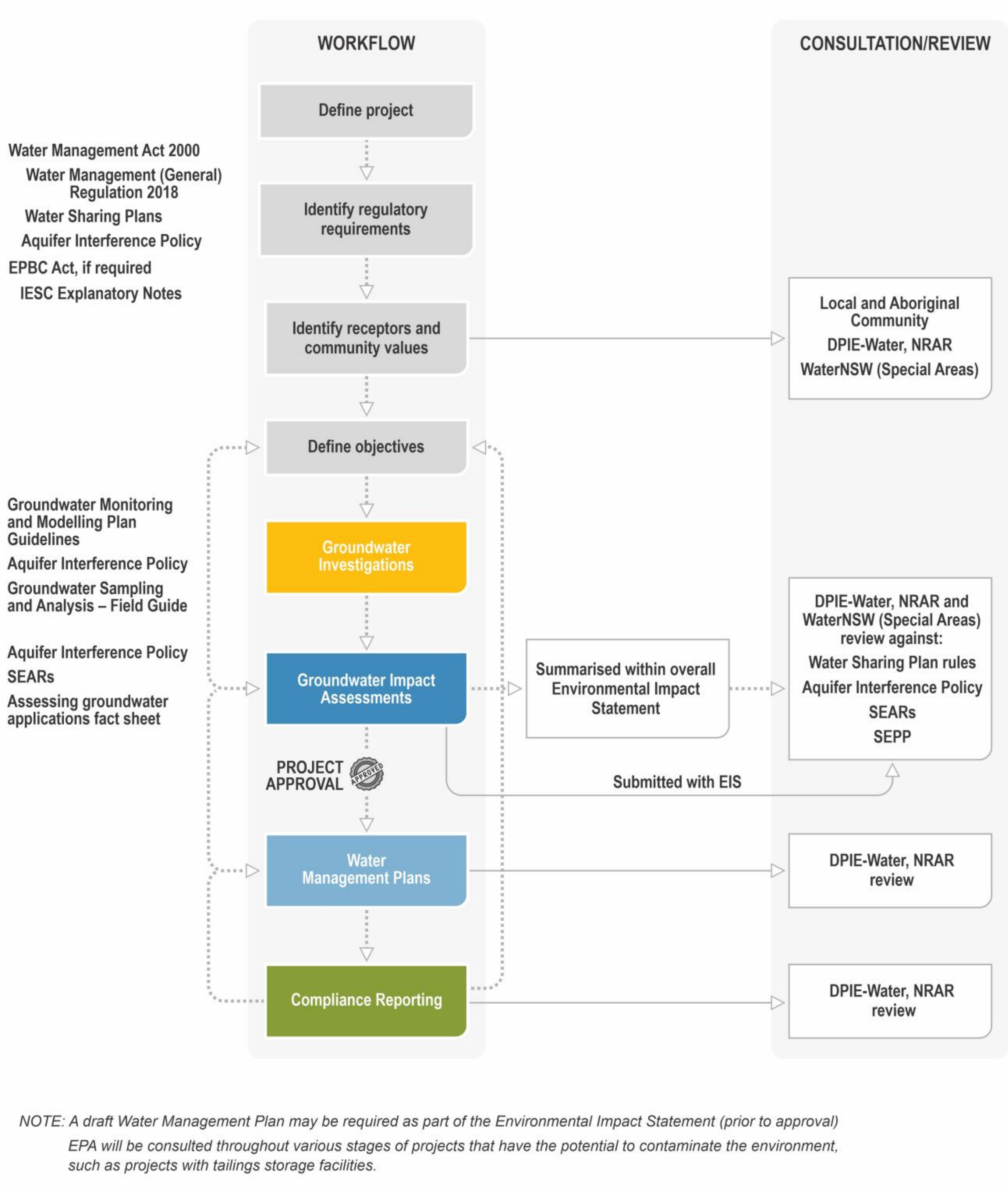


Figure 1: Groundwater assessments and reporting workflow for SSD and SSI projects

Abbreviations

Abbreviations	Definition
2D	Two-dimensional
3D	Three-dimensional
AIP	Aquifer Interference Policy
BoM	Bureau of Meteorology
CCTV	Closed-circuit Television
CoA	Conditions of Approval
DEM	Digital Elevation Model
DiGS	Digital Imaging of Geological Systems
DPE	NSW Department of Planning and Environment
EC	Electrical conductivity
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPL	Environment Protection Licence
ESID	Extraction Site Identification number
GDE	Groundwater Dependent Ecosystem
GIA	Groundwater Impact Assessment
GMMP	Groundwater Monitoring and Modelling Plan
GWMP	Groundwater Management Plan
HEV	High Ecological Value
IESC	Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mine development
Kh	Horizontal hydraulic conductivity
Kv	Vertical hydraulic conductivity
LEV	Low Ecological Value

NATA	National Association of Testing Authorities
NGIS	National Groundwater Information System
NRAR	Natural Resources Access Regulator
NSW	New South Wales
PCT	Plant community type
QA	Quality assurance
QC	Quality control
SEARs	Secretary's Environmental Assessment Requirements
Ss	Specific storage
SSD	State significant development
SSI	State significant infrastructure
SWMP	Surface water Management Plan
Sy	Specific yield
TARP	Trigger action response plan
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
VWP	Vibrating Wire Piezometer
WAL	Water Access Licence
WM Act	Water Management Act 2000
WMP	Water Management Plan

Acknowledgment of Country

The Department of Planning and Environment acknowledges the Traditional Owners and Custodians of the land on which we live and work and pays respect to Elders past, present and future.

Contents

Tables

Figures

1 Introduction

This chapter discusses:

- purpose and objectives;
- structure of this guideline;
- underlying investigation and management approach; and
- tools and templates provided in this Guideline.

1.1 Purpose and objectives

This Guideline focuses on the requirements of the New South Wales (NSW) Government for the assessment of groundwater related matters and consideration of potential impacts of State significant development (SSD) and State significant infrastructure (SSI) projects in NSW.

The Guideline communicates the expectations and requirements of the NSW Department of Planning and Environment – Water for groundwater investigations conducted to inform a groundwater impact assessment (GIA), as well as the GIA itself that is conducted as part of an environmental impact statement (EIS). Following project approval, the department's Water division and Natural Resources Access Regulator (NRAR) continue to provide guidance on and review of post-approvals monitoring and management plans and compliance reporting. This workflow is illustrated in Figure 2

These Guidelines:

- Will assist proponents prepare complete, documented and consistent GIAs as part of EISs.
- Provide advice regarding the collection of groundwater related data required to inform the impact assessment(s), Water Management Plans (WMP) and ongoing compliance reporting.
- Will assist the department's Water division assess SSD/SSI Applications and allow the NSW Government to make informed and consistent recommendations as part of assessment and determination process under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), post-determination requirements and water licensing requirements.
- Will assist proponents to demonstrate if an activity can operate and be compliant with the principles and objects of the NSW *Water Management Act 2000* (WM Act) and the requirements described within the NSW groundwater policy documents.
- Will ensure consistency between proposals and ongoing compliance with their approvals, resulting in efficient assessment and provision of recommendations and advice from the department's Water division under the EP&A Act process, reducing lengthy delays and costs to both industry and agencies.
- When used by proponents, will increase transparency to the NSW Government, community, and other stakeholders.

SSD and SSI project types can include both projects located above the water table and below the water table. Those located above the water table are unlikely to have a major impact on groundwater systems and therefore the required GIA is less rigorous than those projects directly impacting groundwater. Those projects located below the water table will impact one or more water sources and require a more rigorous GIA. Such projects include aquifer interference activities such as tunnelling, underground mining, open cut mining, dredge mining, road and rail (in tunnel) infrastructure, quarrying and petroleum projects, and consumptive use activities such as town water supply borefields. The Guidelines are not specific to a particular project type and are applicable to all SSD/SSI projects.

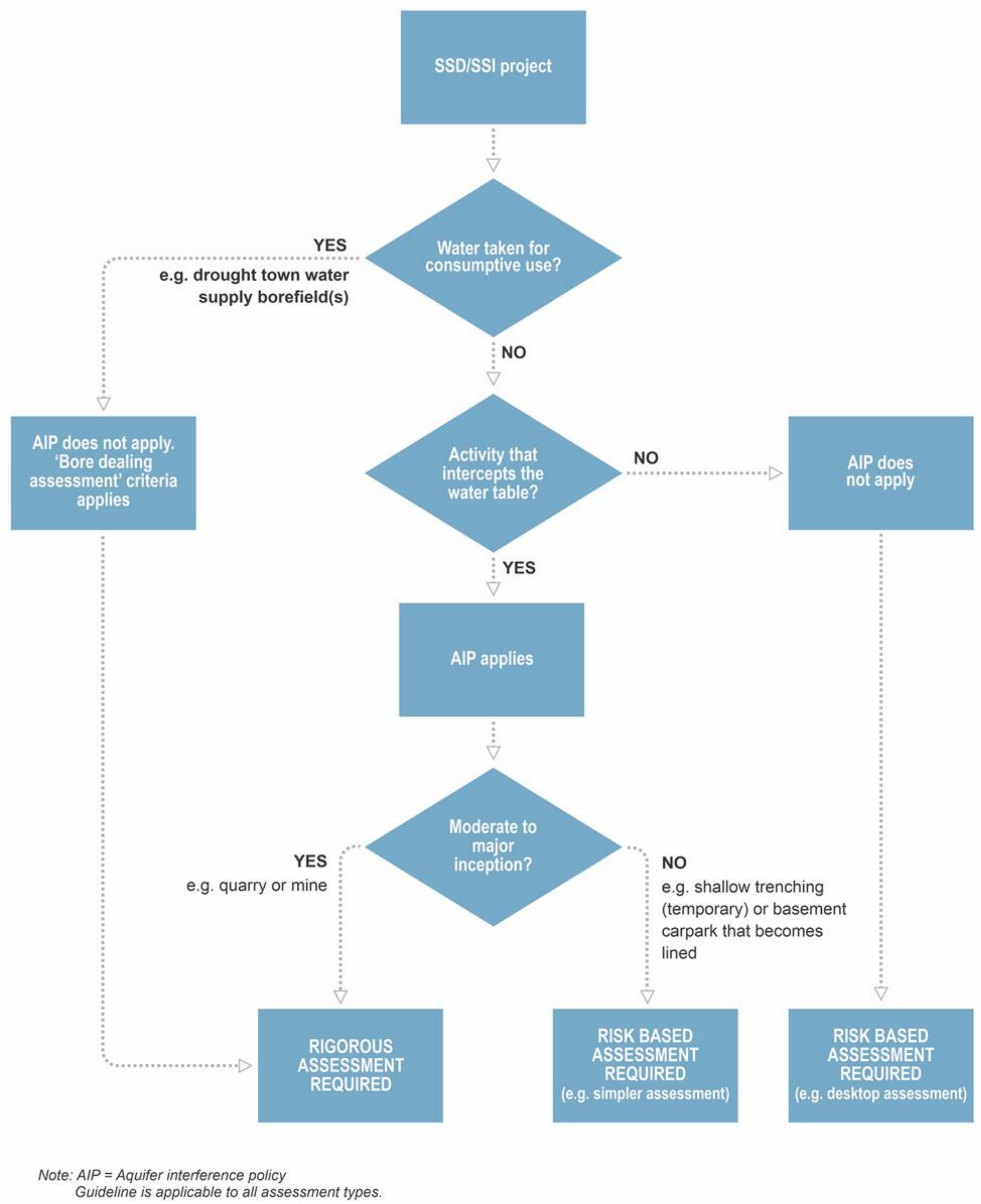


Figure 3 provides high-level guidance on the assessment considerations for SSD/SSI project types, such as aquifer interference activities or borefields. The assessment requirements are discussed further in Part A and B of the Guideline.

Example sheets for aquifer interference activities such as quarries, coal seam gas, underground mining, open cut mining and tunnelling are provided in Appendix A. The example sheets list minimum requirements and issues or challenges that are specific to the project type (for example, a quarry) to highlight specific requirements through different stages of a project.

This Guideline does not provide guidance on groundwater modelling expectations or requirements for soil and surface water impact assessments and associated management.

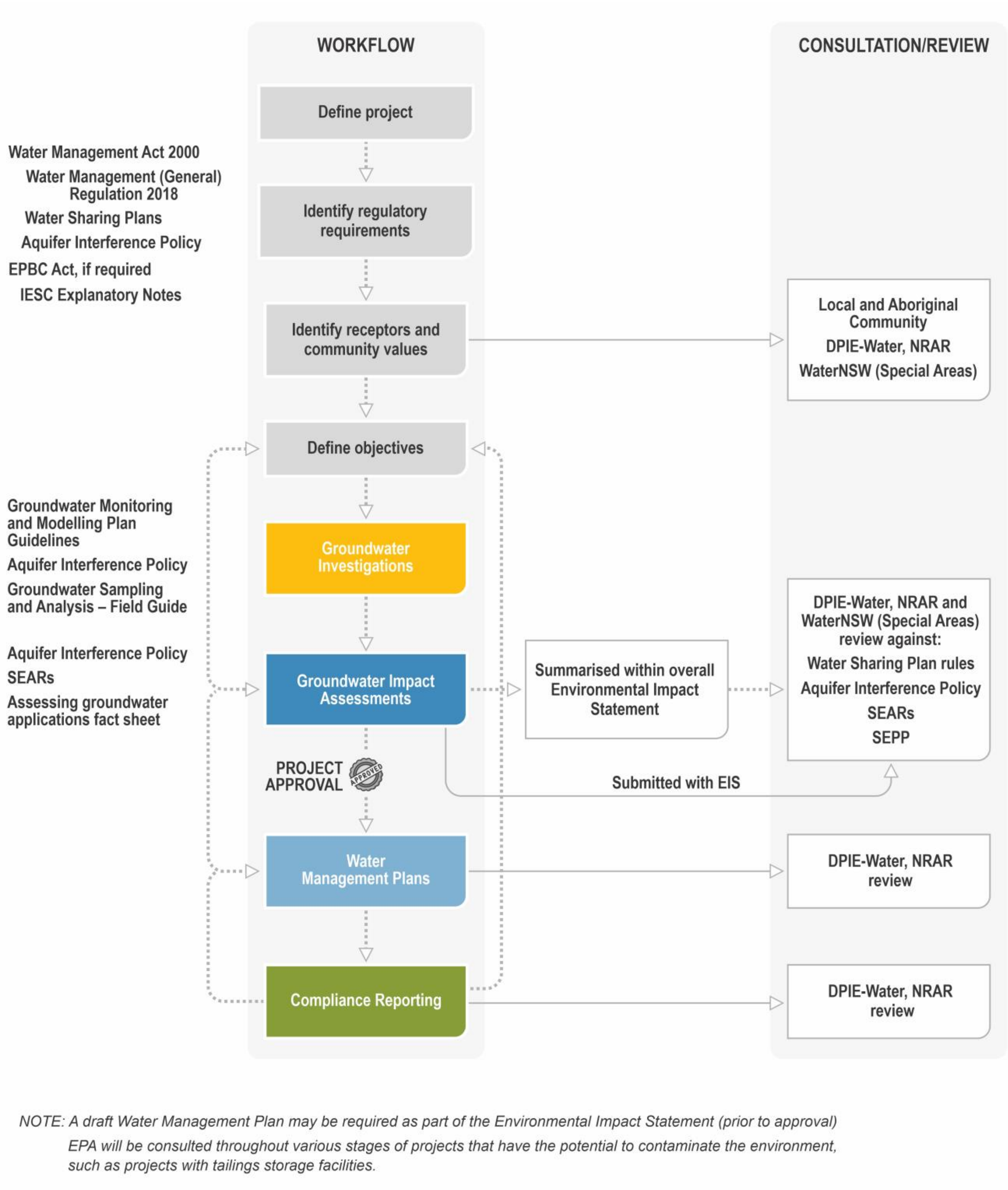


Figure 2: Groundwater assessments and reporting workflow for SSD and SSI projects

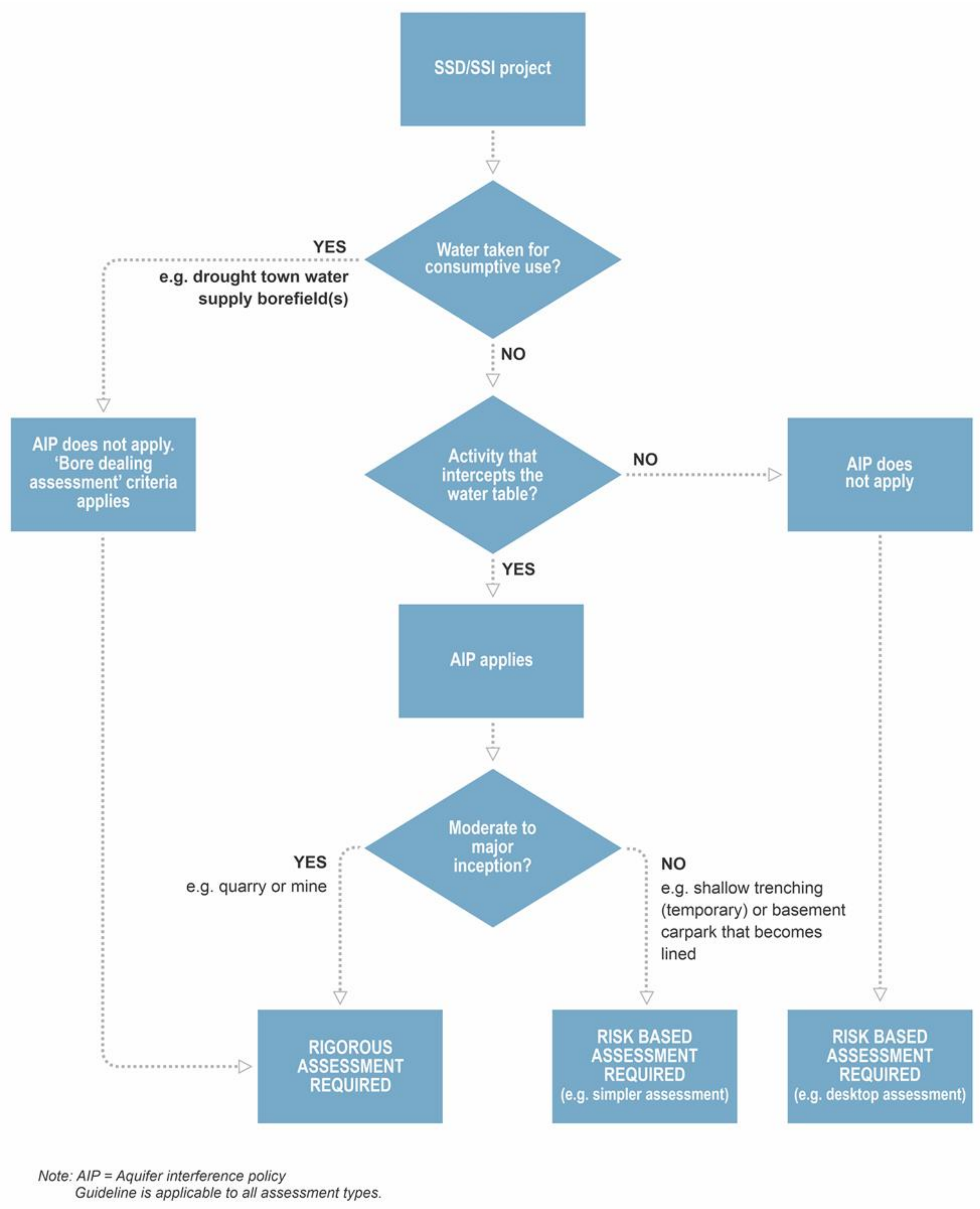


Figure 3: Assessment considerations for different SSD and SSI project types

1.2 Structure of this guideline

This Guideline is comprised of four main parts, aligned with the pre and post-approval stages of projects, with an introductory chapter that includes regulatory overview:

- Regulatory overview: introduction to the relevant regulations and policy which will influence the way in which the requirements of the SSD/SSI groundwater assessments and reporting will be addressed.
- Part A: groundwater investigations to inform groundwater impact assessments.
- Part B: groundwater impact assessments, including licensing considerations.
- Part C: preparation of WMPs.
- Part D: preparation of water compliance reports.

1.3 Underlying investigation and management approach

Figure 4 illustrates the high-level approach to assessing and managing potential impacts of a project on the groundwater environment, both at the early stages of a project and throughout the life of the project. This cyclic approach is based on the “Plan, Do, Check, Act” approach for continuous improvement blended with the concept of adaptive management.

Adaptive management is a form of structured decision making with emphasis on iterative decision making in the face of uncertainty (Thomann et al 2000). There are inherent uncertainties that exist within groundwater systems due to complexity of heterogeneity or uncertainties introduced by effects of error in field measurements, conceptual, spatial, and temporal simplifications (Barnett et al 2012). Adaptive management relies on improvements to the understanding of system behaviour, such that monitoring, interpretation and prediction of system responses reduce the uncertainty that would otherwise impede the reliable design of management strategies (Thomann et al 2000). The combination of the adaptive management and “Plan, Do, Check, Act” approaches provide an efficient and logical approach to the ongoing consideration of groundwater systems and potential impacts.

Consultation with stakeholders, including the local community, council, Aboriginal community, NSW Government and Commonwealth agencies (depending on the project) will be conducted as part of the overall EIS process and will be managed through the Planning and Assessment team of the department. It is necessary for some groundwater specific consultation to occur with the department’s Water division, NRAR, the NSW Environment Protection Authority (EPA) and/or WaterNSW (depending on the project) throughout the various stages of a project life cycle. This interaction and consultation is shown in Figure 2.

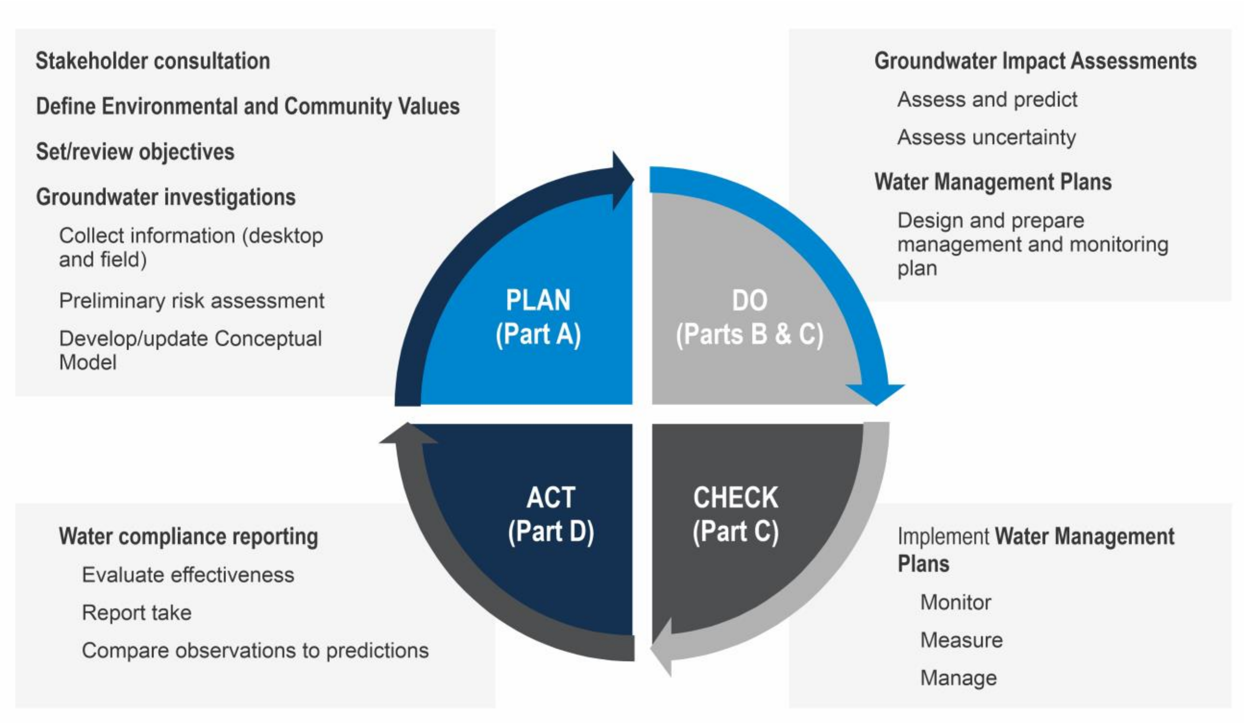


Figure 4: Cyclic approach to groundwater management – assessing potential impacts of a project on the groundwater environment

1.4 Tools and templates provided in this guideline

The following tools and templates are included in this Guideline:

- Example sheets for quarries, coal seam gas, underground mining, open cut mining and tunnelling projects are provided in Appendix A. The example sheets list the department's Water division expectations and requirements and common challenges for each stage of a project, including groundwater investigations, GIA and post reporting. Example conceptual diagrams are also included. The requirements listed in Appendix A are not an exhaustive list; however, should be used by the proponent to guide their assessments.
- The aquifer interference assessment framework checklist that the department's Water division use for assessing project proposals is provided in Appendix B. Proponents should also complete the aquifer interference assessment framework checklist and attach it to the GIA.
- Aquifer interference policy (AIP) fact sheets 1 to 7 are provided in Appendix C. These fact sheets provide useful information about assessing impacts, minimal impact considerations, licensing, risk mitigation and management, and more.
- A checklist summarising key points of the information in this Guideline is provided in Appendix E.
- A list of standard units and terminology is provided in Appendix F.

2 Regulatory overview

This chapter discusses:

- Agency roles; and,
- Overview of the project assessment process and regulatory framework

Relevant legislation, references and information:

- *Environmental Planning and Assessment Act 1979;*
- *Water Management Act 2000;*
    - Principles;
    - Objects;
- Water Sharing Plans;
- NSW Aquifer Interference Policy;
- Aquifer Interference Policy Fact Sheets 1 to 6 (refer Appendix C);
- NSW Government assessing groundwater applications fact sheet;
- Department of Planning and Environment – Water role in assessing major projects;
- National Partnership Agreement on Coal Seam Gas and Large Coal Mining Development; and,
- Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources

2.1 Agency roles

Department of Planning and Environment – Water, the NRAR, WaterNSW and the EPA each play a role in the implementation of the regulatory framework for water management in NSW. The regulatory context for SSD and SSI projects, roles, and responsibilities of each of these agencies is summarised in Table 1.

Table 1: Regulatory context for State significant development/State significant infrastructure Projects

Regulator/agency	Relevant Acts, roles and responsibilities	Involvement in the SSD/SSI process

Department of Planning and Environment – Planning and Assessment	• Environmental Planning and Assessment Act 1979;
	• Issues the Secretary's environmental assessment requirements (SEARs);
	• Assesses the project and provides a recommendation for determination to the consent authority (which is the Minster for Planning and Public Spaces, or the Independent Planning Commission in the circumstances outlined in the State Environmental Planning Policy (State and Regional Development) 2011); and,
	• Approves management plans required under development consents/approvals.
		• Coordinates and leads the whole of Government assessment; and,
		• Seeks advice from relevant agencies on:
		  ○ the SEARs,
		  ○ the EIS; and
		  ○ conditions of consent/approval
		• Administers management plan assessments and determination process.

Department of Planning and Environment – Water	• Water Management Act 2000; • Manages the State's surface and groundwater resource; • Develops and implements water sharing plans; and, • Manages regional and metropolitan water supply and usage.	• Provides advice to the department on the SEARs; • Provides advice and recommendations to the department regarding impacts and water licensing at different stages of the assessment and determination process; and, • Provides advice on relevant draft development conditions of approval.

Natural Resources Access Regulator (NRAR)	• Natural resources management legislation including:
	  ○ *Water Management Act 2000*;
	  ○ *Natural Resources Access Regulator Act 2017*;
	  ○ *Dams Safety Act 2015*; and
	  ○ other relevant legislation
	• Ensures effective, efficient, transparent and accountable compliance;
	• Informs, educates and engages to promote understanding of water laws and users' responsibilities; and,
	• Monitors and audits the use of groundwater and surface water.
		• Provides advice to the department on water licensing for SSD/SSI projects;
		• Administers water licensing for SSD projects, major utilities, state-owned corporations, government agencies;
		• Assesses breaches of natural resource management legislation from SSD/SSI projects; and,
		• Provides advice on relevant draft development conditions of approval.

WaterNSW	• Owns and operates state water infrastructure; • Operates and manages the Greater Sydney drinking water catchment; • Administers all water dealings for rural landholders or industry (licensing, approvals, trades, metering, billing); and, • Monitors groundwater and surface water, and maintains relevant databases.	• Provides data to project proponents; • Provides advice to the department on water issues; and, • Provides advice on draft development consent conditions.

NSW Environment Protection Authority (EPA)	• Protection of Environment Operations Act 1997;
	• Environmental regulator, focuses on water quality, contamination/ pollution;
	• Partners with business, government and community to reduce pollution and waste, protect human health, and prevent degradation of the environment; and,
	• Compliance and investigations; issues orders, fines and prosecutions.
		• Provides advice to the department on:
		  ○ SEARs;
		  ○ Point source water quality and pollution issues; and,
		  ○ Draft conditions;
		• Issues Environment Protection Licences (EPL).

Commonwealth Department of Agriculture, Water and the Environment	• Environment Protection and Biodiversity Conservation Act 1999; and, • Environmental regulator	• Assess and determine applications to carry out a controlled action under the EPBC Act
Commonwealth Office of Water Science	• Environment Protection and Biodiversity Conservation Act 1999; • Liaises with the Australian government regulators on requests for advice; and, • Prepares secretariat support and supporting analysis documentation for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC)	• Reviews requests for advice for adequacy of an EIS/GIA
Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC)	• Environment Protection and Biodiversity Conservation Act 1999 (Section 505D) ; and, • Provides independent scientific advice to the Australian Government Environment Minister on the impact that coal seam gas and large coal mining development may have on Australia's water resources	• Reviews requests for advice; and, • Provides advice to Australian government regulators on potential impacts of coal seam gas and large coal mining development

2.2 Overview of the assessment process and regulatory framework

A detailed discussion on the regulatory framework (water focused) for NSW SSD/SSI projects is provided in Appendix D. This section provides an overview of the regulatory framework.

Under the *Environmental Planning and Assessment Regulation 2000*, the Secretary of the department must consult with relevant public authorities when preparing the Secretary's Environmental Assessment Requirements (SEARs) for an SSD or SSI project. The Planning and Assessment Group consults with the Water Group on water resource impact assessment and management requirements when preparing the SEARs for SSD/SSI proponents. Upon public exhibition of the EIS, the Water Group is further consulted and is asked to assess the EIS and any supplementary specialist studies, and to provide relevant draft consent conditions (or confirm the proponent's Statement of Commitments) should the project be approved. The typical assessment process is shown in
Figure 5.

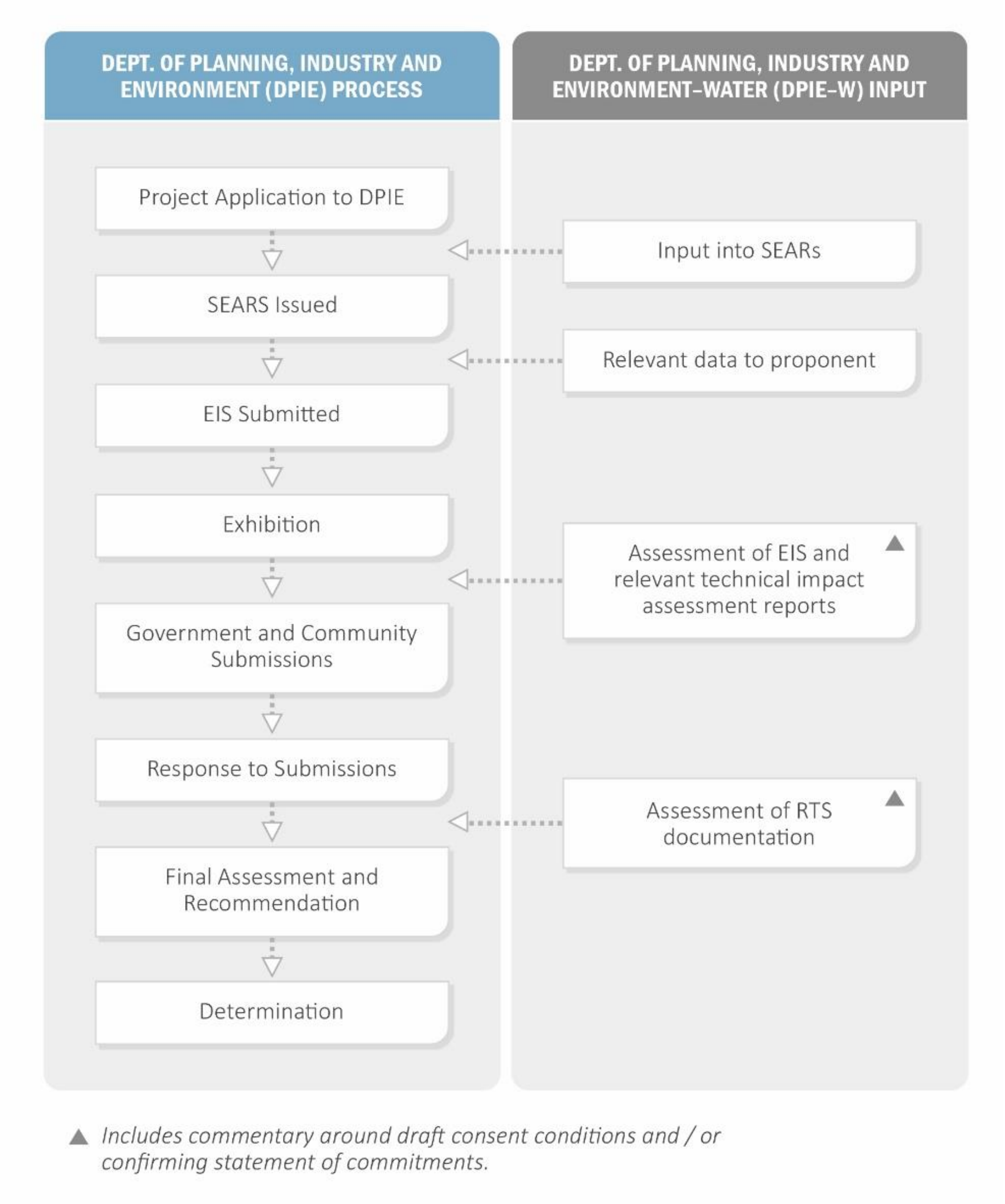


Figure 5: Simplified process for assessing major project applications

2.2.1 *Water Management Act 2000* (WM Act)

The WM Act is the primary legislation governing water management and licensing in NSW. It is based on the principles of ecologically sustainable development and the need to share and manage water resources for future generations. The WM Act recognises that water management decisions must consider economic, environmental, social, cultural and heritage factors.

The licensing provisions of the WM Act apply to those areas where a water sharing plan has commenced. The WM Act requires water users or proponents to hold (unless exempt under the *Water Management (General) Regulation 2018* or the EP&A Act):

- A water access licence (WAL) to take water from a river, lake, dam or groundwater for irrigation, industrial, or commercial purposes;
- A water supply work approval to construct and use a water supply work, such as a pump, dam, channel or bore; and,
- A water use approval for a specific purpose at a particular location.

However, under Clause 4.41(1)(g) of the EP&A Act, SSD projects are exempt from requiring a water use approval under Section 89, a water management work approval under Section 90, or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act. Clause 5.23 (1)(g) of the EP&A Act exempts an SSI project authorised by a development consent from requiring a water use approval under Section 89, a water management work approval under Section 90, or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act.

2.2.2 Aquifer Interference Policy (AIP)

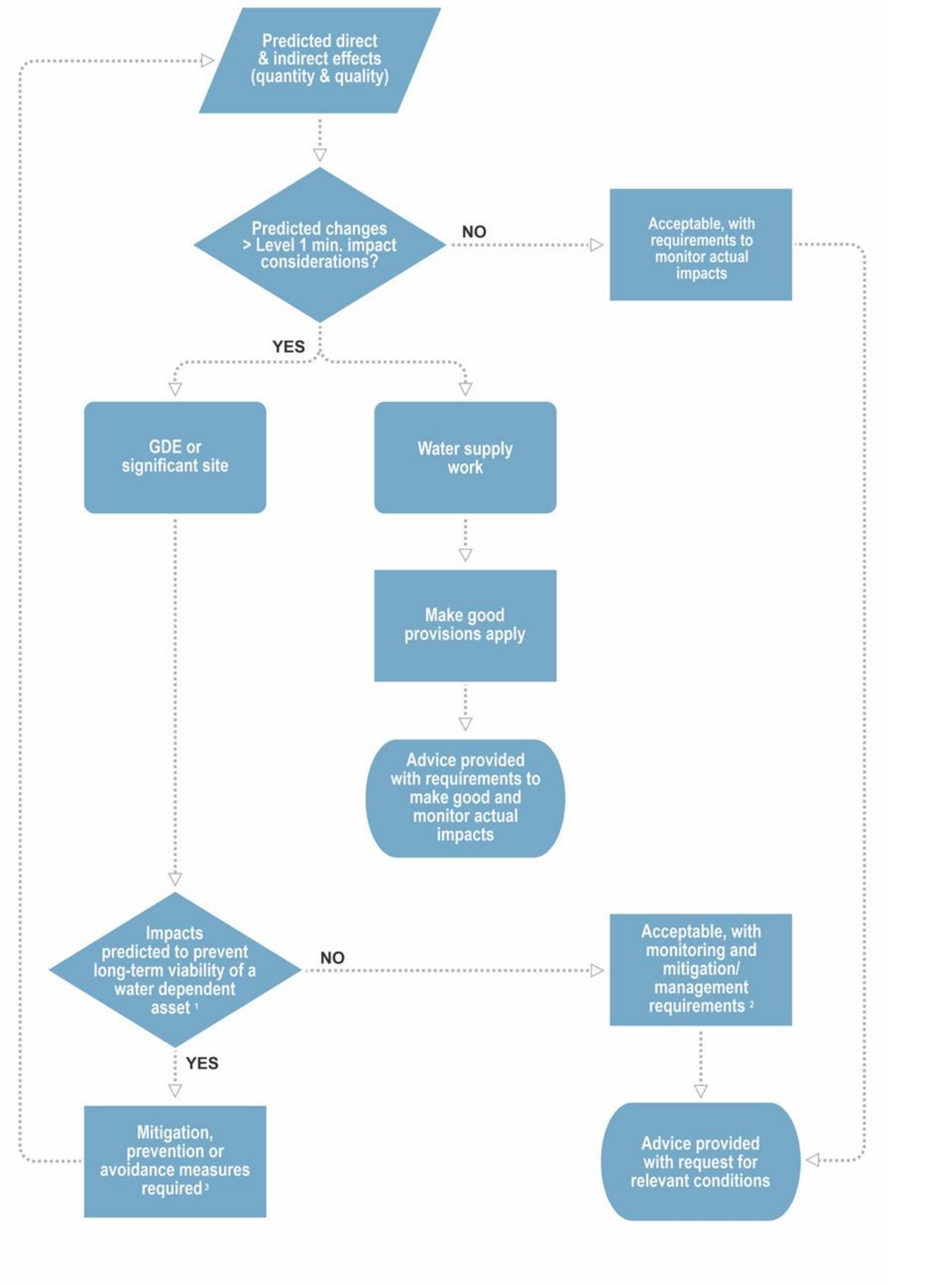
Aquifer interference activities, which are those that take water incidentally to the primary purpose of the activity, are assessed against the requirements of the AIP. The AIP clarifies the requirements for obtaining water licences for aquifer interference activities and defines considerations in assessing and providing advice on whether more than minimal impacts might occur to a key water-dependent asset. The Aquifer Interference Assessment Framework is a step-by-step guide that the department’s Water division use to assess project proposals against the AIP. The framework is available for proponents to use as a tool to aid the development of an EIS and is provided in Appendix B of this Guideline.

The WM Act includes the concept of ensuring “no more than minimal harm” for both the granting of WALs and the granting of approvals. The minimal impact considerations have been developed for impacts on groundwater sources, connected water sources, and their dependent ecosystems, culturally significant sites and water users. The AIP minimal impact considerations process is shown in Figure 6.

AIP Fact Sheet 3 (refer Appendix C) provides guidance regarding licensing and accounting for water. Water can be taken directly from a groundwater or surface water source, usually via a pump (in a river or an excavated area) or bore. It can also be taken indirectly when an aquifer interference activity causes water to flow from another connected groundwater or surface water source. Flows induced from other water sources also constitute take of water. In all cases, separate WALs are required to account for the take from all individual water sources.

Take of water is licensed by the source from where the water is taken. Figure 7 provides an illustration of this concept.

The total volume of water to be taken from each water source as a result of an aquifer interference activity needs to be estimated and documented in the EIS. A proponent is not required to hold sufficient entitlement prior to project approval; however, the proponent is required to demonstrate the licensing pathway to secure sufficient entitlement for the peak take (including documenting the proposed mechanisms to secure the entitlement, for example trade or controlled allocation orders). A proponent is required to hold sufficient entitlement prior to the take occurring.



1. Assessment as per Serov et al 2012, with consideration of uniqueness, ecological/cultural value and timeframe of the impact.
2. Conditions of approval may include requirements for adaptive management to monitor and mitigate or remediate impacts that exceed level 1 thresholds.
3. Where there are no suitable or practical mitigation or prevention options, the proponent may be asked to avoid impacts by modifying the proposed activity.

Figure 6: AIP minimal impact considerations process

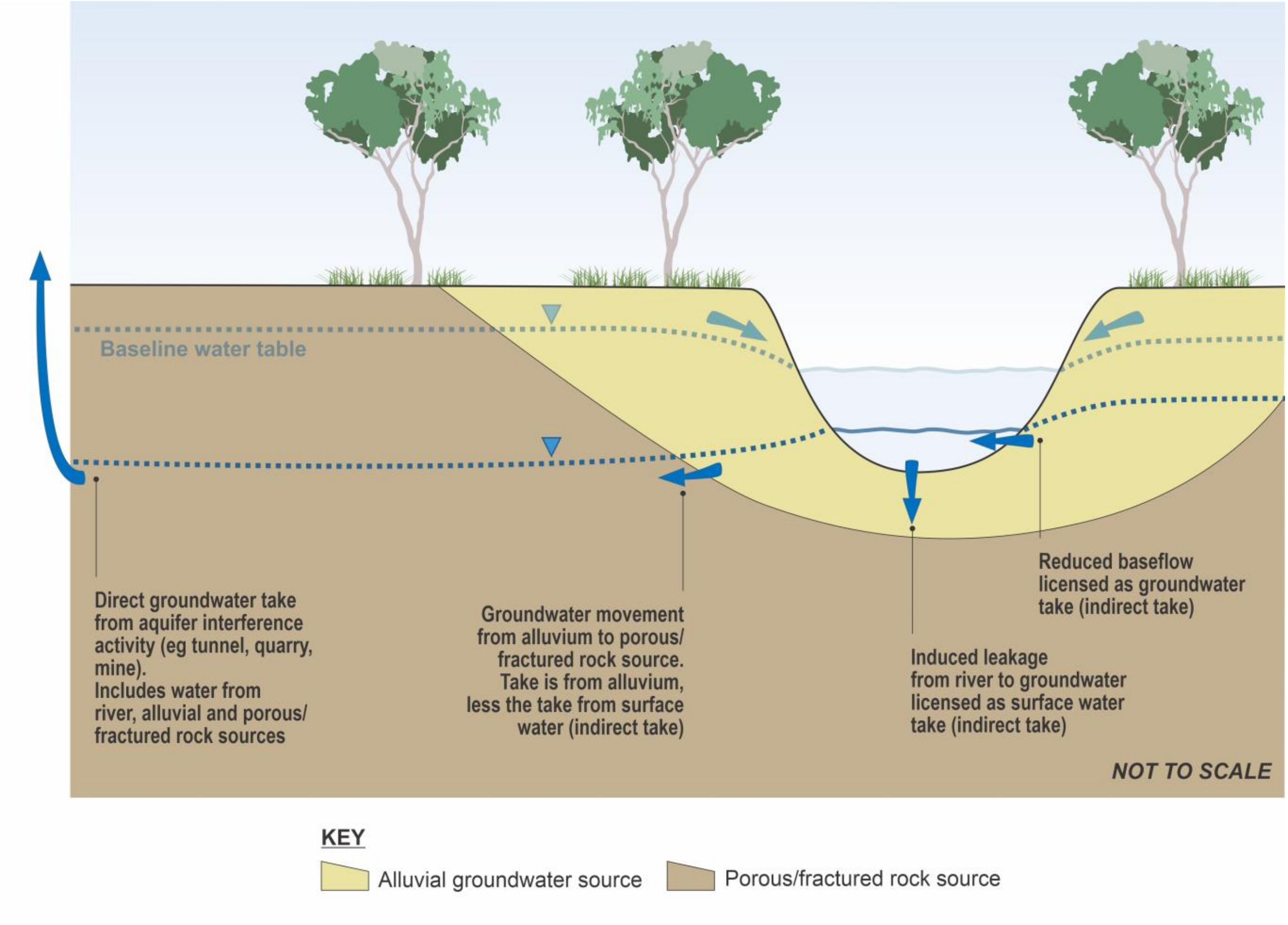


Figure 7: Licensing requirements by the source (surface water vs groundwater)

2.2.3 Bore dealing impact assessment

Where water is taken primarily for consumptive use from a bore or borefield, the intent is that these activities be assessed and licensing requirements applied in the same way as water supply works. The assessment criteria of bore(s) for consumptive use differs to the AIP criteria.

The potential impact of groundwater extraction is managed through the assessment of all applications for groundwater dealings (trade) and water supply work approvals (bores). Either WaterNSW or NRAR receives applications and then refers them, as required, to the department's Water division for hydrogeological assessment. The NSW Government has a fact sheet regarding the process for assessing groundwater work approval applications (NOW 2018).

Where sufficient detail is included in an EIS for a proposed development, such as modelling of abstraction from established production bores, the assessment conducted by the department's Water division will be informed by the assessment provided in the GIA/EIS. Under Clause 4.41(1)(g) of the EP&A Act, a proponent (where a project is approved under the EP&A Act) will be exempt from requiring a water use approval under Section 89, a water management work approval under Section 90, or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act. This includes approval for production bores. Should the project be approved, and if a proponent already holds a WAL, the proponent can apply to amend the existing WAL to link it to a Miscellaneous Work for all works associated with the project (as detailed in and assessed as part of the EIS). The 'dealing' will be referred to the department's Water division for assessment under the department's Water division's 'dealing impact assessment' process.

The hydraulic assessment conducted by the department's Water division involves the analysis of expected drawdown impacts compared to the acceptable levels of impact specified for each groundwater source. Cumulative drawdown from existing authorised works and entitlements and the likely compaction of sediments within the groundwater source are also considered.

The assessment criteria applied for groundwater source and aquifer type is discussed further in Appendix D.

Part A – groundwater investigations

This chapter discusses:

- Overview;
- Data requirements for a GIA;
- Desktop assessments;
- Preliminary conceptual hydrogeological model;
- Preliminary risk identification;
- Gap analysis;
- Field investigations and baseline monitoring network; and,
- Review of conceptual hydrogeological model.

Relevant guidelines, references and information:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Management Framework; Guideline Values;
- Groundwater Monitoring and Modelling Plans – Information for prospective mining and petroleum activities;
- Water Sharing Plans;
- NSW groundwater dependent ecosystems information;
- Minimum requirements for pumping tests on water bores in New South Wales (Department of Planning and Environment, 2019);
- Risk assessment guidelines for groundwater dependent ecosystems (Serov et al 2012);
- Minimum Construction Requirements for water bores in Australia (NUDLC 2020); and,
- Groundwater Sampling and Analysis – A Field Guide (Sundaram et al 2009).

A.1 Overview

In order to assess the potential impact of a project on the water environment, the pre-development baseline conditions[1] must be established. This is essential even if the proposed development is located above the water table and is unlikely to have any substantial impacts on the underlying groundwater systems.

A critical part of a groundwater assessment is the development of a conceptual hydrogeological model that adequately describe the recharge, discharge and flow characteristics of the different groundwater (and potentially surface water) systems that may be impacted by the project. Figure 8 illustrates the typical stages of groundwater investigations conducted to inform groundwater assessments where a groundwater system may be impacted.

The requirements for each project type and location will vary and is dependent on the potential risk of the proposed development on the water environment. Risk is discussed further in this chapter. Example requirements for groundwater investigations for different aquifer interference project types is provided in Appendix A. In addition, Appendix E provides a checklist for proponents to consider in planning the groundwater studies for a project.

[1] Conditions, such as groundwater level and quality spatial and temporal trends, prior to the development of a project, against which subsequent changes can be referenced.

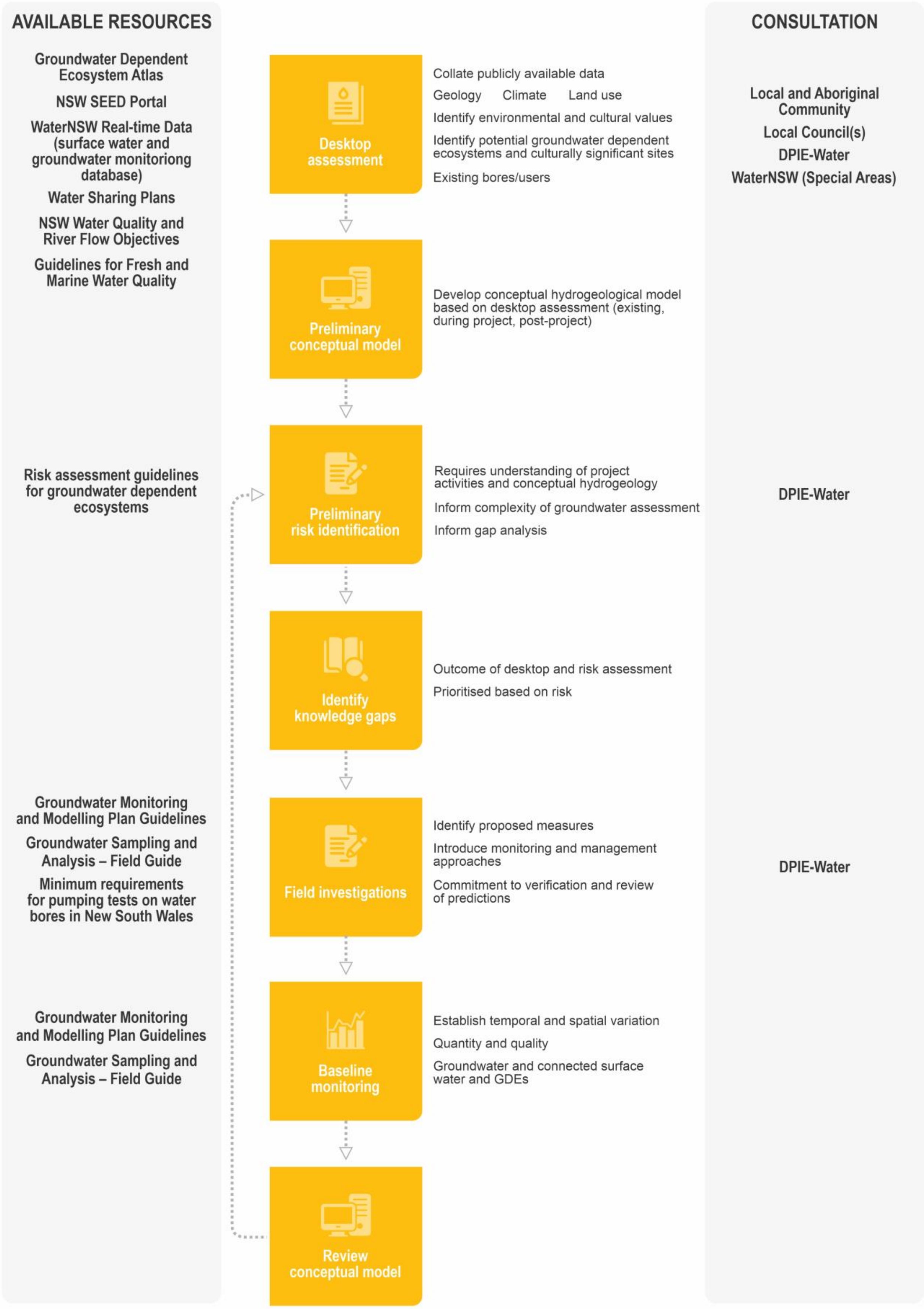


Figure 8: Typical stages of groundwater investigations to inform GIA

A.2 Data requirements for GIA

Data requirements will vary for a project depending on the scale and scope of the project, and whether the project activities will intercept the water table.

For projects that are not expected to intercept the water table, the proponent must ensure that:

- Sufficient groundwater data (spatially and vertically) are available to demonstrate that the proposed activities will not intercept the water table; and,
- Sufficient baseline temporal monitoring data is obtained to demonstrate that the proposed activities will not intercept the water table under varying climate and/or surface water flow conditions.

For projects that are expected to intercept the water table, the proponent must ensure that:

- Sufficient groundwater (and related surface water) data are available to:
    - Define baseline conditions (see point 2 below);
    - Describe the conceptual hydrogeological model; and
    - Assess the potential changes to groundwater and surface water resources due to future operations.
- A minimum of two years of baseline monitoring data is typically required to capture two seasonal cycles[2]. It is recognised that climatic variation may be significant over periods in excess of two years; however, there may be practical limitations to collecting data for longer periods; and,
- Any publicly available data for longer historical periods across the region and within the same groundwater source(s) are considered and referenced in the GIA.

Table 2 provides guidance on baseline data and monitoring requirements.

Table 2: Data requirements for projects that will intercept the water table

Consideration	Requirement
Groundwater level and quality data	
Spatial extent	Sufficient to inform the local settings of the project and specifically in areas where: • Groundwater sources may be impacted by the proposed project; • Surface water sources are thought to be or known to be connected to groundwater; • Groundwater users with the potential of being impacted by the project; and, • Environmental/ecological receptors that are potentially reliant on groundwater.

[2] It will not always be possible or practical to collect two years of baseline monitoring data, for example, where land access constraints limit data collection. This constraint and data gap should be considered as part of a risk assessment and data gap analysis, and a plan put in place for future monitoring. Any assumptions made due to the data gap should be communicated and checked as the project develops.

Hydrostratigraphic unit coverage and depth	As a minimum, groundwater baseline data, such as groundwater levels and quality, and estimates of hydraulic properties, should be collected for hydrostratigraphic units: • Intercepted by the project; • Have the potential to be impacted; • Of high significance (that is, highly productive or highly connected to surface water); and • Of high significance to support groundwater impacts prediction (i.e. aquifer characteristics).
	Nested monitoring sites (recording groundwater elevation and quality at multiple depths at the same location) may be required to inform groundwater systems connectivity and hydraulic gradients. Noting all pressure data using vibrating wire piezometers must be confirmed through the use of direct measurements at a suitable frequency (discussed further in the 'Groundwater level monitoring' section below).
	Deep monitoring bores installed to the proposed project development depth should be installed to ensure characterisation of the lithology to the full depth.
	Structural features affecting the hydrostratigraphy sequence must be documented and characterised with respect to connectivity of groundwater.
	Hydrogeochemistry of all formations in the study area.
Density	Sufficient to inform spatial variations of hydraulic properties, recharge processes, groundwater flow, connectivity and surface water-groundwater interactions across the site.
Duration	Minimum of two years for baseline assessment (AIP requirement).
	Longer baseline monitoring periods may be necessary for calibration where groundwater models are required (dependent on the scale and duration of the project) or during prolonged drought periods where typical seasonal variation is not evident.
Frequency	Sufficient to identify typical temporal variations and response to the climatic changes.
	Minimum requirements: • Groundwater levels: monthly – use of pressure transducer data loggers is recommended for higher frequencies. • Groundwater quality sampling: quarterly.
	Higher frequency may be required, dependent on the connectivity to surface water, and scale and potential risks of the project.
Surface water flow and quality (if surface water and groundwater are highly connected)	

Spatial extent	Sufficient extent to ensure collection of data from surface water sources in connection with groundwater.
Duration	Minimum of two years to collect sufficient data to understand seasonal variation and establish baseline conditions.
Frequency	Sufficient to identify typical temporal variations and response to the climatic changes.
	Minimum requirements: • Surface water flows: hourly – use of data loggers is recommended. • Surface water quality sampling: quarterly.
	Higher frequency may be required, dependent on the scale and potential risks of the project and if a 'high flow' sampling event is required.
Receptor identification	
Groundwater users	Identification of nearby licensed groundwater works using WaterNSW's Real Time Data website.
	Bore census survey to confirm location, measure depth to groundwater, collect groundwater samples and currency of groundwater use in the area.
	Where possible (and if suitable), a selection of existing bores should be included in the project monitoring program.
Groundwater dependent ecosystems (GDEs)	Minimum desktop study to identify potential GDEs (discussed further under ' Desktop assessments' and 'Receptor identification' below).
Culturally significant sites	Minimum desktop study and via consultation.

Figure 9 presents categories of understanding of a groundwater system on the basis of available data and information; the more data and information collated, the greater the understanding.

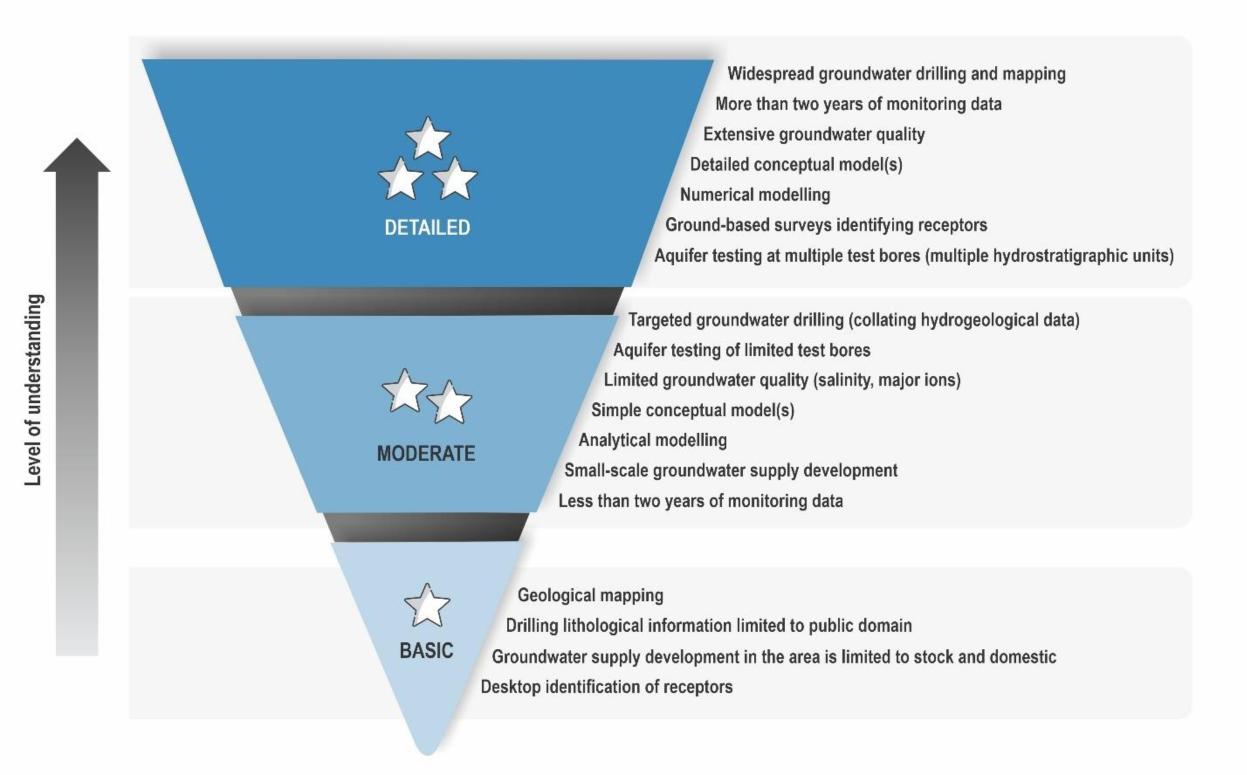


Figure 9: Information complexity and related data sources (adapted from Howe and Dettrick 2010)

A.3 Desktop assessments

A.3.1 Data collation

Collation of all relevant available data, information and past technical studies undertaken in the early stages informs the preliminary assessment of the hydrogeological setting and design of future investigations. Extra effort applied at this stage will avoid unnecessary replication of effort where data and monitoring infrastructure already exist.

The following desktop-based information is used to inform the baseline assessment and hydrogeological conceptualisation:

- Geographical information: topography, climate, drainage and surrounding land use;
- Geological information: comprising the local stratigraphy (including a stratigraphic column), lithology and mapped geological structural features to at least the depth of the proposed project;
- Hydrogeological information and data: local hydrostratigraphic units, existing groundwater development, aquifer management, regional monitoring networks, groundwater levels/pressure and quality, bore search, environmental and cultural values, and vulnerability of the aquifers; and
- Groundwater receptors: groundwater users, potential groundwater dependent ecosystems (GDEs), culturally significant site and connected groundwater and surface water sources.

Some areas of NSW will be data rich, whereas other more remote areas may have limited data available in the public domain. The outcome of the desktop assessment, with assessment of risk will inform the data gap analysis, which are discussed further below.

At completion of this task, the proponent will have developed a database that should include the source, the reference citation, an overview of the reference or dataset and its applicability to the groundwater assessment. There may be references that do not end up being cited in the documentation, however, all sources of data and references used in the assessment, including verbal communication should be captured and documented in the GIA.

A.3.2 Environmental and cultural values

As part of the desktop assessment and through consultation with stakeholders (including local community, Aboriginal community, council, the department's Water division), the proponent should identify environmental and cultural values for the surface water and groundwater sources in the project area. Establishing the values early on allows the development of management objectives and informs the impact assessment.

An environmental and community value is defined in the national water quality guidelines (ANZG 2018) as a particular value or use of the environment that is important for a healthy ecosystem or for public benefit, health, safety or welfare, and requires protection from the effects of stressors. The term 'beneficial use' is also often used to describe the same term. For each catchment in NSW, the Government has endorsed the community's environmental values for water, known as 'Water Quality Objectives'.

Environmental and community values recognised by the national water quality guidelines (ANZG 2018) are listed in Figure 10.

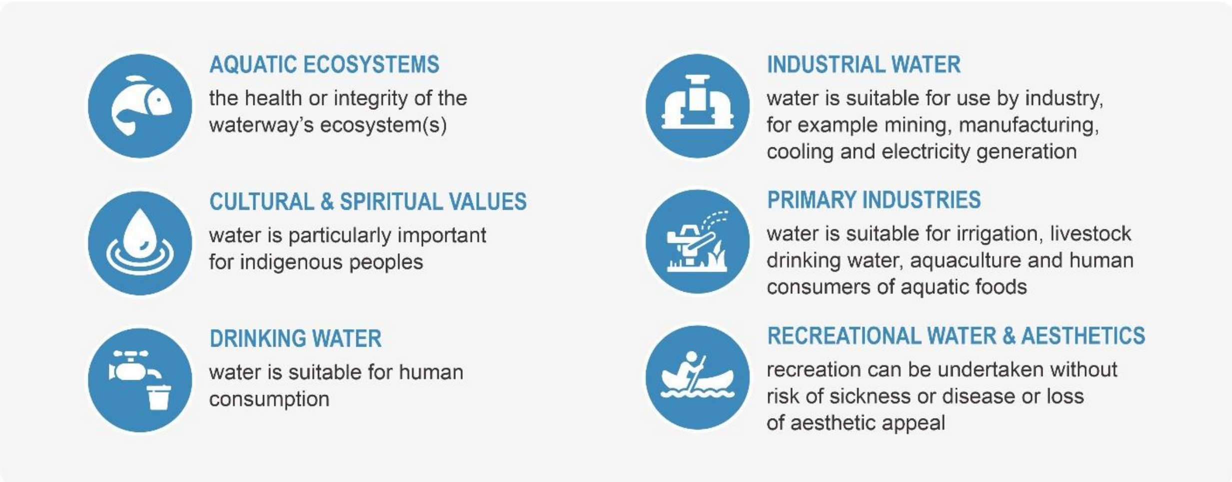


Figure 10: Environmental and community values (adapted from ANZG 2018)

A.3.3 Data sources

Example public sources of data and information are presented in Table 3. Public data are not always reliable and should be carefully considered and documented. The collected information should be reviewed and filtered to remove erroneous data. An example method is to apply a data quality score to data sourced from the public domain, such as information recorded on the *Form A Particulars of completed work* (required as part of drilling a bore in NSW). For example, following analysis of the data, a score of:

1. Poor quality data score - applied to data considered to be erroneous and not recommended for use in interpretation. This may be outliers, lithological records that disagree with neighbouring data or literature. These data would typically be excluded from use in charts, maps and so on, but would be retained in the database in the event future investigations or if further analysis suggest the data is reliable.
2. Moderate quality data score – data that is likely to be used with only minor adjustment (such as topographic elevation), however, should be treated with caution and be examined in the event that data deliverables appear incorrect (for example, bullseye on a contour map). An example is assuming an elevation for ground level or top of casing for a depth to groundwater measurement, or use of water quality data where quality assurance/quality control (QA/QC) information is missing.
3. High quality data score – data that has been collected by competent personnel and where QA/QC information is available. For example, lithological logging recorded by the proponent's competent geologist or groundwater level observations recorded by an experienced hydrogeologist and where raw data and field records are available for review. Typically, this data would be used in interpretations and the development of the conceptual hydrogeological model or presentation on data deliverables (such as charts, maps).

Table 3: Publicly available data sources for desktop assessments

Setting	Source	Description	Reliability
Climate	BoM's climate database	Actual rainfall and evaporation records from climate stations	High
	SILO Australian climate gridded data	Statistical spatial interpolation of available data	High where BoM data is dense Low where BoM data is sparse
Topography	Geoscience Australia's Digital Elevation Data	National elevation data	High
	ELVIS, Elevation and Depth, Foundation Spatial Data	Online data	High
	Digital Elevation Model (DEM) data	Packaged data derived from LiDAR model, 5 metre grid	High
Land use	DPE's eSPADE information system	Map-based land use	High

Geology, geochemistry, soil	Publicly available geological/structural maps	Available digital and hard copies of geological maps at different scale (commonly 1:25,000 to 1:500,000)	Moderate to low – lack of accuracy at project's scale
	Mining, Exploration and Geoscience Geological Survey of NSW	Geological mappings Mineral systems studies Geophysical surveys Mineral exploration assessment	Moderate – possible lack of accuracy at project's scale
	DPE's eSPADE information system	Map-based soil data in NSW (including acid sulfate soils risk mapping)	High
	Mining, Exploration and Geoscience data, through MinView MinView web-based display system	Map-based data (drillholes, geochemistry, mineral occurrences, petrology and more) Geoscience data packages for various regions	Moderate – possible lack of accuracy at project's scale
	Digital Imaging of Geological Systems (DiGS)	Public online archive for NSW's geological, exploration, mining and geotechnical documents (including reports and maps)	High
Hydrogeology (aquifers, groundwater levels, groundwater quality)	Publicly available hydrogeological maps (eg 1:5M Hydrogeology Map of Australia and 1:250,000 Hay NSW Hydrogeological map of the Murray Basin)	Available digital and hard copies of hydrogeological maps at different scale	Moderate to low – lack of accuracy at project's scale
	Groundwater vulnerability maps available for a number of catchments in NSW	Maps showing the vulnerability (or level of risk) of aquifers to contamination relating to physical characteristics of the location	Moderate to low – lack of accuracy at project's scale

	National Groundwater Information System (NGIS) BoM's Australian Groundwater Explorer (AGE)	ESRI file geodatabase of national groundwater data Bore information from the NGIS can be visualised using the AGE	Typically high, however may be low where bore construction, bore condition or screened lithology is unknown
	WaterNSW's real time database MinView web-based display system	Data collected from State groundwater monitoring network and following drilling of private bores	Typically high, however may be low where bore construction, bore condition or screened lithology is unknown
Surface water	DFSI hydro line spatial data	Dataset of mapped watercourses and waterbodies in NSW	Moderate – possible lack of accuracy at project's scale
	WaterNSW's real time database	Data collected from surface water monitoring network	High
Endangered species as potential receptors	Department of Agriculture, Water and the Environment Protected Matters Search Tool	Tool to locate matters of national environmental significance or protected by the *Environment Protection and Biodiversity Act 1999* (EPBC Act)	Moderate – possible lack of accuracy at project's scale
	Department of Planning and Environment BioNet Atlas search	Records of threatened species listed under the EPBC Act and *Biodiversity Conservation Act 2016* (BC Act)	High (dependent on accuracy of record – listed in attribute table)
GDEs	BoM's Groundwater Dependent Ecosystems Atlas	National dataset of mapped potential GDEs	Moderate – possible lack of accuracy at project's scale, additional ground-truthing often required to confirm accuracy and reliance on groundwater
	NSW SEED portal	Spatial layer of High Ecological Value Aquatic Ecosystems (HEVAE) vegetation GDEs in NSW	Moderate – possible lack of accuracy at project's scale, additional ground-truthing often required to confirm accuracy and reliance on groundwater

	DPE's spatial portal	Spatial layer of High Ecological Value Aquatic Ecosystems (HEVAE) vegetation GDEs in NSW	Moderate – possible lack of accuracy at project's scale, additional ground-truthing often required to confirm accuracy and reliance on groundwater
	Water Sharing Plans	water sharing plans include information and maps of mapped potential GDEs	Moderate - possible lack of accuracy at project's scale, data may not be exhaustive
Water availability, usage and licensing	Water Sharing Plans	Policy frameworks, strategies and plans related to water management	High
	Water source areas (spatial data)	Boundaries for water sources defined in Water Sharing Plans	High
	NSW Water Register	Register of all water access licences, approvals, trading and other water entitlements in NSW	High

Proponents also often collect data for the purposes of defining the project feasibility (for example, extent and grade of a mineral resource). This information may include geological and geophysical data that may contribute to the development of the conceptual model and establishment of baseline conditions.

It is also recommended that the proponent make use of all technical reports and data (from hydrogeological, geological, geotechnical and ecological studies) undertaken for the project or for other projects in the vicinity to avoid unnecessary duplication of previous investigations.

A.4 Preliminary conceptual hydrogeological model

A preliminary conceptual understanding of the hydrogeology and hydrodynamics of the project area is required to identify knowledge gaps and design a monitoring program. The preliminary conceptual hydrogeological model should be developed as an outcome of the desktop assessment, to identify:

- Hydrostratigraphic units including:
    - Their extent (spatially and vertically);
    - Characteristics (aquifer or aquitard), hydraulic conductivity, storage parameters;
    - Water quality;
    - Water pressure (or total head); and,
    - Recharge and discharge features;
- Mechanisms for recharge and discharge;
- Geological structures and conceptual boundaries;
- Interpreted directions and magnitude of groundwater flow/flow pathways;
- Surface water-groundwater interactions;
- Water sources (highly productive vs less productive);
- Environmental and cultural values, and potential receptors (social, economic, environmental and cultural);
- Existing bores (monitoring, investigation, operating/production, private and Government owned);
- Climate variability;
- Existing groundwater development and use in the area (for example, irrigation areas, town water supply borefields);
- Activities or infrastructure likely to be intercepting groundwater (for example quarries, mines, tunnels); and
- Sources of potential contaminants (for example, waste storages, water treatment plants).

At this early stage, the conceptual hydrogeological model will typically be preliminary and based on a number of assumptions. As the assessment proceeds, the proponent should continuously update the conceptual hydrogeological model including description of existing conditions, conditions during the project and conditions post-development.

The conceptual hydrogeological model should be presented graphically through the use of cross-sections and three-dimensional (3D) block diagrams, with supporting descriptive text and charts to describe the hydrodynamics. Further discussion on the requirements for presentation of data, including supporting text, charts and figures to describe the conceptual model is provided in Part B.

Example diagrams that illustrate the conceptual understanding for various projects is provided in Figure 11 to Figure 13. Further examples are provided in Appendix A.

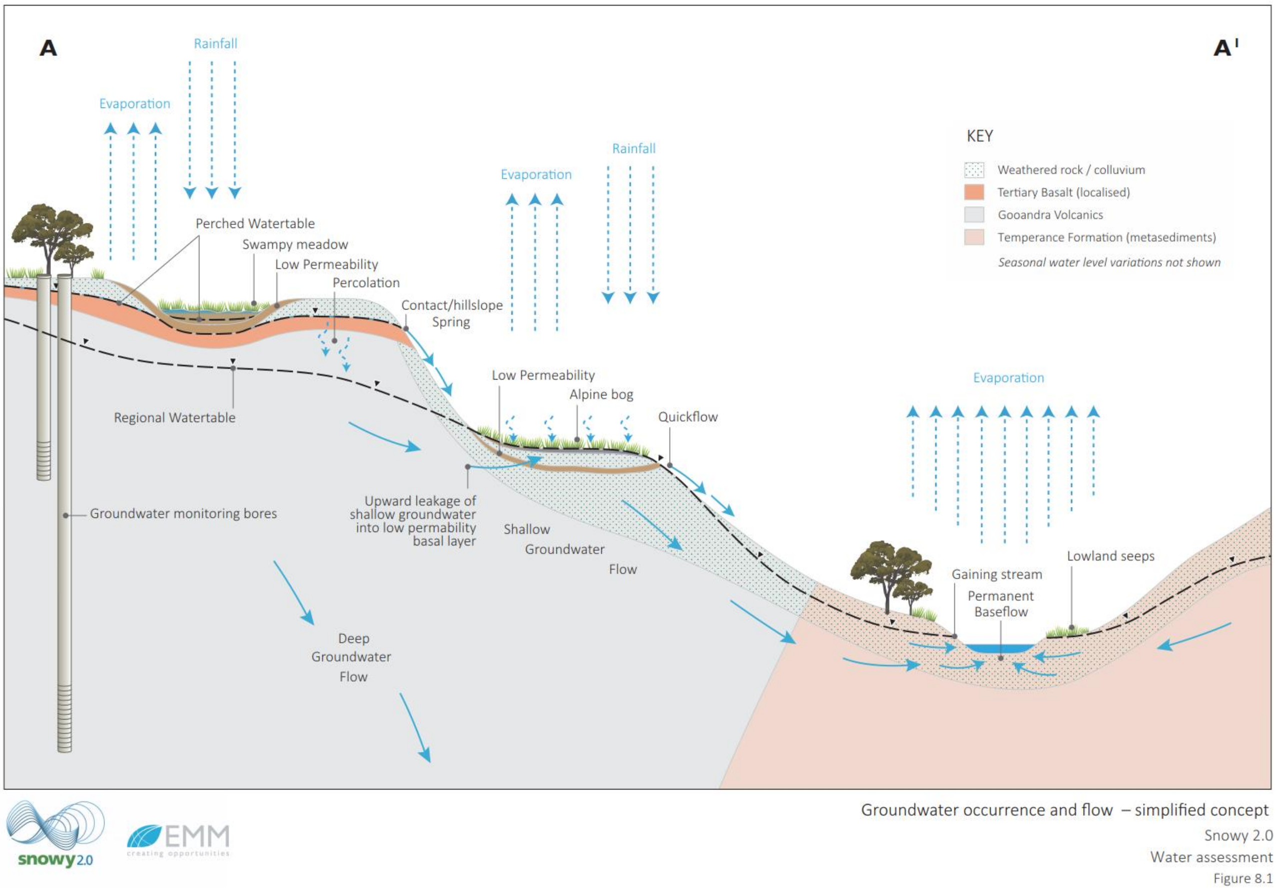


Figure 11: Example conceptual diagram - Snowy 2.0 water assessment

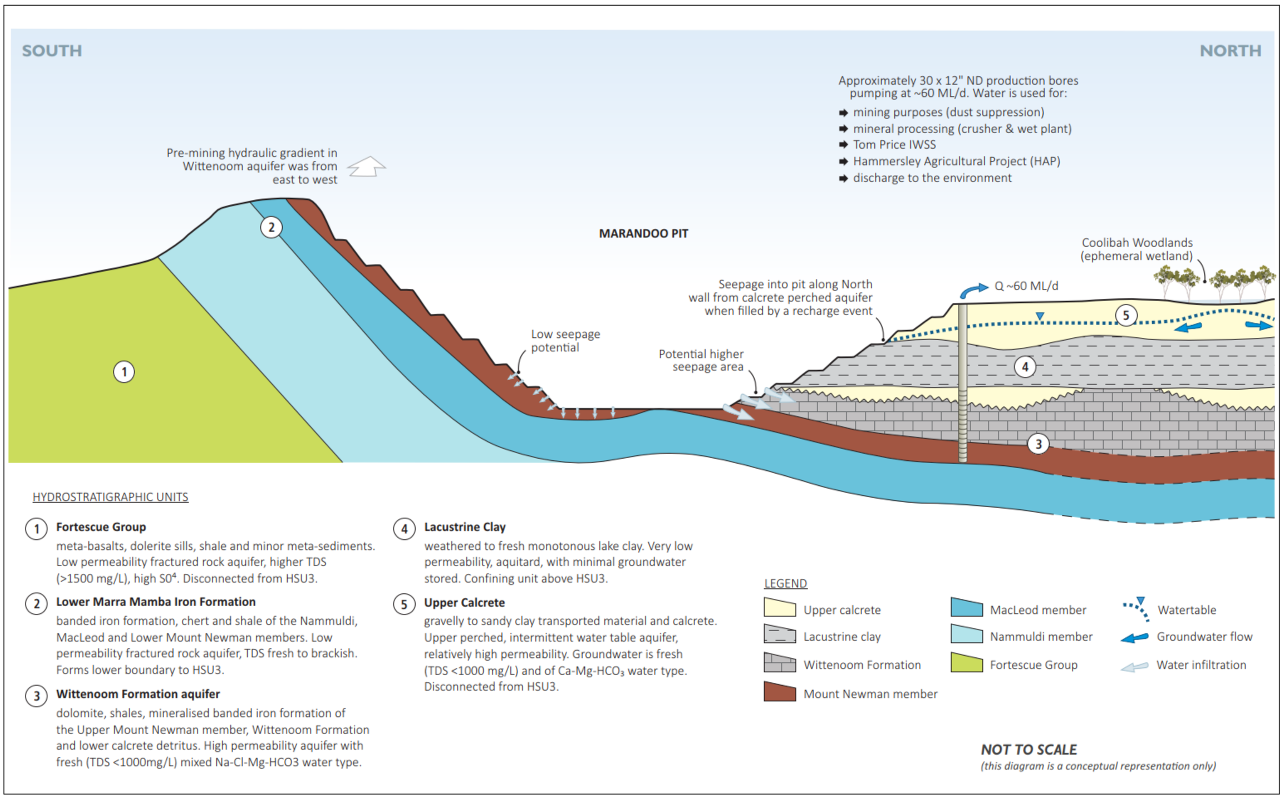


Figure 12: Example conceptual hydrogeological model (EMM, not published)

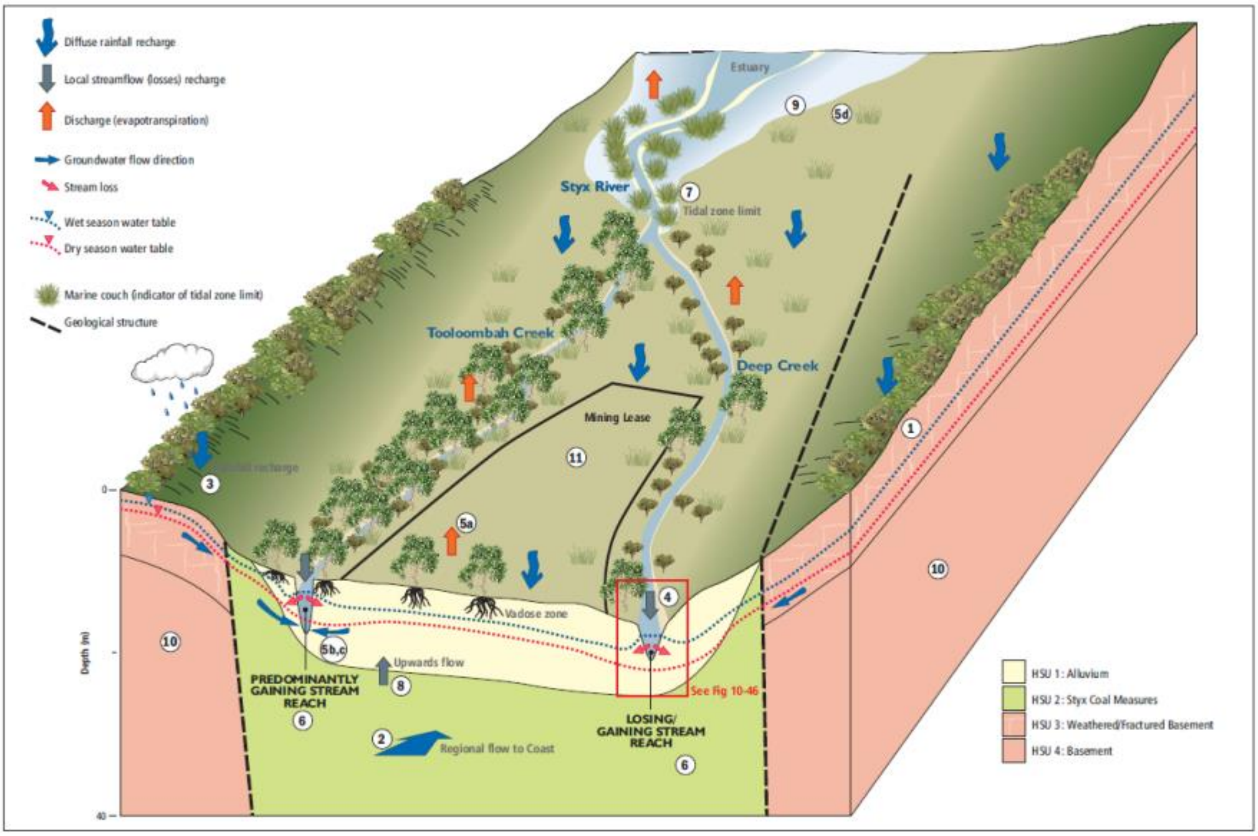


Figure 13: Example conceptual hydrogeological model - Central Queensland Coal Project (CDM Smith 2018)

A.5 Preliminary risk identification

Following the development of the preliminary conceptual hydrogeological model, a risk assessment should be developed, which will inform the requirements for the type and density of data required to estimate baseline conditions, further develop the conceptual hydrogeological model and inform the GIA. The principles of risk assessment should be considered and are well documented. For example, international standard (ISO) 31000:2018 provides guidance on risk management, framed around the principles, framework and process of risk identification and management.

As the conceptual hydrogeological understanding improves and as the project develops, the risk assessment should be continuously reviewed and adapted, throughout all stages of a project. This is common practice in most large-scale projects such as mining projects.

To select the most appropriate format for the preliminary (and potentially future) risk assessment(s), it is important to consider the proposed project activities (scale, duration and scope) and how they might affect the water environment. Consideration factors for the risk assessment include:

- Is the water source a highly productive aquifer or less productive (as defined in the AIP)?
- What are the project activities that have the potential to affect surface water and groundwater?
- Does the project have the potential to affect a highly connected alluvial or surface water source?

- Does the project have the potential to affect high value GDE or culturally significant site (defined in the water sharing plan)?
- Is the project a large coal mine or coal seam gas project?
- Does the project have the potential to affect Sydney drinking water supply?
- Does the project have the potential to affect town water supplies?
- Is the project located near high density water supply works (for example, irrigation areas)?
- Is the project located in an area with high density of existing data (for example, government monitoring)?
- What is the duration of potential impact?

A.6 Gap analysis

Knowledge gaps will have been identified as an outcome of the preliminary risk identification and preliminary conceptual hydrogeological model developed in the desktop stage of the assessment.

For an SSD/SSI scale project, a field investigation program is typically required to fill knowledge gaps and develop a monitoring network to collect baseline data.

Table 4 lists example field investigations that can be conducted to fill knowledge gaps. The section on ‘ Field investigations and monitoring network’ discusses various types of field investigations that are conducted to improve the conceptual understanding and fill knowledge gaps.

Table 4: Examples of data gaps and how to address them

Data gap	Possible investigations
Geological knowledge	Surface geological mapping to identify surficial lithology, structures, outcrop areas.
	Geophysical surveys (e.g. magnetic surveys, gravity or electromagnetic surveys, downhole) to assess surface and sub-surface geology, structures, lithological interfaces.
Hydrogeological knowledge	Existing infrastructure that may be useful for establishing baseline conditions and ongoing monitoring includes existing landholder bores, WaterNSW’s monitoring bore network and surface water stream-gauging stations (subject to necessary access approvals). WaterNSW monitoring data is available online, however landholder bore information is usually limited to driller records (completed as part of a Form A which is required after drilling and installing a bore).
	Landholder bore census/surveys in the area, including information about use/pumping activity, confirmation of bore construction, measurement of groundwater elevation and water quality sampling.
	Exploration drilling to investigate hydro-lithological conditions and aquifer properties through installation of monitoring and/or test production bores.
	Installation of monitoring bores to establish groundwater flow directions, hydraulic gradients (vertical and lateral), assess aquifer connectivity and interaction with surface water, and assess groundwater quality.

Surface water – groundwater connectivity	Watercourse surveys, including streamflow monitoring and water quality and invertebrate sampling to assess the presence of groundwater.
	Drilling and installation of standpipes near watercourses to monitor shallow groundwater levels and assess whether watercourse is a losing or gaining system.
	Site walkovers to gather information in the project area, including information on geology (for example, outcrop or structures), surface water bodies and seeps and springs.
Groundwater dependence of environmental receptors	Ecological surveys, including vegetation mapping to identify plant community types (PCTs) and targeted threatened species surveys. This data can be cross correlated with mapped depth to water table (and seasonal variation) to ascertain groundwater dependence.
	Invertebrate sampling, undertaken using the existing network of bores and sampling various lithologies, to identify invertebrate communities.

A.7 Groundwater monitoring and modelling plan for mining and petroleum projects

For mining and petroleum projects, a Groundwater Monitoring and Modelling Plan (GMMP) must be developed in the early stages of the project (as part of exploration drilling activities) in accordance with the GMMP guideline (former DPI Office of Water 2014). A GMMP, developed in consultation with the NSW Government ensures the data requirements, such as the establishment of a baseline and a history of data, that cannot be met retrospectively, are considered at the exploration phase of a mining or petroleum project.

GMMPs are required as a standard condition of licence for exploration drilling under the *Mining Act 1992* and *Petroleum (Onshore) Act 1991*. GMMPs document proposed groundwater, and related surface water, monitoring programs to inform:

- Assessment of baseline and regional conditions;
- Hydrogeological conceptualisation; and
- Time series data for future groundwater model calibration.

A GMMP is a live document that needs to be developed and updated as a project progresses in consultation with the department’s Water division to ensure the groundwater monitoring requirements, which can have a long lead time, are adequately planned and underway when required.

The GMMP would typically be developed following the desktop assessment and development of the preliminary conceptual hydrogeological model, as described in ‘ Desktop assessments’ and ‘ Gap analysis’ above.

A.8 Field investigations and monitoring network

A.8.1 Surface geophysical surveys

Results of geophysical surveys (for example, seismic, electromagnetic, gravity or magnetic surveys; ground-based or airborne) can be useful for:

- Two-dimensional (2D) or 3D mapping of geological formations and stratigraphy with the interpretation of lithological interfaces and dimensions, and/or aquifer parameters including water quality;
- Delineation of geological structures (for example, faults, shear zones, intrusions, dykes) at the surface and at depth; and,
- Identification of potential aquifers and /or aquitards.

The above information can then be used to select drilling locations for monitoring and/or test production bores, which would be used to collect hydrogeological information about lithology and geological structures in the project area, informing the hydrogeological conceptual understanding.

Mapping and ground-truthing of geological structures that have the potential to influence groundwater flow is an important consideration for most projects (refer Appendix A).

A.8.2 Drilling and construction of bores

Typically, the purpose of groundwater test and monitoring bores is to:

- Identify hydrostratigraphic units (aquifers and aquitards);
- Investigate hydrostratigraphic unit depth and thickness, hydraulic behaviour;
- Obtain hydraulic properties for modelling purposes;
- Measure groundwater elevation in hydrostratigraphic units and allow collection of water samples for laboratory water quality analysis; and,
- Assess interaction between hydrostratigraphic units and any connected surface water bodies.

All bores should be drilled and constructed by an appropriately licensed driller in accordance with WM Act and the *Minimum Construction Requirements for water bores in Australia* (NUDLC 2020). Relevant licences and approvals must be obtained prior to the drilling and construction of monitoring bores if deeper than 40 metres below ground level. The details of all constructed bores (including those shallower than 40 metres depth) should be recorded on a *Form A Particulars of completed work* and submitted to WaterNSW following completion.

The placement of monitoring bores should consider both depth and location. Commonly nested monitoring bores (that is, monitoring bores at different depths at the same location) are required to understand vertical dynamics. For example, for deep open cut mines or underground mining operations, placement of monitoring bores should include installation of monitoring locations to the same depth of the proposed excavation.

The monitoring bore network must be sufficient to address the knowledge gaps identified and to gain an understanding of the:

- Hydraulic interactions between hydrostratigraphic units and surface water sources;
- Water quality variations; and,
- Potential impacts to any identified receptors.

In addition, the design of the monitoring program should consider the proposed project activities if known, targeting up and down gradient monitoring bore locations. Locations should consider the possible location of potentially contaminated elements of a project, including stockpiles, sludge ponds, water storages, tailings storages and so on.

A.8.3 Downhole geophysical surveys

Downhole geophysical surveys (in open drillholes or cased holes) can be used to measure various physical properties of lithology and the fluids they contain. In groundwater investigations, such surveys can be used to obtain information on bore construction, rock lithology and fractures, permeability and porosity, and water quality. They can also be used to inform production bore designs. Common geophysical logging tools include caliper (borehole diameter), natural gamma, single-point resistance, spontaneous potential, normal resistivity, fluid resistivity, temperature, flow, and acoustic televiewer (or CCTV).

A.8.4 Groundwater level monitoring

Groundwater level monitoring should be undertaken to establish baseline conditions and assess changes in groundwater levels and flow as the project progresses. It is important to monitor for spatial, vertical and temporal variations in groundwater elevations to assess hydraulic gradients, changes due to climatic variations and potential drawdown or rising head impacts from the project.

In hard rock geological environments with low hydraulic conductivity, where quarrying or open cut mining projects may occur, it can take time for groundwater to flow into and stabilise in newly drilled bores. Sufficient time is required to allow groundwater levels to stabilise at new monitoring sites.

A.8.4.1 Vibrating wire piezometers

Appropriately installed and calibrated vibrating wire piezometers (VWPs) can be utilised to collect data on groundwater pressure, which can be used to assess hydraulic connection and hydraulic conductivity. VWPs monitor pore pressures within a geological formation instead of directly recording groundwater head or hydrostatic pressures. VWPs can provide cost effective data across multiple intervals within a single drillhole.

VWPs are commonly used for geotechnical monitoring purposes (for example, slope stability, dam or foundation construction control). The use of VWPs for groundwater level monitoring should be carefully considered as the actual depth of water cannot be measured after the VWP is installed. Also once grouted, it is not possible to obtain water quality samples from these sites. VWPs are installed in boreholes and are usually fully grouted in place. This installation limits the reliability of and ability to verify the data collected for groundwater purposes as their calibration can vary over time if the boreholes have not been sealed perfectly.

It is not recommended that VWPs be used as an alternative to standpipe monitoring bores. Open standpipe monitoring bores provide robust data on the potentiometric surface across a known horizon (screened interval) for long periods of time. In contrast, and depending on installation methodology, VWPs provide a pressure measurement over an unknown vertical interval for periods generally less than 10 years. VWP pressure data should be routinely verified and, ideally, interpreted in conjunction with data from open standpipe bores. Documentation of the installation, calibration and verification of VWP data should be included in relevant reports (such as the GIA and WMPs) for quality assurance purposes.

A.8.5 Aquifer testing

Aquifer testing is used to estimate the hydraulic properties and characteristics of an hydrostratigraphic unit and the characteristics of its hydraulic interaction with other hydrostratigraphic units and surface water sources. Hydraulic properties inform the conceptual understanding and can be used to constrain or guide the calibration of a numerical model.

Such testing could include pumping drawdown and recovery tests, slug tests and packer tests. Laboratory core testing can also be considered to inform some hydraulic properties of the formation (for example, porosity and in-situ permeability). Observation of groundwater level drawdown at adjacent and surrounding monitoring bores during testing allows storage parameters to be estimated, which are important for assessing the area of influence of an aquifer interference activity and in turn, potential impacts on receptors. Connection to overlying surface water and alluvial systems may also be assessed during longer term aquifer tests. This can be more effective when combined with detailed chemistry of the surface water and groundwater. Records of water make and groundwater elevation response during early periods of the project development can be assessed as a large-scale aquifer test to estimate and/or review native or host rock hydraulic conductivities.

The following additional comments are provided:

- In dual porosity systems such as fractured rock environments, results from pumping drawdown tests such as step tests and constant rate pumping tests can be biased to higher hydraulic conductivity areas of an aquifer and can over-estimate the bulk the hydraulic conductivity of a hydrostratigraphic unit. Conversely, laboratory core testing is conducted on competent core and as such, estimates of hydraulic properties will be biased to the low hydraulic conductivity portions of a hydrostratigraphic unit.
- Where possible, aquifer testing should also be used to estimate hydraulic properties of confining layers, such as the leakage parameter.
- For groundwater modelling and assessment of potential impacts on identified receptors, it is important to estimate storage properties of the hydrostratigraphic units the project area. This can be estimated from core testing and from pumping tests where groundwater drawdown is observed at one or more adjacent monitoring bore.

All pumping drawdown and recovery tests should be conducted in accordance with the *Minimum requirements for pumping tests on water bores in New South Wales* (Department of Planning and Environment, 2019).

The results of aquifer test analysis should be appended to the GIA for quality assurance purposes.

A.8.6 Hydrogeochemical analysis

Standpipe groundwater monitoring bores allow the sampling and analysis of groundwater quality. Baseline water quality should be established, with ongoing, periodic sampling undertaken as a project progresses. It is important to monitor for spatial and temporal variations in groundwater quality. Whilst salinity is a common primary water quality concern, it will usually be necessary to analyse for other analytes to determine baseline groundwater conditions.

In some instances, the sampling and analysis for a range of hydrogeochemical analytes may assist the assessment of hydrodynamic processes. For example, environmental isotopes can be used to better understand aquifer recharge and discharge processes, aquifer interconnectivity, groundwater-surface water interaction and GDEs.

The selection of the water quality suite of analysis will vary for different project types and will be dependent on the proposed activities and identified risks. The suite of analysis should be selected by identifying ‘indicators’ of water quality change as a result of the water affecting activity. For example, a tailings storage facility at a gold mine may require monitoring of arsenic, cyanide and other analytes of concern. Also, baseline comprehensive suite of groundwater quality analysis for coal seam gas and large coal mines, should include major ions, dissolved metals, salinity, trace metals, dissolved gases, nutrients and hydrocarbons with sufficient frequency to establish potential seasonal variation (such as quarterly). Consideration factors should include:

- Project activities – will the development introduce potential pollutants into the area? For example, processing, tailings storage facilities, risk of acid sulfate soils or acid metalliferous drainage, storage of hydrocarbons, movement of poorer quality water into an area of higher quality water.
- Existing land use – are there activities occurring in the area that may be altering or have the potential to alter water quality in the area? For example, agriculture can introduce pesticides and/or nutrients.

- Receptors (social, economic, environmental, cultural) – sensitivity of receptors to changes in water quality (for example, salinity and pH).
- Water Quality Objectives for NSW waterways (DECCW 2006) – applicable to projects that have the potential to impact or interact with surface water.
- Water Quality Guidelines (ANZG 2018) – The Australian and New Zealand Guidelines for Fresh and Marine Water Quality are available online. The guidelines provide default guideline values and guidance on deriving guideline values related to the protection of aquatic ecosystems and community values (for example, primary industry, drinking water, recreation and aesthetic values, and cultural and spiritual values).

Table 5 lists example water quality analysis suites, ranging from basic analysis up to comprehensive analysis.

Geoscience Australia have developed guidelines for groundwater sampling and analysis (Sundaram et al 2009). Proponents should follow standard methods for groundwater sampling and analysis, including documentation of quality assurance and quality control protocols. This will ensure collection of representative, repeatable and high integrity water samples are collected and submitted for laboratory analysis. Methods include (but are not limited to):

- Regular calibration of water quality meters used to measure field water quality meters (evidence of calibration records should be retained);
- Sampling conducted by a suitably qualified person;
- Collection of duplicate samples and blanks for quality assurance purposes;
- Sample transport to the laboratory following documented chain-of-custody procedures and occurring within prescribed holding times; and,
- Laboratory analysis preferably at a National Association of Testing Authorities (NATA)-accredited laboratory, including quality assurance and quality-control checks and reporting to demonstrate the validity of results.

Table 5: Example water quality analysis suite

Field parameters	Major ions	Dissolved metals/ trace elements	Other analytes	Total suspended solids	Nutrients	Dissolved gases	Hydrocarbons	Isotopes
EC TDS pH Temperature Dissolved oxygen Redox	Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate Sulphate	Aluminium Antimony Arsenic Barium Beryllium Boron Bromide Cadmium Chromium Cobalt Copper Iron Lead Manganese Mercury Molybdenum Nickel Selenium Strontium Uranium Vanadium Zinc	Fluoride Total organic carbon Cyanide Silica	TSS	Nitrate Nitrite Ammonia Reactive phosphorus Total phosphorus	Methane Hydrogen sulphide Carbon monoxide Nitrogen	Phenol compounds Polycyclic aromatic hydrocarbon (PAH) Total petroleum hydrocarbon (TPH) Benzene, Toluene, Ethyl Benzene and Xylenes (BTEX)	Stable isotopes (oxygen-18 and deuterium) Radio isotopes (e.g. carbon-14, chloride-36, tritium)

Basic analysis									
Intermediate analysis									
Comprehensive analysis									
									If required

Note: EC = electrical conductivity; TDS = total dissolved solids; TSS = total suspended solids

A.8.7 Receptor identification

At the desktop assessment stage, potential receptors will have been identified. It is recommended that this be assessed further through ground-based surveys to gather additional information, identify other potential receptors that were not identified through the desktop assessment, and gather data to improve the understanding of receptor reliance on groundwater. Potential groundwater receptors within or near the proposed project can include:

- Existing groundwater users; and,
- Environmental receptors that potentially rely on groundwater, including:
    - Aquatic ecosystems (for example, creeks/rivers, wetlands, swamps);
    - Terrestrial ecosystems (for example, vegetation, threatened species habitat);
    - Subterranean ecosystems (for example, stygofauna living in saturated alluvial or karstic aquifers); and,
    - Culturally significant sites (sites such as springs, waterholes that have cultural or spiritual importance).

The list of high priority GDEs identified in a water sharing plan will not always be exhaustive. Therefore, ecological surveys to identify other potential GDEs are often needed for SSD/SSI projects.

When assessing ecosystem dependence on groundwater (for example, terrestrial vegetation), it is important to understand the depth to groundwater. In an unconfined system, this will be the water table elevation. In a fractured rock or confined system, the important consideration factor is the depth of first water strike/cut and therefore requires well documented hydrogeological observations during drilling. Where available, data from the groundwater model may be used to assist in estimating the depth to groundwater.

It is recommended that a classification of any environmental receptors, including GDEs, is undertaken in accordance with the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (Serov et al 2012) to determine the groundwater dependence of identified environmental receptors. Environmental receptors should be classified into the following categories according to their increasing dependence on groundwater:

- Non-dependent;
- Facultative:
    - Opportunistic;
    - Proportional;
    - Highly dependent; and,
- Entirely dependent/obligate.

The ecological value of identified environmental receptors should also be determined in line with the requirements of Serov et al (2012). Environmental receptors should be categorised into low, moderate or high value considering sensitivity to changes in groundwater, location in reserves, condition, uniqueness and ecosystem services.

Where a high value GDE is identified and there is the potential for impacts from the project, the proponent should install shallow monitoring bore(s) adjacent to the GDE to confirm the conceptual understanding and allow monitoring of shallow groundwater levels.

A.8.8 Surface water monitoring

Surface water monitoring should occur where a connected surface water source has the potential to be impacted by the proposed project and to inform the conceptual hydrogeological model. WaterNSW operates stream-gauging stations on most significant rivers. Surface water flow and river channel data can be used to estimate baseflow, which can be complimented with collection of surface water and groundwater quality data. The proponent may need to install their own gauging station where adequate baseline data is needed to support conceptualisation and groundwater model development, particularly in higher ecological value or higher use systems.

A.9 Review conceptual hydrogeological model

As field-based data is collected and assessed, the assumptions and input data used to develop the preliminary conceptual hydrogeological model(s) and risk assessment should be reviewed. As more data is collected, knowledge gaps should be reduced, increasing understanding, reducing conceptual uncertainty and potential risks.

Proponents are required to provide graphical representation of the conceptual hydrogeological model in the GIA report (discussed further in Part B). Conceptual models should represent baseline conditions (pre-development), during development and post-development stages of a project.

At this review stage, following the field investigations to address knowledge gaps, the conceptual hydrogeological model should be reviewed and updated with consideration of the following components:

- Hydrostratigraphic unit extent (spatially and vertically);
- Use of existing geological models developed by the proponent (for example, for the resource investigation phase of mining or petroleum developments);
- Potential receptors (social, economic, environmental/ecological and cultural);
- Existing bores (monitoring, investigation, operating/production, private and government owned);
- Climate variability;
- Groundwater and surface water quality data to inform interaction and mixing;
- Aquifer characteristics including hydraulic conductivity and storage parameters;
- Groundwater age, residence time, recharge and discharge processes;
- Topographic and geomorphic information including stream locations and bed elevations;
- Seasonal variation in groundwater levels and quality;
- (If connected) seasonal variation in surface water flows and quality;
- Existing groundwater development (for example, irrigation areas, town water supply borefields) and project capturing incidental groundwater (for example, quarries, mines and tunnels) in the project area and area of potential impact (for each water source);
- Sources of potential contaminants (for example, waste storages, water treatment plants); and,
- Location, timing, volume and method of proposed water take and use by the proponent (for each water source).

A.10 Reporting

The outcomes of the desktop assessment, field investigations, baseline conditions and understanding of the conceptual hydrogeological model is sometimes documented within the GIA or as an appendix to the GIA report. The department’s Water division require the information to be provided as part of the GIA/EIS as it provides the supporting evidence and basis of the impact assessment. This is discussed further in Part B (‘Hydrogeological conceptual model’).

Part B – Groundwater impact assessments

This chapter discusses:

- Overview;
- Context setting;
- Conceptual hydrogeological model;
- Impact assessment;
- Risk assessment review;
- Mitigations, management and monitoring; and,
- Licensing considerations.

Relevant policy, guidelines, references and information:

- NSW Aquifer Interference Policy;
- Aquifer interference assessment framework (Appendix B);
- International standard (ISO) 3001:2018 *Risk management – Guidelines*;
- National Water Commission - - Framework for assessing potential local and cumulative effects of mining on groundwater resources;
- Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources; and,
- IESC information guidelines and explanatory notes

B.1 Overview and approach

Groundwater related aspects of projects can be complex and diverse. GIAs should consider all stages of the project, identifying and assessing aquifer interference activities, other water affecting activities (such as bores for water supply) and groundwater receptors, and provide an assessment of the potential for the water affecting activities to either directly or indirectly affect the identified receptors.

Water affecting activities and their potential effect on groundwater sources and receptors is discussed in this chapter. Examples of water affecting activities for SSD/SSI projects that have the potential to affect receptors include:

- Water supply development (surface water and/or groundwater), including borefields;
- Excavation (for example, open cut mine, underground mine, quarry);
- Tunnelling (for example, road, rail and other services);
- Building dewatering (for example, large high-rise developments)
- Conventional and non-conventional petroleum exploration, pilot and production;
- Solid and putrescible waste landfilling;
- Tailings storage;
- Waste (rock) storage;
- Water storage (above or below ground);
- Storage of chemicals; or,
- Dust suppression or irrigation.

GIAs need to be conducted in consideration of and consistent with the requirements of the AIP, relevant water sharing plans and Water Resource Plans, SEARs, risk assessment guidelines for GDEs (Serov et al 2012) and other relevant State and Commonwealth guidelines and policies, including consideration of cumulative impacts.

The approach to conducting an impact assessment described in this section is a risk-based approach, consistent with ISO 3001:2018 risk management guideline and is consistent with the Source-Pathway-Receptor model for assessing impacts. For an impact on a receptor to arise, there must be hazard that consists of a source (for example, underground mine); a receptor (for example, high value GDE); and a pathway between the source and the receptor (for example, groundwater level decline).

A GIA should:

- Be clear, concise, transparent, written in plain English and self-contained for ease of use;
- (If appropriate) meet the requirements of the AIP, including use of the aquifer interference assessment framework (see Appendix B);
- Meet the requirements of the SEARs, relevant water sharing plans and Water Resource Plans;
- Address other relevant legislative and policy requirements;
- Be scientifically robust, evidence-based assessments supported by diagrams and graphics; and,
- Demonstrate an understanding of the water environment, water affecting activities and potential impacts.

The recommended stages of a GIA are listed in Figure 14, along with available resources for some stages and guidance on when consultation with stakeholders, including the department’s Water division, should occur. It is recommended that these stages form the basis for the GIA report structure for ease of the department’s Water division review. Each stage is discussed further in the following sections.

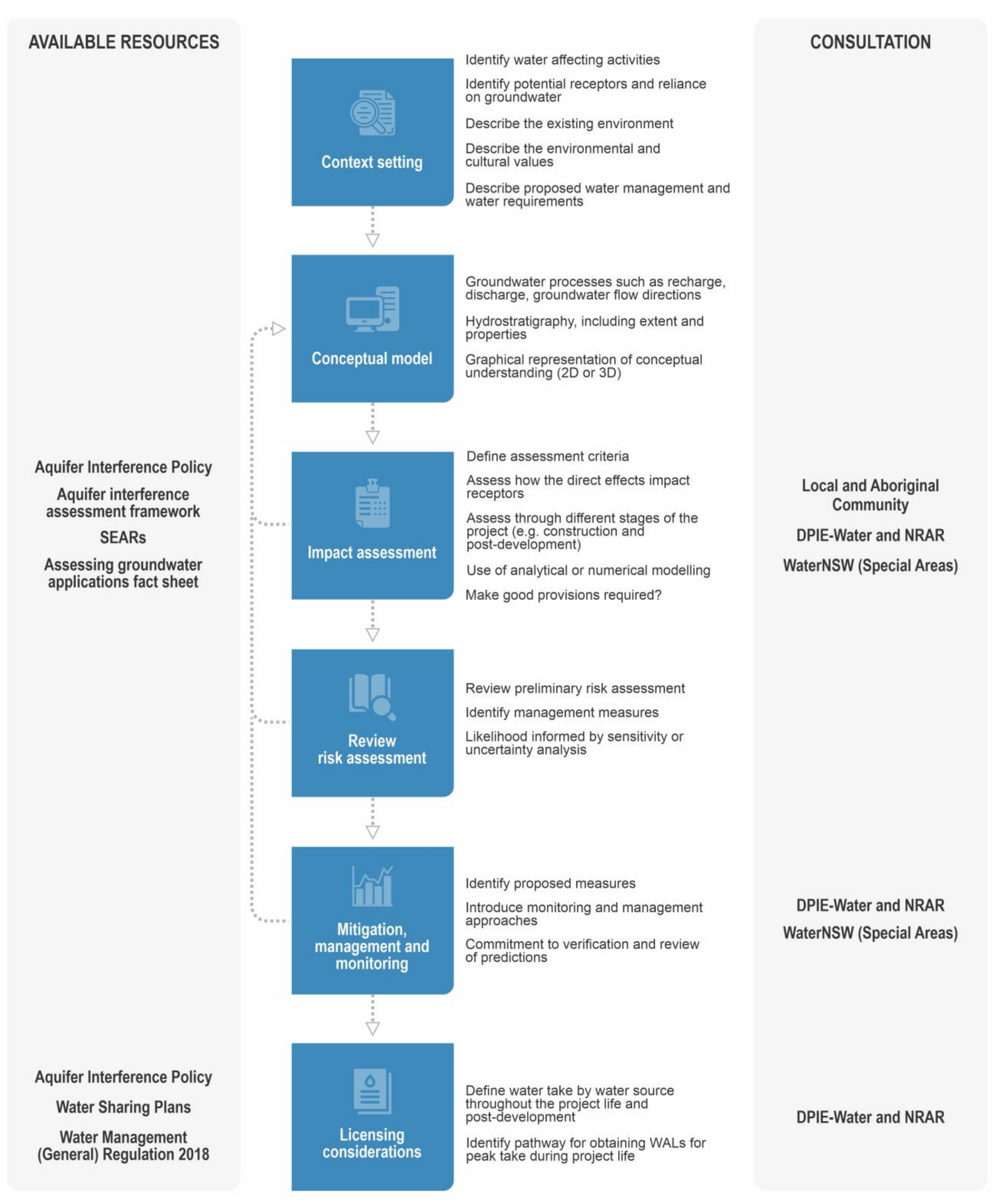


Figure 14: Groundwater impact assessment flow chart

B.2 Context setting

An impact assessment starts by setting the context for assessing potential water-related impacts arising from a proposed project and setting management objectives. Context setting places the project into a regional context, focusing on hydrogeology but also providing an overview of topography, climate, geology and hydrology. The development of a robust hydrogeological conceptual model is a key component of this stage of the assessment (discussed in more detail in the next section).

Setting management objectives is an important part of the impact assessment process as it will define those aspects of the water regime that are to be protected and provide a basis from which to measure the success of any strategies to be implemented. The management objectives for a project will be developed in consideration of the NSW defined water quality objectives, AIP, water sharing plan rules, the environmental and cultural values identified through consultation with the local and Aboriginal community, local council and NSW Government (for example, WaterNSW and the department's Water division). An example management objective may be to maintain the beneficial use of the groundwater source and connected surface water source. Objectives will be accompanied by performance indicators that will allow assessment of whether the overall water management objectives are being achieved during construction, operations and post-development stages of a project, if approved. This is discussed further in Part C and Part D of this Guideline.

The findings of the desktop assessment and groundwater investigations conducted by the proponent (refer Part A of this Guideline), including baseline monitoring, should be documented in the GIA report, setting the context and the basis for undertaking the impact assessment.

This step forms part of the hazard identification step in a risk assessment and will have been, at least partially, completed as part of the initial groundwater investigations described in Part A of this Guideline.

This context setting stage of the assessment should include description and/or identification of:

- Topography, climate, geological and hydrogeological setting;
- Regulatory frameworks of relevance to the project location and activities;
- Environmental and cultural values;
- Receptors that potentially rely on groundwater (social, cultural, environmental/ecological and economic), including ecosystem extent (for ecological receptors);
- Receptor reliance on groundwater and receptor resilience and resistance to change in groundwater (or connected surface) conditions;
- Baseline monitoring network (groundwater and surface water);
- Surface water-groundwater interaction (including baseflow estimates where available);
- Location and type of water affecting activities already occurring in the region; and,
- Water affecting activities of the project, including proposed water management and water requirements (including presentation of project design/plans), and how they will interact with groundwater resources and connected systems.

Consultation with key stakeholders during this stage is important to communicate the proposed project and environmental context.

B.3 Hydrogeological conceptual model

A conceptual hydrogeological model describes the key processes in the hydrogeological environment and groundwater regime. It is based on hypotheses and assumptions, some of which will be derived from data sourced from the groundwater system under investigation and others will be based on general hydrogeological principles. Key components of the conceptual model include topography, geology, climate, groundwater distribution, flow paths, hydrogeological properties, chemical characteristics, and variability over time. A conceptual model forms the basis of assumptions adopted in analytical and numerical models and is the basis for all impact assessments. The inputs and assumptions should be defined and tested so that those factors or processes can be refined as more information and data become available.

The conceptual hydrogeological model derived from the preliminary conceptual model and through the groundwater investigations described in Part A of the Guideline will be summarised and reported in the GIA report, and is a key stage of the context setting of an impact assessment.

Proponents are required to provide graphical representation of the conceptual hydrogeological model in the GIA report, through the use of 2D cross-sections and /or 3D block diagrams. The GMMP guidelines, AIP and Australian Groundwater Modelling Guidelines (Barnett et al 2012) provide guidance on the requirements of a conceptual hydrogeological model. The proponent should consider developing conceptual models for the pre-development, during development and post-development stages of a project.

Table 6 lists all the components and elements that should be included in the presentation of a conceptual hydrogeological model. Where insufficient data is available, the proponent should include estimates based on literature, assumptions and hydrogeological principles, ensuring that these assumptions and literature-based estimates are clearly identified in the reporting.

For reporting on the context setting and hydrogeological conceptual model in the GIA report, it is important that high quality and high-resolution figures be used to present information and data. The proponent may be asked to provide electronic (soft) copies of supporting data (inputs and predictions) to the NSW Government. With improvements in technology and digital platforms, some proponents are submitting EIS and supporting reports via online and downloadable report formats, sometimes supported by online web maps. Such online visualisation of EISs, including GIAs, is encouraged by the department’s Water division.

Table 6: Conceptual hydrogeological model components

Component	Information to be documented
Climate	Variation in rainfall, temperature and evaporation
	Supporting charts/figures showing seasonal variation and describing recent and historical climate trends
	Supporting charts and maps showing locally monitored rainfall data recorded during the baseline period used to inform the conceptual understanding
Water sources	Alluvial, porous rock, fractured rock - as defined relevant water sharing plans
	Identifying highly productive vs less productive sources
	Highly connected systems?
	Supporting maps showing water source extents

Geology	Description of regional and local geology
	Stratigraphic column
	Supporting maps showing surface geology (regional and local scale) and mapped geological structures
	Supporting maps showing extent of proponent geological model and location of mineral drillholes (if relevant)
Hydrostratigraphic units	Description of aquifers/aquitards
	Spatial and vertical extent, with consideration of boundaries such as geological structures
	Boundaries such as geological structures (faults, folding, shear zones, intrusions)
	Supporting maps showing spatial extent, depth, elevation and thickness of hydrostratigraphic units
Hydraulic properties	Location, type and number of aquifer tests
	Supporting maps showing spatial coverage of aquifer tests identified by hydrostratigraphic unit
	Range in estimate hydraulic properties (Kv, Kh, Ss, Sy) from measured data
	Range in hydraulic properties (Kv, Kh, Ss, Sy) from literature reviews
	Results of aquifer test analysis appended to the GIA for quality assurance
Groundwater monitoring network	Location and type (eg VWPs or standpipe) per hydrostratigraphic unit
	Presentation through the use of tables providing the location (coordinates), screened interval, screened lithology, GW identification number (as provided by WaterNSW) and proponent identification (if desired)
	Supporting maps showing the spatial coverage of the monitoring network, identified by hydrostratigraphic unit and identifying use of proponent installed bores, landholder bores and Government bores, where applicable
Topography and drainage	Identification and description of watercourses, including seasonal variation and stream gauge data if available
	Topographic and geomorphic information including stream locations and bed elevations
	Supporting maps showing topography and drainage lines in the project area
	Description of surface water quality, through the use of supporting charts and maps showing the location of surface water monitoring/sampling locations
	Spatial, temporal and vertical variation in groundwater elevation and gradients

Groundwater levels and flow direction	Supporting maps showing mapped depth to water table, water table and groundwater elevation for various unconfined and confined hydrostratigraphic units, showing locations of measured data and inferred groundwater flow directions
	Supporting charts/figures showing seasonal variation and response to recent and historical climate trends
	Supporting charts/figures showing vertical gradients
	Supporting QA/QC information for monitoring data, including VWPs and/or pressure transducer data loggers (such as correction for barometric effects, density effects, instrument drift)
Groundwater quality	Spatial, temporal and vertical variation in groundwater quality
	Supporting maps showing variation in salinity for various hydrostratigraphic units
	Supporting laboratory reports and sampling methodologies for quality assurance purposes
	Supporting charts/figures showing statistical variation and trend analysis
Recharge and discharge processes	Estimates of inputs and outputs to the local and regional groundwater system, including description on processes and estimates of quantities
	Description of recharge (eg rainfall infiltration, irrigation, surface water), discharge (eg baseflow, groundwater pumping, coastal), throughflow
	Supporting data used to derive estimates (for example chloride mass balance or literature)
	Groundwater age, residence time through the use of isotope analysis
Receptors	Location and type of receptors (social, economic, environmental/ecological and cultural)
	Supporting maps showing mapped GDEs sourced from water sharing plans and BoM GDE Atlas
	Supporting maps showing field-based mapped GDEs, derived through consultation/collaboration with ecological specialists
	Supporting maps showing cultural receptors identified through consultation
	Supporting maps showing the location of existing bores monitoring, investigation, operating/production, private and Government owned), including licensed users and stock/domestic users
Surface water-groundwater interaction	Description of surface water-groundwater interaction through assessment of water quality, field observations and stream flow data
	Supporting charts and maps

Existing groundwater development	Location and description of existing activities, such as irrigation areas, quarries, mines
	Supporting maps showing the location of the identified activities in proximity to the proposed project and receptors
Proposed project activities	Location and description of proposed water affecting activities for the project, including sources of potential contamination (for example, waste storages, water treatment plants, tailings storage facilities)
	Supporting maps and charts presenting the proposed activities at key stages of the project (for example, construction, operations, changes to the water management system, post-development, rehabilitation)

Notes: Kh = horizontal hydraulic conductivity, Kv = vertical hydraulic conductivity, Ss = specific storage, Sy = specific yield

B.4 Impact assessment

B.4.1 Direct effects and associated impacts on receptors

The National Water Commission developed guidelines and a risk framework for assessing local and cumulative effects of mining activities on groundwater systems (Moran et al 2010). The framework defines the following four direct groundwater effects arising from mining, which are also relevant to other project types:

- Altered groundwater quantity (groundwater levels, pressures and fluxes);
- Altered groundwater quality (concentration of salts and other important water quality constituents);
- Altered surface water – groundwater interaction; and,
- Physical disruption or removal of aquifers (excavation for tunnelling, mine pits or underground works).

Direct effects encompass the changes to physical and/or quality aspects of groundwater due to aquifer interference activities, or the changes to the physical characteristics of aquifers affected by these activities.

Direct effects of water affecting activities can result in adverse impacts on receptors. The assessment of potential receptor exposure to adverse changes in groundwater and connected systems (quantity, quality, groundwater and surface water interactions and physical disruption of aquifers) requires the following:

- Knowledge of the location of receptors within the landscape, particularly in relation to the location and area of influence of water affecting activities;
- An understanding of the receptor reliance on groundwater (for example, depth to water table, groundwater flux to baseflow fed watercourses, water quality to meet beneficial uses, available drawdown at a water supply work);
- An understanding of the capacity for receptors to adapt to altered groundwater regimes (resilience and resistance); and,
- An understanding of the spatial and temporal scale of direct effects at the location of identified receptors.

Table 7 to Table 11 present example water affecting activities and potential effects typically associated with major aquifer interference projects in NSW (open cut mining including quarries, underground mining, petroleum projects and tunnels), the potential duration of the effect and associated impact on a receptor.

Table 7: Example water affecting activities, potential effects and impacts on receptors – open cut mining, including quarrying and strip-mining

Direct effect	Water affecting activity	Potential effect[1]	Potential duration[2]	Potential impact at a receptor[3]
Pre-development				
Quantity	Water supply exploration/ development (groundwater)	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows, indirect take from overlying or adjacent water sources	Duration of exploration activities and/or construction	Reduced access to water, reduced or loss of habitat
	Water storage (excess water/conditioning)	Perched water table, seepage, water table mounding	Duration of exploration activities and/or construction	Waterlogging, detrimental changes to habitat
Quality	Water supply development (groundwater)	Mobilisation of salt (water quality changes), development of acid sulfate soils	Duration of exploration activities and/or construction	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water storage (excess water/conditioning)	Leaching of solutes	Duration of exploration activities and/or construction	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
		Overflow to watercourses altering surface water quality	Short duration (period of discharge)	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

Surface water-groundwater interaction	Water supply exploration/ development (groundwater)	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of exploration activities and/or construction	Increase in number of no flow days, reduced fish migration passage
Aquifer disruption	Pre-stripping or other ground conditioning activities	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Duration of construction	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)
During operations				
Quantity	Water supply (groundwater) or dewatering	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows, indirect take from overlying or adjacent water sources	Duration of the development, may take years to observe	Reduced access to water, reduced or loss of habitat
	Built infrastructure (roads, buildings, plant)	Altered recharge regime, interception of groundwater flow paths, mounding	Duration of the development, may take years to observe	Changes to habitat, reduced access to water
	Water storage/tailings storage	Perched water table, seepage, water table mounding	Continuous (depends on lining)	Waterlogging, detrimental changes to habitat
	Stockpiling	Altered recharge, hydraulic loading on aquifer/aquifer compaction	Duration of the development, may take years to observe	Changes to habitat, reduced access to water
Quality	Water supply (groundwater) or dewatering	Mobilisation of salt (water quality changes), development of acid sulfate soils	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

	Built infrastructure (roads, buildings, plant)	Solutes in runoff	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water storage	Leaching of solutes, overflow to watercourses altering surface water quality	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Stockpiling/tailings storage	Acid mine drainage, leaching of solutes	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Drill and blast	Changes to groundwater quality through introduced chemicals used in blasting and/or mixing of groundwater from different aquifers due to enhanced connection	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interactions	Water supply (groundwater) or dewatering	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of the development, may take years to observe	Increase in number of no flow days, reduced fish migration passage

	Stockpiling	Hydraulic loading alters baseflow/interaction with watercourse	Duration of the development, may take years to observe	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
	Diversion/disruption of surface drainages	Altered flow regimes, water table fall or rise	Duration of the development, may take years to observe	Adverse changes to aquatic habitat reducing species numbers
Aquifer disruption	Excavation	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Permanent, unless backfilled	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)
	Backfilling	Altered hydraulic properties, change in groundwater flow paths	Permanent, unless removed	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)

Closure				
Quantity	Mine void - passive groundwater inflow to /take by voids	Evaporative losses of water from mine void, continued groundwater drawdown, slow groundwater level recovery	Often hundreds of years	Reduced access to water, reduced or loss of habitat (possibly permanent)
	Tailings storage	Perched water table, seepage, water table mounding	Potentially hundreds of years	Waterlogging, detrimental changes to habitat
	Stockpiling	Hydraulic loading /aquifer compaction, altered groundwater flow paths	Permanent, unless removed	Changes to habitat, reduced access to water, changes to surface water-groundwater interaction

Quality	Mine void	Evapoconcentration of salts within the pit lake, potential acid mine drainage (acidification of pit lake)	Continuous	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Stockpiling/tailings storage	Leaching/introduction of solutes, acid mine drainage while drainage occurs	Potentially hundreds of years, dependent on rehabilitation	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interactions	Mine void - passive groundwater inflow to /take by voids	Altered baseflow to watercourse, increased leakage from watercourse to groundwater	Often hundreds of years	Increase in number of no flow days, reduced fish migration passage (possible permanent)
	Stockpiling	Hydraulic loading alters baseflow / interaction with watercourse	Potentially permanent	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
	Rehabilitation	Altered flow regimes, water table fall or rise	Potentially hundreds of years, dependent on rehabilitation	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
Aquifer disruption	Mine void	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Permanent unless backfilled	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)

Notes: 1. Not necessarily present for all open cut mines
2. Duration is dependent on project duration and hydraulic properties of lithology
3. Extent of impact is dependent on project duration, hydraulic properties of lithology and receptor reliance on groundwater

Table 8: Example water affecting activities, potential effects and impacts on receptors – underground mining

Direct effect	Water affecting activity	Potential effect[1]	Potential duration[2]	Potential impact at a receptor[3]
Pre-development				
Quantity	Water supply exploration/ development (groundwater)	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows, indirect take from overlying or adjacent water sources	Duration of exploration activities and/or construction	Reduced access to water, reduced or loss of habitat
	Water storage (excess water/conditioning)	Perched water table, seepage, water table mounding	Duration of exploration activities and/or construction	Waterlogging, detrimental changes to habitat
Quality	Water supply development (groundwater)	Mobilisation of salt (water quality changes), development of acid sulfate soils	Duration of exploration activities and/or construction	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water storage (excess water/conditioning)	Leaching of solutes	Duration of exploration activities and/or construction	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
		Overflow to watercourses altering surface water quality	Short duration (period of discharge)	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

Surface water-groundwater interaction	Water supply exploration/ development (groundwater)	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of exploration activities and/or construction	Increase in number of no flow days, reduced fish migration passage
Aquifer disruption	Pre-stripping or other ground conditioning activities	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Duration of construction	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)

During operations

Quantity	Water supply (groundwater) or dewatering	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows, indirect take from overlying or adjacent water sources	Duration of the development, may take years to observe	Reduced access to water, reduced or loss of habitat
	Built infrastructure (roads, buildings, plant)	Altered recharge regime, interception of groundwater flow paths, mounding	Duration of the development, may take years to observe	Changes to habitat, reduced access to water
	Water storage (surface) /tailings storage	Perched water table, seepage, water table mounding	Continuous (depends on lining)	Waterlogging, detrimental changes to habitat
	Water storage (underground)	Enhanced groundwater level recovery	Duration of the development, dependent on mine plan	Changes to habitat
	Stockpiling	Altered recharge, hydraulic loading on aquifer/aquifer compaction	Duration of the development, may take years to observe	Changes to habitat, reduced access to water

Quality	Water supply (groundwater) or dewatering	Mobilisation of salt (water quality changes), development of acid sulfate soils	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Built infrastructure (roads, buildings, plant)	Solutes in runoff	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water storage (surface)	Leaching of solutes, overflow to watercourses altering surface water quality	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water storage (underground)	Leaching of solutes	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

	Drill and blast	Changes to groundwater quality through introduced chemicals used in blasting and/or mixing of groundwater from different aquifers due to enhanced connection	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Stockpiling / tailings storage	Acid mine drainage, leaching of solutes	Duration of the development, may take years to observe	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interactions	Water supply (groundwater) or dewatering	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of the development, may take years to observe	Increase in number of no flow days, reduced fish migration passage
	Stockpiling	Hydraulic loading alters baseflow / interaction with watercourse	Duration of the development, may take years to observe	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
	Underground mining	Subsidence leading to leakage from watercourse through enhanced connection	Duration of the development, may take years to observe	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
Aquifer disruption	Excavation	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths, subsidence at ground surface	Duration of the development, as a minimum	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s), impact on surface infrastructure and surface water flows

	Backfilling	Altered hydraulic properties, change in groundwater flow paths	Permanent, unless removed	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)
Closure				
Quantity	Mine void - passive groundwater inflow to/take by voids	Slow groundwater level recovery	Often hundreds of years	Reduced access to water, reduced or loss of habitat (possibly permanent)
	Tailings storage	Perched water table, seepage, water table mounding	Potentially hundreds of years	Waterlogging, detrimental changes to habitat
	Stockpiling	Hydraulic loading/aquifer compaction, altered groundwater flow paths	Permanent unless removed	Changes to habitat, reduced access to water, changes to surface water-groundwater interaction
Quality	Mine void	Mobilisation of salt (water quality changes), development of acid sulfate soils or acid mine drainage	Potentially hundreds of years until equilibrium established	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Stockpiling/ tailings storage	Leaching/introduction of solutes, acid mine drainage while drainage occurs	Potentially hundreds of years, dependent on rehabilitation	Change in beneficial use/ environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

Surface water-groundwater interactions	Mine void - passive groundwater inflow to /take by voids	Altered baseflow to watercourse, increased leakage from watercourse to groundwater	Potentially hundreds of years	Increase in number of no flow days, reduced fish migration passage (possible permanent)
	Stockpiling	Hydraulic loading alters baseflow / interaction with watercourse	Potentially permanent	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
Aquifer disruption	Mine void	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths, subsidence creating enhanced connection between groundwater sources and/or surface water	Permanent unless backfilled or reinforced	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s), impact on surface infrastructure and surface water flows

Notes:
1. Not necessarily present for all underground mines
2. Duration is dependent on project duration and hydraulic properties of lithology
3. Extent of impact is dependent on project duration, hydraulic properties of lithology and receptor reliance on groundwater

Table 9: Example water affecting activities, potential effects and impacts on receptors – petroleum developments (including coal seam gas)

Direct effect	Water affecting activity	Potential effect[1]	Potential duration[2]	Potential impact at a receptor[3]
During operations				
Quantity	Groundwater pumping	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows, indirect take from overlying or adjacent water sources, aquifer compaction	Duration of the development or longer, may take years to observe	Reduced access to water, reduced or loss of habitat
	Hydraulic fracturing	Aquifer pressurisation, changed groundwater flow paths	Duration of the development or longer, may take years to observe	Reduced access to water, reduced or loss of habitat
	Water storage (surface)	Perched water table, seepage, water table mounding	Continuous (depends on lining)	Waterlogging, detrimental changes to habitat
Quality	Groundwater pumping	Mobilisation of salt (water quality changes)	Duration of the development or longer, may take decades to observe	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Hydraulic fracturing	Mobilisation of salt (water quality changes), introduction of potential pollutants, potential connection to overlying or adjacent water sources	Duration of the development or longer, may take decades to observe	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

	Built infrastructure (roads, buildings, plant)	Solutes in runoff	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water storage (surface)	Leaching of solutes, overflow to watercourses altering surface water quality	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water treatment	Potential leaching of solutes from waste water	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interactions	Groundwater pumping	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of the development or longer, may take decades to observe	Increase in number of no flow days, reduced fish migration passage
	Hydraulic fracturing	Potential connection to overlying or adjacent water sources	Duration of the development or longer, may take decades to observe	Increase in number of no flow days, reduced fish migration passage

Aquifer disruption	Hydraulic fracturing	Alteration to of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Duration of the development or longer, may take decades to observe	Change in ecosystem habitat, change in groundwater levels in adjacent water source(s)
	Groundwater pumping	Large volumes extracted may cause surface subsidence	Duration of the development or longer, may take decades to observe	Change in ecosystem habitat, change in groundwater levels in adjacent water source(s)
Closure				
Quantity	Decommissioning wells	Slow groundwater level/pressure recovery	Potentially hundreds of years until equilibrium established	Reduced access to water, reduced or loss of habitat
Quality	Decommissioning wells	Mobilisation of salt (water quality changes)	Potentially hundreds of years until equilibrium established	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interactions	-			
Aquifer disruption	-			

Notes:
1. Absolute worse case examples of potential impacts. Not necessarily likely for all petroleum developments
2. Duration is dependent on project duration and hydraulic properties of lithology
3. Extent of impact is dependent on project duration, hydraulic properties of lithology and receptor reliance on groundwater

Table 10: Example water affecting activities, potential effects and impacts on receptors – tunnel development

Direct effect	Water affecting activity	Potential effect[1]	Potential duration[2]	Potential impact at a receptor[3]
Pre-development				
Quantity	Water supply exploration/ development (groundwater) or dewatering	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows, indirect take from overlying or adjacent water sources	Duration of exploration activities and/or construction	Reduced access to water, reduced or loss of habitat
	Water storage (excess water)	Perched water table, seepage, water table mounding	Duration of exploration activities and/or construction	Waterlogging, detrimental changes to habitat
Quality	Water supply development (groundwater) or dewatering	Mobilisation of salt (water quality changes), development of acid sulfate soils	Duration of exploration activities and/or construction	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water storage (excess water)	Leaching of solutes	Duration of exploration activities and/or construction	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

		Overflow to watercourses altering surface water quality	Short duration (period of discharge)	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interaction	Water supply exploration/ development (groundwater)	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of exploration activities and/or construction	Increase in number of no flow days, reduced fish migration passage
Aquifer disruption	Pre-stripping or other ground conditioning activities	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Duration of construction	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)
	Excavation	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Duration of the development, as a minimum	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)
During operations				
Quantity	Water supply (groundwater) or dewatering	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows, indirect take from overlying or adjacent water sources	Duration of the development, as a minimum	Reduced access to water, reduced or loss of habitat
	Built infrastructure (roads, buildings, plant)	Altered recharge regime, interception of groundwater flow paths, mounding	Duration of the development, as a minimum	Changes to habitat, reduced access to water

	Water storage (excess water)	Perched water table, seepage, water table mounding	Continuous (depends on lining)	Waterlogging, detrimental changes to habitat
	Stockpiling	Altered recharge, hydraulic loading on aquifer / aquifer compaction	Duration of the development	Changes to habitat, reduced access to water
Quality	Water supply (groundwater) or dewatering	Mobilisation of salt (water quality changes), development of acid sulfate soils or acid rock drainage	Duration of the development, as a minimum	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Built infrastructure (roads, buildings, plant)	Solutes in runoff	Duration of the development, as a minimum	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Water storage (surface)	Leaching of solutes, overflow to watercourses altering surface water quality	Duration of the development, as a minimum	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

	Stockpiling	Leaching of solutes	Duration of the development, as a minimum	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interactions	Water supply (groundwater) or dewatering	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of the development, as a minimum	Increase in number of no flow days, reduced fish migration passage
	Stockpiling	Hydraulic loading alters baseflow / interaction with watercourse	Duration of the development, as a minimum	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
Aquifer disruption	Excavation	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Duration of the development, as a minimum	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)
Closure				
Quantity	Void - passive groundwater inflow to /take by voids	Slow groundwater level recovery	Potentially hundreds of years until equilibrium established	Reduced access to water, reduced or loss of habitat (possibly permanent)
Quality	Void - passive groundwater inflow to /take by voids	Mobilisation of salt (water quality changes), development of acid sulfate soils or acid rock drainage	Potentially hundreds of years until equilibrium established	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

Surface water-groundwater interactions	Void - passive groundwater inflow to /take by voids	Altered baseflow to watercourse, increased leakage from watercourse to groundwater	Potentially hundreds of years	Increase in number of no flow days, reduced fish migration passage (possible permanent)
Aquifer disruption	Void	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Permanent unless backfilled	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)

Notes:
1. Not necessarily present for all developments
2. Duration is dependent on project duration and hydraulic properties of lithology
3. Extent of impact is dependent on project duration, hydraulic properties of lithology and receptor reliance on groundwater

Table 11: Example water affecting activities, potential effects and impacts on receptors – dredge mining

Direct effect	Water affecting activity	Potential effect[1]	Potential duration[2]	Potential impact at a receptor[3]
Pre-development				
Quantity	Groundwater pumping for supply or dewatering	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows	Duration of construction	Reduced access to water, reduced or loss of habitat
Quality	Groundwater pumping for supply or dewatering	Mobilisation of salts	Duration of construction	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Hazardous goods storage	Solutes in effluent / contamination leaks	Duration of construction	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interaction	Groundwater pumping for supply or dewatering	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of construction	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
Aquifer disruption	-			
Operations				

Quantity	Groundwater pumping for supply or dewatering	Water table drawdown, aquifer depressurisation, changed groundwater flow paths, local induced flows	Duration of development	Reduced access to water, reduced or loss of habitat
	Excavation	Evaporative losses of water from void	Duration of development	Reduced access to water, reduced or loss of habitat
	Backfilling	Altered recharge	Duration of development	Reduction in ecosystem habitat, change in groundwater levels in adjacent water source(s)
	Waste water ponds & water storage	Perched water table, seepage, water table mounding	Duration of development	Waterlogging, detrimental changes to habitat
	Tailings storage	Perched water table, seepage, water table mounding	Continuous (depends on lining)	Waterlogging, detrimental changes to habitat
	Stockpiling	Altered recharge, hydraulic loading on aquifer / aquifer compaction	Duration of development	Changes to habitat, reduced access to water
Quality	Groundwater pumping for supply or dewatering	Mobilisation of salts	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Backfilling	Introduction of solutes	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

	Excavation	Acid sulfate soils	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Waste water ponds & water storage	Leaching of solutes, overflow to watercourses altering surface water quality	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Tailings storage	Acid mine drainage, leaching of solutes	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Stockpiling	Leaching/introduction of solutes, acid mine drainage	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species

	Built infrastructure (roads, buildings, plant)	Solutes in runoff	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Hazardous goods storage	Solutes in effluent / contamination leaks	Duration of development	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interaction	Groundwater pumping for supply or dewatering	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Duration of development	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
Aquifer disruption	Excavation	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Potentially permanent, unless backfilled	Reduction in ecosystem habitat
Closure				
Quantity	Excavation	Evaporative losses of water from void	Potentially tens of years	Reduced access to water, reduced or loss of habitat
	Backfilling/rehabilitation	Altered recharge, groundwater flow paths	Potentially permanent	
	Tailings storage	Perched water table, seepage, water table mounding	Potentially tens of years, depends on lining	Waterlogging, detrimental changes to habitat

Quality	Excavation	Evapoconcentration of salts, acid sulfate soils	Ongoing	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Backfilling/rehabilitation	Introduction of solutes	Potentially tens of years, depends on lining	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
	Tailings storage	Acid mine drainage, leaching of solutes	Potentially tens of years, depends on lining	Change in beneficial use / environmental or cultural value, detrimental change to ecosystem, reduction in or removal of biodiversity or species
Surface water-groundwater interaction	Excavation	Altered baseflow to watercourse, increased leakage from watercourse to groundwater, induced inflows of different water quality	Potentially tens of years, until equilibrium reached	Change to flow regime, adverse changes to aquatic habitat reducing species numbers
Aquifer disruption	Excavation	Removal of part of whole of an aquifer and/or aquitard, change in groundwater flow paths	Potentially permanent, unless backfilled	Reduction in ecosystem habitat

Notes:
1. Not necessarily present for all developments
2. Duration is dependent on project duration and hydraulic properties of lithology
3. Extent of impact is dependent on project duration, hydraulic properties of lithology and receptor reliance on groundwater

B.4.2 Assessment approach

B.4.2.1 Overview

Once the water affecting activities and potential receptors have been identified, proponents need to assess the potential impact of the activities on the identified receptors and estimate the water take from each relevant water source (as an annualised volume).

The impact assessment predictions should consider the magnitude, duration and extent of a predicted change, beneficial and adverse effects and whether impacts are reversable or permanent. When predicting impacts, a clear distinction must be made between those impacts which can be assessed quantitatively and those for which only a qualitative assessment can be made due to data limitations or conceptual uncertainties (DUAP 1996a).

Whenever conclusions and recommendations have been made based substantially on judgements instead of facts or objective analytical results, the basis of the judgements should be clearly identified. A precautionary approach should be adopted where there is a significant chance a proposal may lead to irreversible consequences (DUAP 1996a).

For those projects that are aquifer interference activities, it is recommended that the proponent use the aquifer interference assessment framework (see Appendix B) as a guide for completing the assessment and append the completed form to the GIA.

For all projects located below the water table, the checklist included in Appendix E should be used by the proponent in preparation of the GIA.

The proponent will need to provide the following (as appropriate to the activity):

- Details of potential groundwater level, quality or pressure drawdown at identified receptors, including:
    - Nearby water users who are exercising their right to take water under a basic landholder right. Consideration will need to be given to any relevant distance restriction requirements that may be specified in any relevant water sharing plan or any remediation measures to address these impacts;
    - Nearby licensed water users in connected groundwater and/or surface water sources;
    - Identified GDEs, reducing ecosystem extent or habitat and/or resulting in loss of GDE function; and
    - Identified culturally significant site, having an adverse impact on social and cultural values;
- Details of potential for increased saline or contaminated water inflows to aquifers and highly connected river systems;
- Details of the potential to cause or enhance hydraulic connection between aquifers (for example due to subsidence or blasting);
- Identify if the predicted impacts meet the minimal impact considerations or if additional management is required (for example make good provisions);
- Details of the potential for river bank instability, or high wall instability or failure to occur (where applicable);
- Predicted annual water take from each relevant water source;
- Details of the method for disposing of produced water (in the case of petroleum activities); and,
- A strategy for complying with any water access rules applying to relevant categories of WALs, as specified in relevant water sharing plans. For example, returning water of an acceptable quality to the affected water source during periods when flows are at levels below which water users are not permitted to pump.

The method for deriving the above estimates should be determined in consultation with the department's Water division, meeting the requirements for the AIP and the SEARs. Any modelling (analytical or numerical) should be undertaken in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al 2012).

All GIAs should summarise the key assumptions and factors that the impact assessment relies on, and if altered, may change the predicted impacts.

In addition, where uncertainty in the predicted inflows to or take for an aquifer interference activity may have a significant impact on a receptor (including authorised water users), the proponent will also need to specifically report on the following:

- Potential for causing or enhancing hydraulic connection between aquifers or between groundwater and surface water sources, and quantification of this risk in the volumetric inflow/take estimates; and,
- Strategies in place for monitoring actual and reassessing any predicted take of water and how any changes in these requirements will be accounted for, including analysis of water market depth and/or in-situ mitigation and remediation options.

Table 12 presents an overview of the typical considerations that should be addressed during the environmental approvals process for major projects (new and modifications).

Approaches utilised in undertaking an assessment of the potential impact of a project on a receptor will vary depending on the scale, duration and receptor characterisation (reliance, resilience and location). Example assessment methods include (but are not limited to):

- To estimate groundwater level (including water table) drawdown or mounding: analytical or numerical groundwater modelling.
- To estimate direct water take and indirect take from adjacent or overlying water sources (either from pumping, dewatering or evaporative losses): analytical or numerical groundwater modelling.
- To estimate water quality changes: hydrogeochemical characterisation and testing, geochemical modelling and/or solute transport modelling (analytical or numerical).
- To estimate potential subsidence effects: subsidence or numerical groundwater modelling.
- To estimate changes in recharge rates or seepage from water storages or tailings storages: unsaturated-saturated zone modelling.
- To estimate changes in surface water-groundwater interaction: numerical groundwater modelling, surface water modelling or coupled surface water-groundwater modelling.

Note that further discussion on modelling (including analytical or numerical groundwater modelling) is not provided in this Guideline.

Table 12: GIA considerations for natural resource attributes (adopted from Howe and Dettrick 2010)

Attribute	Issue	Consideration
Climate	Rainfall & evaporation	• To what extent is groundwater depletion likely? • Over what timeframe will resource replenishment take place? • What water-use efficiency measures will be implemented?
Physical setting	Water resources	• What water systems might be impacted by the project activities? • What will be the scale of change induced to water systems by the operations (quantity & quality)? • What is the spatial distribution of groundwater elevations?

	Lithology & soils	• What is the spatial distribution of lithology and soil types? • How will lithology and soil type constrain the location of water holding facilities? • Are there suitable materials available for rehabilitation at completion of the development? • How will acid rock drainage be managed?
	Topography	• What is the spatial distribution of depth to water table (i.e. Difference between topography and groundwater elevations)? • What is the location of proposed infrastructure in relation to the depth to water table plan?
Community	Traditional owners	• Are there culturally significant sites (for example, springs) that may be impacted by the project activities? • Has an assessment been conducted of the effect project activities might have on maintenance of spring environmental flows?
	Agriculture	• Have pastoral and irrigated agriculture interests that utilise groundwater been identified? • Has an assessment been conducted of the effect proposed activities might have on continued access to groundwater by agricultural interests?
	Municipal & domestic	• Have municipal and domestic interests that utilise groundwater been identified? • Has an assessment been conducted of the effect project activities might have on continued access to groundwater by these water users?
Environment	Terrestrial vegetation Spring-fed wetlands & baseflow-fed streams Aquifer Marine	• Have groundwater dependent ecosystems that might be impacted by the project been identified? • Has vadophytic vegetation that might be impacted by mining activities been identified? • Have the environmental water requirements of the groundwater dependent ecosystems and vadophytic vegetation been assessed? • Has an assessment been conducted of the effect project activities might have on continued access to assessed environmental water requirements?
Economic	Commercial interests	• Have municipal and domestic interests that utilise groundwater been identified? • Has an assessment been conducted of the effect project activities might have on continued access to groundwater by these water users?

B.4.2.2 Assessing impacts on GDEs

Impacts on GDEs should be assessed in accordance with Serov et al (2012) using the risk assessment approach and should be documented in the GIA and the biodiversity assessment for an EIS, where applicable. This approach considers a number of risk factors to determine potential impacts. The risk factors, potential impacts and data sources from which this information can be determined are provided in Table 13.

Table 13: GDE risk assessment – risk factors and potential assessment tools

Risk factor	Potential impact	Potential assessment tool
Impacts to water quantity	Reductions or fluctuations in groundwater levels and/or piezometric pressure, including timeframes for any changes.	Groundwater and surface water models predicting changes in water quantity, including baseflow.
	Reduction in seasonal baseflow conditions	
Impacts to water quality	Changes in water quality attributes, such as pH, dissolved oxygen, nutrients, temperature, turbidity, salinity	Groundwater model, hydrogeochemical analysis. Hydrogeochemical modelling
	Changes in water quality (as above) that may impacts on any beneficial use of the aquifer	Bore census data, understanding of other beneficial users, groundwater modelling.
Impacts to the integrity of the aquifer	Changes in the geological structure supporting an aquifer associated with a GDE, including the timeframe and severity of impacts	Geophysical surveys, geological and subsidence predictions, groundwater modelling.
Impacts to the biological integrity of the GDE	Changes in species diversity or composition, dieback of vegetation due to water stress, increases in exotic species or removal/alteration of habitat.	Ecological surveys and assessment.

The risk assessment approach outlined in Serov et al (2012) considers the risk of impact (low, medium or high risk) as well as the ecological value of a GDE (low, medium or high value) to determine the overall risk (see Figure 15). Impact assessments should consider GDEs in their regional, State and national contexts.

High Ecological Value (HEV) Sensitive Environmental Area (SEA)	A	B	C
Moderate Ecological Value (MEV) Sensitive Environmental Area (SEA)	D	E	F
Low Ecological Value (LEV)	G	H	I
	Low risk	Moderate risk	High risk

Figure 15: GDE risk matrix (adapted from Serov 2012)

To enable proponents to undertake this assessment many of the steps outlined in the ‘Overview’ section above should be undertaken at identified GDEs, treating these as receptors. Wherever possible, quantitative data derived from numerical groundwater models should be used. This data should include an assessment of the likelihood of an impact occurring. Where quantitative data is not available qualitative data may be required; this may need to be verified during monitoring.

B.4.2.3 Cumulative effects

The National Water Commission (Moran et al 2010) define cumulative effects as “the successive, incremental and combined effects of an activity on society, the economy and the environment”. Under the requirements of the AIP and IESC guidance notes (where relevant), cumulative groundwater-related effects should also be reported in the GIA. This will include presenting the predicted groundwater elevation (or depth to water table) at an identified receptor during and post project development. There are areas in NSW where existing groundwater development (for example, irrigation areas, quarries, mines) in the project area may already be affecting groundwater quantity, quality and/or surface water-groundwater interaction.

B.4.3 Assessment criteria

Proponents should clearly document the assessment criteria used in the impact assessment. The assessment of project-related impacts to water resources and water users should consider:

- The requirements of the:
    - Water Management Act;
    - Relevant water sharing plans;
    - AIP (if relevant);
    - State Environmental Planning Policies (SEPP) (such as Sydney Drinking Water Catchment) 2011 (if relevant);
    - IESC guidelines (if relevant);
    - Australian Groundwater Modelling Guidelines (Barnett et al 2012) (if relevant).
- Management objectives (refer

- Context setting' above) based on environmental and cultural values and NSW water quality objectives.

Proponents are required to assess and present the predicted impacts using terminology and minimal impact criteria consistent with the AIP (for example, greater than 2 metre drawdown at a water supply work will require make good provisions). As discussed in the 'Regulatory overview' section and illustrated on Figure 6, the AIP defines level 1 impacts as 'acceptable' and where impacts are greater than level 1, additional management and mitigation may be required (for example, make good provisions).

Table 14 provides further details of assessment criteria for various potential groundwater effects and/or impacts to a receptor (for projects that intercept the water table).

Table 14: Assessment criteria for activities that intercept the water table (not exhaustive)

Potential effect/impact on receptor	Project type	Assessment criteria
Groundwater drawdown /rise at a water supply work	All aquifer interference activities	AIP minimal impact criteria
	Projects with bore(s)/ borefield(s) for consumptive purposes	Bore dealing impact assessment (refer Appendix Figure D-1)
	Coal seam gas or large coal mines	Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (DoE 2013)
	Coal seam gas or large coal mines	IESC Explanatory Notes
Groundwater drawdown /rise at a GDE	All aquifer interference activities	AIP and GDE risk assessment (Serov et al 2012)
	Projects with bore(s)/ borefield(s) for consumptive purposes	Bore dealing impact assessment (refer Appendix Figure D-1)
	Coal seam gas or large coal mines	Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (DoE 2013)
	Coal seam gas or large coal mines	IESC Explanatory Notes
Groundwater drawdown at a culturally significant site	All aquifer interference activities	AIP minimal impact criteria
	Projects with bore(s)/ borefield(s) for consumptive purposes	Bore dealing impact assessment (refer Appendix Figure D-1)
	Coal seam gas or large coal mines	Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (DoE 2013)

Change in groundwater quality	All aquifer interference activities	AIP minimal impact criteria
	All	National water quality guidelines (ANZG 2018)
	Located in Special Areas	Neutral or Beneficial Effect on Water Quality Assessment Guideline (SCA 2015)
	Coal seam gas or large coal mines	Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (DoE 2013)
Change in surface water quality (where connected to groundwater)	All	NSW Water Quality Objectives National water quality guidelines (ANZG 2018)
	Located in Special Areas	Neutral or Beneficial Effect on Water Quality Assessment Guideline (SCA 2015)
	Coal seam gas or large coal mines	Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (DoE 2013)

B.4.4 Presentation of the impact assessment

Presentation of the impact assessment results need to be clear, concise, transparent and written in plain English. This includes (but is not limited to):

- Clear definition of modelled scenarios (analytical or numerical) used to derive drawdown estimates. For example, definition and description of the null (that is, baseline) model used to compare predicted groundwater heads under the simulated project activity. For example, a clear description of whether the null model has been run with climate variations (and what has been used to define these variations), or whether the model results reference back to the commencement of the relevant water sharing plan.
- Clear definition of assumptions, limitations and simplifications made in the assessment methodology. For example, clear explanation of the reason why simulation of faults were (or were not) included in a numerical groundwater model (as per alignment to the conceptual hydrogeological model) or assumptions made for a simple analytical assessment.
- Where a project will not intercept the water table, the EIS must provide clear explanation and sufficient data to demonstrate that the activities will not intercept or interact with the water table. For example, diagrams (2D or 3D) presenting the depth of an excavation, hydrostratigraphy and the depth to the water table, ideally supported by depth to water table measured at bores in the project area and likely water table flux based on either historic observations or projections based on defined hydrogeological principles.
- Use of conceptual diagrams (such as cross-sections or 3D diagrams) to illustrate the predicted maximum impact (quantity and/or quality) on groundwater sources and/or connected surface water sources and/or at receptors. These diagrams should include (as appropriate based on available data and project risk) water balance components such as altered groundwater flow directions, water table and groundwater elevation/depth changes

and other items discussed in the 'Conceptual hydrogeological model' sections of this Guideline.

- Presentation of quantitative water balances for pre-development, construction and operational phases of the project (and if appropriate post-development, until the groundwater systems recover or reach a new equilibrium).
- Where applicable, presentation of cumulative impacts using maps to present predicted groundwater level (including water table) maximum drawdown and elevation, use of hydrographs to present predicted groundwater level change with time. Identified receptors should also be identifiable on maps.
- Where applicable, presentation of the predicted range in water table/ potentiometric/ groundwater level decline, under varying scenarios or consideration of alternative conceptualisations. For example, potential variations in hydraulic properties of various hydrostratigraphic units or modelled layers. Presentation material should include maps showing contours (and identified receptors) and hydrographs.
- Description of predicted groundwater level recovery following completion/ closure/ decommissioning of the development. This should include consideration of other water affecting activities in the project area.
- Use of conceptual diagrams (such as cross-sections or 3D diagrams) to illustrate the predicted post-development hydrogeological conditions, including impacts on groundwater sources and/or connected surface water sources and/or at receptors. For example, hydraulic properties of hydrostratigraphic units overlying an underground mine will change due to subsidence or enhanced fracturing. These changes should be considered as part of the conceptualisation and assessments.
- Clearly identify the number of water supply works predicted to be impacted greater than the AIP level 1 minimal impact considerations, and thus subject to make good considerations.
- Clearly identify the ecosystems environments that may potentially wholly or partially rely on groundwater and also known GDE's that are predicted to be impacted (referencing back to the AIP criteria and GDE risk assessment (Serov et al 2012)), describing the predicted effect that causes the impact (such as lower water table) and then how the impact will manifest. For example, signs of stress or reduced ecosystem function.
- Clear justification and definition of the significance of the predicted impact(s) based on management objectives, environmental and cultural values, ecological significance, DoE (2013) Significant Impact Guidelines (where applicable). For example, reduced access to groundwater for a GDE could be significant (or potentially unacceptable) for a critically endangered ecological community or listed matter of national environmental significance (under the EPBC Act). However, reduced access to groundwater for a GDE may be minor or moderate for an ecological community that is not listed as threatened under the NSW *Biodiversity Conservation Act 2016* or the EPBC Act and has been compromised by prior land use disturbance.

B.5 Risk assessment review

Following evaluation of the project activities and potential impacts on groundwater, connected surface water and associated receptors associated with these activities, the preliminary risk assessment completed in the early stages of the GIA should be updated. At this stage, the proponent's knowledge of the groundwater system as described in the conceptual hydrogeological model will be much more advanced (following completion of the field investigations and groundwater assessment).

As discussed in AIP Fact Sheet 6 (refer Appendix C), assessment and management of risk is one of the three key elements on the AIP. No assessment or prediction of potential impacts will be completely accurate. During the follow up risk assessment, the proponent will review the assumptions, identified hazards (water affecting activities), likelihood of occurrence and consequence (impact or magnitude of change), which will be informed by the results of the impact assessment. Likelihood is an equivalent of probability. For a quantitative risk assessment, where the risk of the proposed project is considered high, the assessment of likelihood should be informed by sensitivity and uncertainty analysis performed for the impact assessment (either through analytical or numerical modelling). A proponent should consider where the main uncertainties lie in the predictions and what the impacts could be if any of the predictions (or input assumptions) differ to reality.

Once the risks and uncertainties are considered and documented, the proponent must develop strategies to minimise the risks. The risk rating for an identified hazard should then be reviewed with consideration of mitigation and management strategies (control measures). Mitigation, management and monitoring is discussed further in the next section.

B.6 Mitigation, management and monitoring

B.6.1 Proposed mitigation, management and monitoring measures

Recommended management, mitigation and monitoring measures should be identified as part of the risk assessment, as controls to manage and reduce the likelihood of a potential adverse impact to a receptor from occurring. Water management strategies can take a number of forms and these strategies should be summarised in the GIA report.

A high-level summary of the technically feasible and measurable management and mitigation measures must be reported in the GIA.

Even at this stage of the process, the proposed management measures should be SMART:

- Specific (simple, sensible, significant).
- Measurable (meaningful, motivating).
- Achievable (agreed, attainable).
- Relevant (reasonable, realistic and resourced, results-based).
- Time bound (time-based, time limited, time/cost limited, timely, time-sensitive).

Following project approval, the proponent will then prepare a follow up and detailed WMP(s) or updated GMMP to document:

- Mitigation and management requirements for the project (through various stages). For example, make good strategy, or biodiversity offsets.
- Monitoring program, including network, with consideration of project water affecting activities (for example, sludge lagoon(s), water storages, tailings storages) and receptor location.
- Trigger action response plan(s) (TARP), which will define contingency plans and remedial measures.
- Other controls and administrative requirements.

Part C of this Guideline discusses the requirements for WMPs further. In all cases, undertaking monitoring activities, combined with the evaluation and reporting of newly acquired and existing data and information will be an important component of any risk management strategy.

Where impacts to a third-party water supply work are predicted to be greater than the minimal impact considerations as defined in the AIP (refer Appendix A), the proponent is required to ensure that the affected landholder has access to an equivalent supply of water through enhanced infrastructure or other means. For example, deepening an existing bore, funding extra pumping costs or constructing a new pipeline or bore (that is, make good provisions). As make good strategies may vary for landholder to landholder, a high-level summary of these proposed make good provisions should be reported in the GIA.

For GDEs, mitigation, management and monitoring should be informed by the risk assessment, in line with Serov et al (2012), with the level of risk used to determine the required management actions. Avoidance of impacts to GDEs is the preferred option, particularly for high value GDEs. Where avoidance is not possible, measures to mitigate and manage impacts should be considered. Any proposed mitigation and management measures must be in place prior to any impacts occurring.

As discussed in AIP Fact Sheet 6 (refer Appendix C), the NSW Government will require ongoing monitoring and reporting to ensure that the impacts are within the range predicted in the GIA, and to evaluate the efficacy of the proposed mitigation and management. As part of the WMP, a monitoring plan will be developed to provide monitoring data and evaluation in relation to the main risks and areas of uncertainty. For example, if a community is concerned about impacts on a high value aquifer that is above a deeper aquifer where an aquifer interference activity is occurring, then monitoring may focus mainly on the high value aquifer, to make sure that any impacts are detected as early as possible.

B.6.2 Model verification and review

As a project develops, proponents should re-visit and confirm the validity of/ and/or update the existing conceptual hydrogeological models, and refine, or develop new (if required), numerical or analytical models. With increasing knowledge about the groundwater system, the more able proponents and NSW Government will be in managing groundwater effects and receptor response to water affecting activities. This is consistent with the adaptive management model presented in the introduction section of this Guideline (see Figure 4).

Improvements to analytical or numerical groundwater models should be undertaken as and when sufficient new data become available that justify an update, particularly where there is a divergence of observed groundwater system response from the predicted. Groundwater monitoring data (including groundwater abstraction and groundwater level observations), as well as surface water flow monitoring data should be used to verify and validate the predictions presented in the GIA.

New data may prompt a revision and update of the conceptual hydrogeological model prior to updating (and possibly recalibrating) a numerical model and re-running of predictive scenarios. This will be important in the early stages of a project to guide water management requirements, review predicted impacts and guide water licensing requirements.

B.7 Licensing considerations

As discussed further in Appendix D, Fact Sheet 3 of the AIP (NOW 2013b, refer Appendix C) provides guidance regarding licensing and accounting for water. Water can be taken directly from a groundwater or surface water source, usually via a pump (in a river or an excavated area) or bore. It can also be taken indirectly when an aquifer interference activity causes water to flow from another connected groundwater or surface water source.

Take of water is licensed by the water source for where the water is taken.

The total annual volume of water estimated to be taken from each water source (incidental take) as a result of an aquifer interference activity (during and post-development) and/or a bore/borefield must be clearly reported in the GIA/EIS. Where there is ongoing take of water (post closure), the licence holder must retain a WAL for the period until the system returns to equilibrium or surrender it to the Minister.

In determining the type and the number of WALs required, either through the water trading market or by licence application, the proponent needs to demonstrate the following:

- Which water source(s) will the activity take water from;
- Proposed pathway for securing the required water entitlements, reporting on any potential constraints to obtaining the entitlement(s) and how any relevant licence exemptions might relate to the water to be taken by the activity;
- Water sharing plan trading rules (for example, carryover rules for unused water allocations) and assessment of market depth; and,
- A strategy for accounting for water take following completion of the project (that is, post-development).

Section 3.2.3 of the AIP requires that proponents hold water entitlements equivalent to the predicted maximum annual water take at the commencement of the project, regardless of when the water will be taken. The principle behind this is to limit the risk of there being insufficient market depth to obtain the necessary water entitlements in the future. In practice, the NSW Government requires the proponent to demonstrate the licensing pathway to secure sufficient entitlement for the peak take (including documenting the proposed mechanisms to secure the entitlement, for example trade or controlled allocation orders). This should be clearly documented in the GIA/EIS. A proponent is required to hold sufficient entitlement prior to the take occurring.

For many projects, the predicted maximum water take occurs over one to two years (that is, it is often of short duration in comparison to the duration of the project). This can be managed by the proponent obtaining sufficient water entitlements to cover the long-term average predicted annual water take and use temporary trading to cover the additional take that is predicted to occur during the peak period. The proposed licensing pathway approach should be developed in consultation with the department's Water division and NRAR.

Part C – Water management plans

This chapter discusses:

- Overview;
- Context and project setting;
- Purpose and objectives;
- Environmental requirements;
- Existing environment;
- Site water management and water balance;
- Environmental aspects and impacts;
- Environmental control measures;
- Compliance management; and,
- Review and improvement.

Relevant policy, guidelines, references and information:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Management Framework; Guideline Values;
- IESC information guidelines and explanatory notes; and,
- NSW Non-Urban Water Metering Policy

C.1 Overview

Under the Minister's Conditions of Approval (CoA) issued for SSD/SSI projects under the EP&A Act, proponents are required to submit a range of post-approval reports to the department.

Construction (and Operational) Environmental Management Plans (CEMP/OEMP) and associated sub-plans are key post-approval documents required by the consent. The EMP is a mechanism for managing a proposal once it is approved and is usually a comprehensive technical document. The CoA will specify the required subplans which generally include WMPs (or updated GMMPs) for the project construction and operation phases. A Water Management Plan (WMP) may also be required for closure which should be considered in all WMPs.

The WMP should be prepared to address the requirements of the CoA, the EIS, the environmental management measures listed in the project submissions, any project modifications, and all applicable legislation. The WMP should demonstrate how the proposal will be capable of complying with statutory obligations under all water related licences and approvals. The outline should provide a framework for managing or mitigating water related impacts for the life of the proposal, for remedial action if water level/water quality triggers are activated during operation, and for rehabilitation of the site upon completion of the operation.

A WMP typically includes a Groundwater Management Plan (GWMP) and Soil and Surface Water Management Plan (SWMP). Depending on the complexity of the project and the potential impacts to water, the GWMP and SWMP could be included within the WMP or appended as standalone sub-plan documents.

Key operational aspects of WMPs are the accompanying monitoring programs (typically appended as sub-plans to the WMP), which:

- Inform the identification of potential water related impacts identified in the EIS;
- Quantify actual water take (and validate predictions);
- Provide clear action strategies to mitigate and report on identified impacts (commonly referred to as a “Trigger Action Response Plan” (TARP)); and,
- Validate the conceptual hydrogeological model and predictions from the EIS.

The recommended stages of a WMP development (with a groundwater focus) are listed in Figure 16, along with available resources for some stages and guidance on when consultation with stakeholders, including the department’s Water division, should occur. Each stage is discussed further in the following sections.

The CEMP/OEMP and sub-plans (including the WMP) must be prepared in consultation with the relevant Government agencies, to the satisfaction of the Planning Secretary, and construction must not commence until the CEMP and sub-plans have been approved by the Secretary. The CEMP and OEMP sub-plans, as approved by the Secretary, must be implemented for the duration of construction or operation phase of the project.

WMPs should be practical and binding, providing clear direction to personnel responsible for its implementation. The plans should detail all relevant CoAs and management measures upfront, referencing how (and where) they are addressed in the plan (or sub-plans).

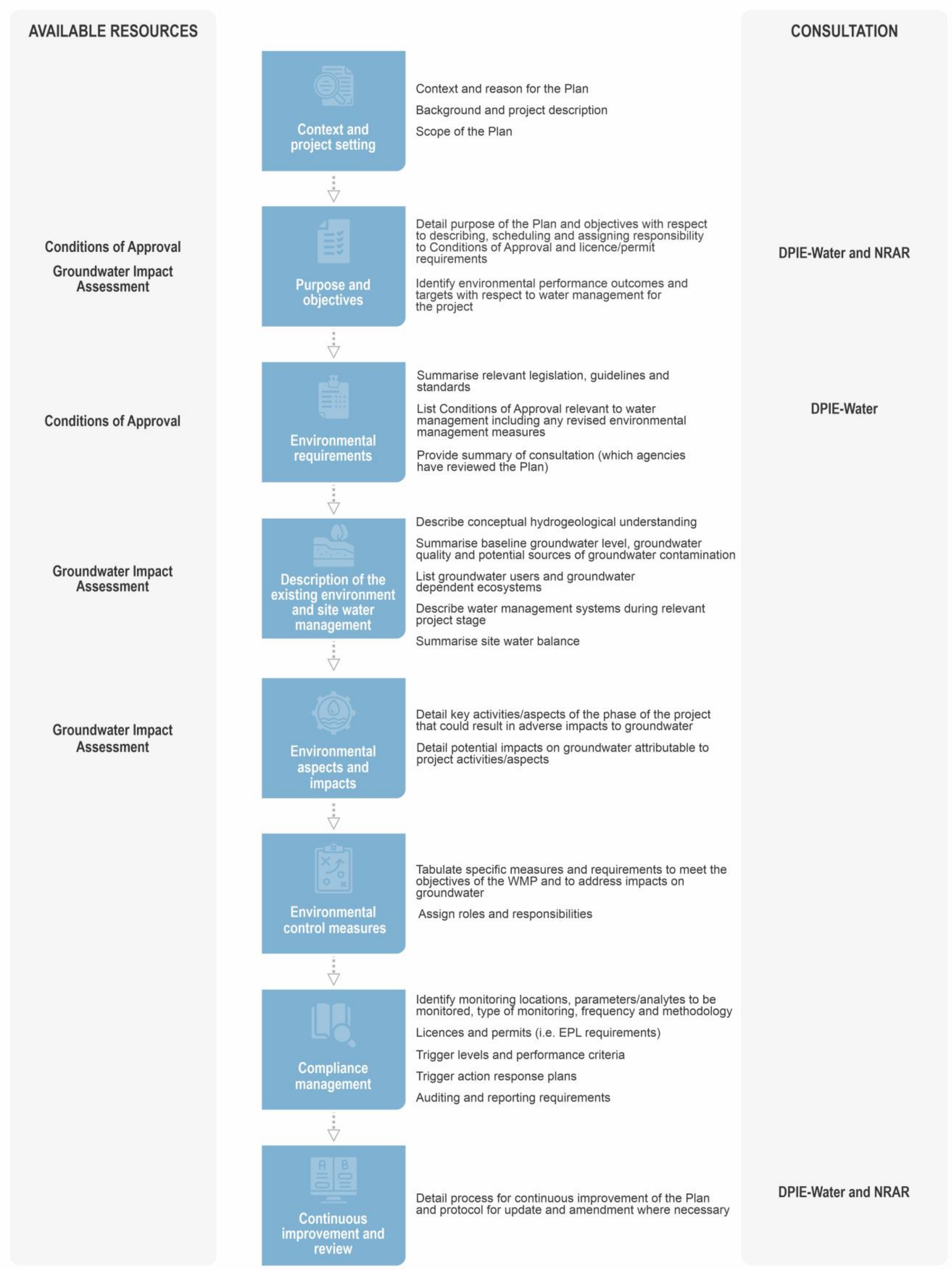


Figure 16: Water management plan workflow

C.2 Context and project setting

When preparing a WMP, the proponent should confirm the context of the document with respect to the project and include a brief discussion on the project background and project description.

The scope of the WMP and associated sub-plans describe how the proponent proposes to manage and protect water resources during construction and operation of the project.

C.3 Purpose and objectives

The purpose and objectives of the WMP should be clearly stated, and the WMP should describe the schedule and assign responsibilities. The objectives described should link back to the objectives identified through the GIA stage of the project and be aligned with the identified environmental and cultural values, and agreed water quality objectives.

Example objectives include:

- Maximise water efficiency and minimise take;
- Prevent unauthorised release of project-affected water; and,
- Maintain the beneficial use/environmental and cultural values of the downstream groundwater and surface water sources.

C.4 Environmental requirements

In addition to listing the CoA that relate to water, relevant legislation, guidelines, policy and standards should be documented in the WMP. Ideally the relevant CoA and the environmental management measures listed in the project submissions (including the EIS) and any project modifications, will be listed in a table format in the WMP.

The CoA can require WMPs to be prepared by a suitably qualified and experienced person(s) whose appointment has been endorsed by the Planning Secretary. WMPs are also typically required to be developed in consultation with the NSW Government (such as the department's Water division, NRAR and the EPA, depending on the project) and local councils depending on the project. This consultation should be acknowledged in the WMP.

C.5 Existing environment

A description of the existing environment should be included in the WMP, including description of:

- Topography;
- Climate;
- Surface water (such as streams, rivers, wetlands);
- Geology and hydrostratigraphy;
- Surface water-groundwater interaction;
- Conceptual hydrogeological model;
- Identified receptors (including third-party bores and GDEs); and,
- Summarise the existing hydrogeological (groundwater level and groundwater quality) and biological (for GDEs) baseline established in the GIA including any additional site data.

This section of WMP should be based on the information presented in the GIA, with updates provided as additional data is collected and understanding increases.

C.6 Site water management and water balance

C.6.1 Water management system

Where relevant to the project, the site water management system should be described in the WMP, including description of the methods for categorising and managing water of varying quality and use (for example, separating clean water runoff from natural undisturbed areas versus groundwater intercepted or pumped). The water management system should also be presented graphically and be representative of the project water balance.

The water management system may vary as the project develops.

C.6.2 Water balance

Direct (metered) measurements of water take are preferred; however, where not practical a combination of observed data (such as pumping rates) and a well-considered site water balance approach can provide estimates of water take. Water balance components during the operational phase should include (but may not be limited to):

- Groundwater inflows/abstraction;
- Groundwater recharge/infiltration (where applicable);
- Natural groundwater discharge (baseflows);
- Surface water take (for example, pumping from a river);
- Rainfall-runoff captured by storages;
- Volumes pumped / transferred between storages or other components of the water management system;
- Estimated evaporation;
- Leakage from surface water features (for example, rivers and/or dams);
- Intercepted baseflow; and,
- Other site water losses.

The measurement and documentation of water movement across site is recommended for all SSD/SSI projects and is typically a CoA. Licensed water users are required to install compliant metering equipment on works that meet the metering thresholds, by their roll-out date. The metering framework includes:

- The NSW Non-Urban Water Metering Policy;
- The metering-related provisions of the *Water Management (General) Regulation 2018*; and,
- The metering-related provisions of the WM Act.

A summary of the water balance inputs and results should be included in the WMP, supported by graphical representation of the inputs and outputs within the water management system.

A list of all water entitlements held, including WAL number and water source, should be provided in the WMP. Where the water entitlement held by the proponent is less than the predicted maximum take, a clear and justifiable pathway for obtaining WALs for peak take during project should be provided in the WMP. This requires consultation with the department's Water division.

All water take (per WAL) should also be reported to WaterNSW to allow WaterNSW and the department's Water division to account for total water take from a water source in a water year.

C.7 Environmental aspects and impacts

Key aspects of the project that have the potential to affect groundwater should be identified and described in the WMP.

The identified water affecting activities and the potential impact on groundwater and associated receptors will have been assessed as part of the GIA and should be summarised in the WMP. However, as the project develops and additional data is collated and assessed, the key assumptions and factors that the impact assessment relies on should be periodically reviewed. Therefore, this section of the WMP will need to be periodically review and updated. An outcome of the reviews may be an adjustment to the predicted impacts.

C.8 Environmental control measures

Specific measures and requirements to meet the objectives of the WMP and to address impacts on groundwater should be outlined in the WMP. The table should detail the mitigation and management measures that will be undertaken to effectively manage the potential groundwater impacts that may arise as a result of the project.

For ease of reference, the proponent could consider assigning a unique identification number to each control measure, referencing the relevant CoA or environmental management measures listed in the project submissions (including the EIS) and any project modifications. Each measure should include information on “when to implement” the measure and who will be responsible for implementation. Finally, the source of evidence that will provide proof that a measure has been implemented should be included (for example, construction site inspection reports or water compliance reporting (see Part D of this Guideline)).

The WMP should clearly list the roles and responsibilities for implementing the commitments of the WMP. This will range from responsibilities at the highest operations level to all personnel. Ideally this information will be presented in a tabulated format.

C.9 Compliance management

C.9.1 Groundwater Monitoring Program

C.9.1.1 Overview

Groundwater monitoring beyond project approval is required to identify deviations from baseline and modelled predictions, and initiate management response actions and mitigation on exceedance of defined thresholds.

A comprehensive groundwater monitoring program should:

- Clearly detail the rationale and objectives for the monitoring program;
- Describe what will be monitored (for example, potential seepage from effluent ponds or tailings storages), how it will be monitored (for example, manual sampling or depth measurements, pressure transducer data loggers) and, how collected data will be assessed;
- Characterise the approved project impacts and detail how monitoring data will be collected to validate those impacts;
- Articulate logical assessment criteria to identify monitoring data that deviate from approved predictions and provide a clear TARP to investigate exceedances and implement mitigation measures; and,
- Clearly detail how monitoring data will be used to periodically update impact predictions and/or prediction methods.

C.9.1.2 Training

All employees, contractors and utility staff working on a project site should undergo site induction training relating to water management issues. The induction training should address elements related to water management including:

- Water monitoring methodology and protocols; and,
- Project obligations including requirements to assess and classify contamination on site.

Targeted training in the form of toolbox talks or specific training should also be provided to personnel with a key role in groundwater management.

C.9.1.3 Structure

The structure of a groundwater monitoring program should fit the purpose of the document. At a minimum, a groundwater monitoring program should:

- Detail the monitoring network including:
    - Bore identification, using both local IDs and the WaterNSW GW number;
    - Bore construction details (listed separately if a nested location);
    - Bore location details;
    - Data collection methods (for example, pressure transducer data loggers (including frequency of measurements), telemetry, downhole micro-purge systems)
    - Groundwater take measurement and locations (such as, sump pit extraction, bore extraction, any metering points on pipelines/storages);
    - Purpose of monitoring locations, with reference to project activities;
    - List groundwater receptors, including water users;
    - Detail the appropriate monitoring methodology (including quality assurance/control);
    - Define the monitoring analytes and frequency; and,
    - Set the performance criteria and/or trigger levels;
- Summarise held water entitlements (per water source) in a table format; and,
- Detail the TARP following an exceedance of the trigger levels. Examples include:
    - A water level decline below model predictions for the project stage;
    - An inflow of water outside of prediction and/or licence entitlements; and,
    - A water quality parameter exceeding set and defined water quality trigger values.

Depending on the complexity of the project and the potential impacts to groundwater, the groundwater monitoring program could be included within the WMP or appended as a standalone sub-plan document.

C.9.1.4 Monitoring strategy

There are two basic types of post-approval groundwater monitoring:

- Reference – to assess conditions in undisturbed or least-disturbed setting to act as a reference against which targeted monitoring information can be compared; and,
- Targeted – to assess local impacts of water affecting activities on groundwater elevation, quality, and so on.

A comprehensive groundwater monitoring program should contain reference and targeted monitoring components with monitoring frequency tailored to the individual project. Typical data that should be presented in, and collected in accordance with, the groundwater monitoring program include (but is not limited to):

- Pumping rates/volume (dewatering, abstraction and site water use/movement);
- Methods for measuring and metering (including frequency of measurement);
- Inflow/seepage rates/volume;
- Groundwater elevation (potentiometric surface, water table, pressure head);
- Water quality (field parameters and laboratory analytes); and,
- Climate data.

As discussed in Part B of this Guideline, some project activities have the potential to alter groundwater flow and quality characteristics. This should be addressed in the EIS and monitored as part of the WMP. For example:

- Subsidence, typically associated with underground mining, has the potential to alter hydraulic properties of overlying hydrostratigraphic units, creating enhanced hydraulic connection between hydrostratigraphic units and/or surface water and groundwater. In this example, monitoring and reporting of subsidence should tie into and utilise groundwater monitoring results (and vice versa); or,
- Project water take has potential to cause drawdown and/or change water flow gradients. In this example monitoring of groundwater take is critical to validating impact assessment predictions.

Where potential impacts on high priority GDEs have been identified as part of the EIS and monitoring is required, biological (GDE) monitoring should also tie into and utilise groundwater monitoring and climate (rainfall and temperature) monitoring data. Impacts to groundwater (quantity or quality, termed direct effects or primary impacts by Serov et al (2012)) are likely to precede any impacts to the biological indicators associated with GDEs (termed secondary impacts by Serov et al (2012)) and should be used as early indicators of possible receptor impact. Typical data that may be presented in, and collected in accordance with, the groundwater monitoring program and biodiversity management plan for high priority GDEs (as per the CoA) may include (but may not be limited to):

- Depth to water table monitored at shallow piezometers or bores located in close proximity to GDEs; and,
- Ecological monitoring at high priority GDEs or as per a biodiversity management plan including:
    - Data on species diversity and composition for vegetation communities associated with GDEs;
    - Data on fauna assemblages for baseflow/surface water ecosystems;
    - Data on fauna assemblage for underground stygofauna communities; or,
    - Vegetation condition (stress).

Monitoring programs should be designed to effectively monitor the predicted impacts to receptors, including GDEs identified as part of the EIS and consistent with the biodiversity management plan, and assess the efficacy of proposed mitigation and management measures. Due to the variability of ecological data, proponents should consider the level of replication required to effectively monitor and detect changes.

C.9.1.5 Trigger levels

As part of the GIA, performance criteria and indicators for stresses/impacts on the groundwater systems and associated receptors will have been selected, with consideration of the water affecting activities, agreed environmental and cultural values and management objectives.

Example groundwater performance criteria include:

- No change to the beneficial use of groundwater and/or connected surface water;
- Responsible surface water and groundwater management (fulfilling the requirements of relevant licences and water sharing plan rules); or,
- Maintaining access to water at identified high value GDEs.

An example performance indicator for the performance criteria to ensure no change to the beneficial use of groundwater and/or connected surface water may be salinity. An increasing salinity trend may be an indicator of potential deviation from the performance criteria.

As part of the groundwater monitoring program, trigger levels should be selected for each performance indicator. The primary objective of trigger levels is to provide an early indication of potential impacts to receptors and initiate a management response (TARP). They are not intended to be an instrument to assess ‘compliance’ and should not be used in this capacity (ANZG 2018).

Ideally, trigger levels should be relevant to local conditions and project activities. These are ‘site-specific trigger levels’ (referred to as ‘site-specific guideline values’ in the national water quality guidelines (ANZG 2018)). Trigger levels can also be selected as the default guideline values defined in the national water quality guidelines (ANZG 2018), and should be in line with the water quality objectives for NSW waterways (DECCW 2006). The IESC and national water quality guidelines (ANZG 2018) provide guidance on the selection of site-specific trigger values (refer to *Relevant policy, guidelines, references and information* listed at the beginning of this chapter).

Trigger level criteria will vary based on the location. For example, trigger levels will have stricter criteria closer to a receptor and may have broader criteria closer to the water affecting activity. Effective trigger levels will be based on baseline data, environmental and cultural values of the water source(s), target the potential impacts identified in the GIA, assess management infrastructure, and validate groundwater impact predictions.

Examples of effective trigger levels include:

- Groundwater level criteria, set to modelled predictions and/or based on agreed thresholds at a receptor (for example, ecological threshold);
- Water quality criteria, set by the baseline data, environmental and cultural values, and water quality objectives;
- Groundwater inflow/abstraction rates, set to modelled predictions (time and rate) and licence (or exemption); or,
- Groundwater level and/or water quality criteria, benchmarked against reference sites.

For GDEs, performance indicators (or bioindicators) need to reflect the predicted changes that may arise from changes in groundwater quantity or quality (direct effects) and may include:

- Observed die-back or senescence of vegetation (gradual deterioration);
- Changes in species diversity and composition of vegetation communities that are dependent on groundwater; or,
- Changes in fauna assemblages.

The proponent is encouraged to set representative, flexible and adaptive trigger levels. Incorrectly set trigger levels can fail to notify an actual impact or, conversely, may initiate a management response without an impact actually occurring (false triggering) (ANZECC and ARMCANZ 2000). False triggering can create an unnecessary compliance burden and may reduce the effectiveness of the impact assessment. Control sites may be required to ensure observed changes are not the result of overarching environmental or climatic variables; this is particularly the case for GDEs.

C.9.1.6 Trigger Action Response Plan (TARP)

A TARP is a list of management actions to be implemented when trigger levels are exceeded. Actions should be commensurate with the risk and staged to allow for investigation and confirmation.

The WMP/groundwater monitoring program should define clear steps following the identification of a deviation from predicted impacts or if impacts exceed approved predictions. These steps present well as a table, clearly staging response tasks and assigning responsibilities.

C.9.1.7 Reporting

The method and frequency for the provision and distribution of monitoring data and reports should be defined in the groundwater monitoring program in accordance with the CoA.

Groundwater compliance reporting is typically annual and in a standardised format that assesses monitoring data against CoAs, performance measures and climatic trends. This is discussed further in Part D of this Guideline.

Exceedance of a trigger level or licence condition may require reporting at any time (that is, outside of the regular compliance reporting period). The triggering of such reporting requirements should be documented in the TARP.

Reporting should also comprise the validation of groundwater impact predictions, this may include model updates and revised predictions. Revised predictions may inform revisions of the monitoring program, trigger levels, management measures and water licence entitlement.

C.9.2 Surface Water Monitoring Program

The integration of the groundwater and surface water monitoring programs (and trigger levels) is an effective way to holistically assess water resources and impacts of a project. Individual programs are reasonable, and often more practical, provided the documents are prepared to complement each other. It should be noted that drinking water catchment areas are likely to have a higher level of monitoring requirements. Examples of routine and rainfall event-based surface water monitoring that may inform on groundwater-surface water interaction and assessment of potential impacts on connected systems includes (but is not limited to):

- Streamflow monitoring; and,
- Surface water quality monitoring in selected watercourses.

Estimating baseflow and connected water sources can be difficult and problematic. Proponents are encouraged to:

- Monitor streamflow in selected watercourses (both pre and post-approval), as agreed with the department’s Water division;
- Utilise nested groundwater monitoring sites (shallow and deep standpipe piezometers); and,
- Identify trends in both groundwater and surface water sources to characterise interaction and assess project impacts.

C.10 Continuous improvement and review

WMPs are dynamic documents that are expected to evolve with project development. As a project develops, it is necessary to review and verify the predictions made as part of the EIS. This includes predictions made using analytical or numerical modelling techniques. As part of the GIA, the proponent will have documented their commitment to do this. Often, the project water affecting activities (for example, mining/ excavation rate) will be adjusted as the project design advances following approval. Therefore, the timing of the predictions (such as take and drawdown) made in the GIA may differ to reality as the project advances. These differences may not affect the maximum predicted take or maximum predicted drawdown; however, the timing for these things to occur may differ.

The proponent should document when the verification and review will occur (for example, every two years or every three years, or as required as a consequence of a management action).

Examples of project stages that may trigger a review of the WMP (and monitoring programs) include:

- Change of project phase (that is, construction/operations/closure);
- Observations outside of predictions (for example, subsidence, drawdown, inflow rate);
- Modification to a project; or,
- An observed impact not predicted by the GIA.

Continuous improvement of the WMP will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives and targets for the purpose of identifying opportunities for improvement.

The continuous improvement process should be designed to:

- Identify areas of opportunity for improvement of environmental management and performance;
- Determine the cause or causes of non-conformances and deficiencies;
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies;
- Verify the effectiveness of the corrective and preventative actions;
- Document any changes in procedures resulting from process improvement; and,
- Make comparisons with objectives and targets.

When updates are made, a copy of the updated WMP and changes should be distributed to all relevant stakeholders in accordance with the approved project document control procedure, typically documented in the project EMP.

Part D – Water compliance reporting

This chapter discusses:

- Overview;
- Objectives;
- Description of the environment;
- Description of project activities;
- Monitoring data;
- Trend analysis;
- Performance criteria and trigger levels;
- Management measures;
- Water take;
- Review and verification; and,
- Recommendations.

D.1 Overview

Annual environmental reports are post-approval documents typically required by the CoAs under the EP&A Act. These reports form a key pillar of the environmental management process. Some projects may be required by the CoAs to provide compliance reports on a more frequent basis, and may require multiple compliance reports to different agencies.

Whether a standalone report or a chapter within a broader annual environmental report, typically, groundwater compliance reports require a review of groundwater performance against established baseline conditions or trigger levels (discussed in Part C).

Other typical NSW post-approval reporting requirements related to groundwater may include:

- Subsidence reporting (typically limited to underground mining projects);
- Project commissioning assessments;
- Biodiversity /ecological condition reporting; and,
- Triggered reporting requirement.

Figure 17 illustrates the typical workflow/stages in the preparation of water compliance reporting. These are discussed in the following sections and can be used by the proponent to form the structure of the compliance report.

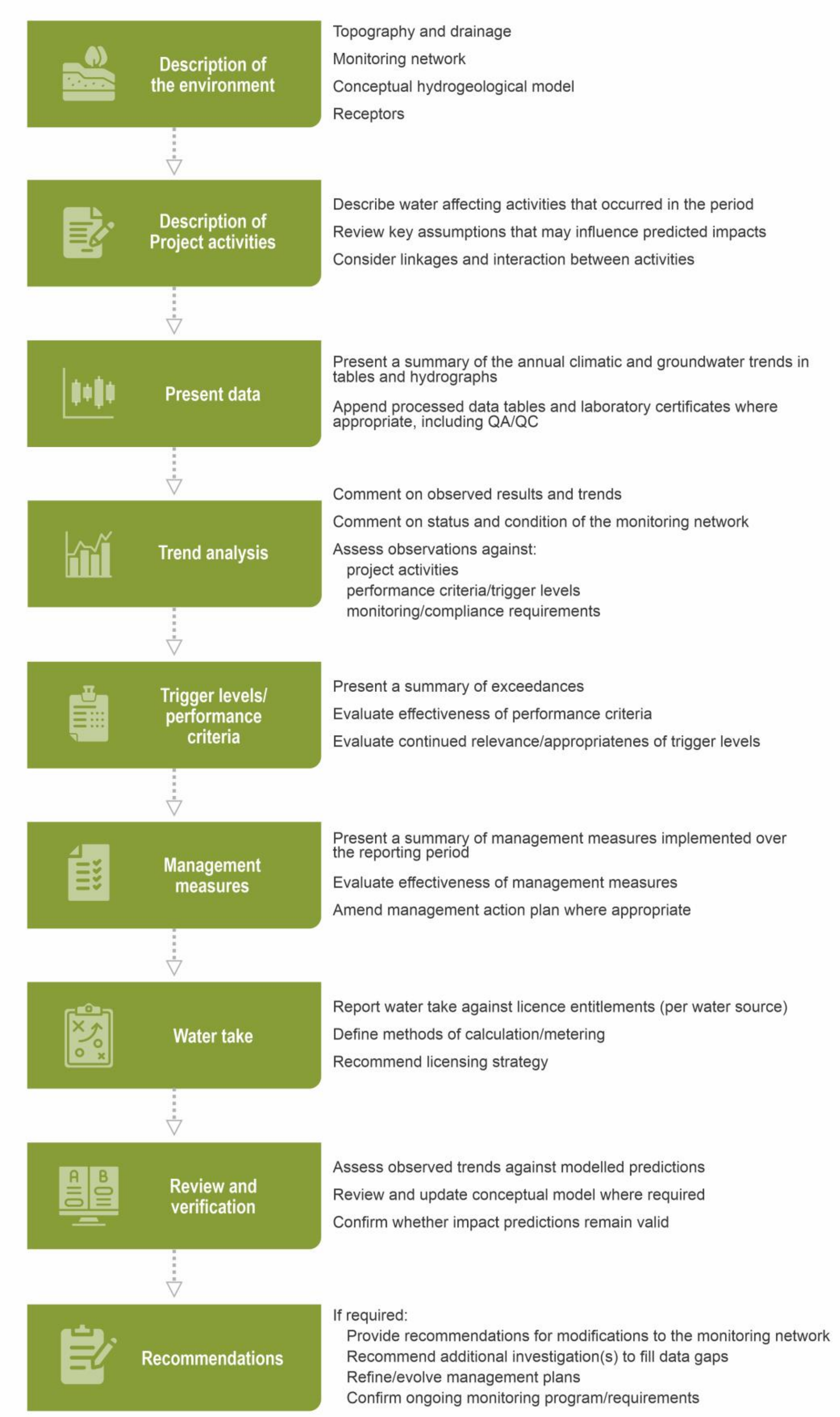


Figure 17: Typical water compliance reporting workflow

D.2 Objectives

Reporting on the groundwater management of a project has several objectives:

- Verify GIA predictions or identify observations outside of predictions;
- Identify impacts and/or the requirement for make good provisions;
- Ensure water taken is consistent with the amount of water available and licence entitlements; and,
- Trigger a review of the GIA and/or WMP.

D.3 Description of the environment

D.3.1 Overview

A brief summary of the existing environment should be included in the compliance report, including description of:

- Topography;
- Climate;
- Surface water (streams, rivers);
- Geology and hydrostratigraphy;
- Groundwater monitoring network (description and supporting figure(s) showing locations);
- Conceptual hydrogeological model (discussed further below); and,
- Identified receptors (including third-party bores and GDEs).

D.3.2 Conceptual hydrogeological model

As the conceptual hydrogeological model forms the basis for the impact assessment, it should evolve with new data, undergoing review and, if necessary, updated as data is collected during the construction and operation stages of a project.

Those areas where the conceptualisation has changed should be highlighted and explained within this section of the compliance report, referring to the new (post-EIS submission) monitoring data that has influenced this change. As discussed above, it is important that the proponent review the key assumptions and factors that the impact assessment relies on (including the conceptual hydrogeological model). Changes to these key assumptions may change the predicted impacts. Therefore, groundwater compliance reports should assess water related impacts against the key assumptions and conceptual hydrogeological model. Significant changes may require an update the predicted impacts at identified receptors and/or adjustments to water entitlements held by the proponent.

D.4 Description of project activities

The water compliance report must provide detail of the project water affecting activities that occurred in the reporting period. This may include:

- Excavations, tunnels and below water table pits;
- Abstraction from bores;
- Contamination sources;
- Standing water;
- Dredge mining; and,
- Drainage/discharge.

As part of the reporting, the proponent should review the key assumptions and factors that the impact assessment relies on. Changes to these key assumptions or project activities may change the predicted impacts.

It is important that the proponent be aware of the interaction and linkages between water and other aspects of the project, such as subsidence monitoring and reporting, tailings seepage management, biodiversity monitoring and management. Exceedance of trigger levels for other aspects of the project may have implications for groundwater and associated receptors. Where trigger levels are exceeded for those other related project activities (for example, subsidence), groundwater compliance reports should include assessment of groundwater levels, water quality (including trace metals), groundwater inflows/take, and bioindicators (for GDEs). This will allow robust evaluation of the mitigation and management measures.

D.5 Monitoring data

D.5.1 Presentation of data

The main component of the water compliance report is presentation of the monitoring data collected throughout the reporting period.

Requirements for the data presentation are summarised in Table 15.

Table 15: Presentation of monitoring data

Data	Presentation requirement
Rainfall data	Graphically, as monthly totals over the review period, with comparison to the long-term monthly average and cumulative deviation from the mean (if data available)
	A brief description of the trends observed and comparison to historical trends is also required
Monitoring network	Maps showing the location of groundwater monitoring bores and surface water monitoring locations.
	Supporting tables summarising bore locations, construction and listing bore ID using the state-wide GW number.
Groundwater level	Hydrographs, presented in depth below surface and metres elevation (metres Australian Height Datum, mAHD), with trigger levels shown on the graph (where applicable)
	For shallow monitoring bores installed in groundwater sources connected to surface water, presentation of streamflow data is also recommended
	A brief description of measurement methodology (eg manual and/or pressure transducer data logger or vibrating wire piezometer, with evidence of calibration) is also required
	Maps showing water table contours and groundwater elevation (for key groundwater sources) for a selected period of time in the reporting period

Groundwater quality	Time-series charts for indicator analytes (eg salinity) where trigger levels are assigned (trigger levels to be shown on the graph)
	Laboratory reports
	A brief description of sampling methodology and QA/QC protocols is also required
Groundwater take	Annual volume presented per water source in table format, with a comparison to water entitlements held by the proponent and reference to the relevant conditions of the licence
	Monthly totals in graphical format, where available

D.6 Trend analysis

Groundwater reports should include groundwater monitoring data recorded over the reporting period and an analysis of aquifer response to groundwater abstraction over that period.

Depending on the nature of the operation, and consent requirements, the reports can include a complete history of groundwater monitoring data or a recent history. An analysis of all the data should be undertaken to describe trends in water quality and quantity, and describe the impacts of the abstraction on water source(s) and receptors, including other water users. The trend analysis should include consideration of whether water quantity impacts (such as water take) are consistent with GIA predictions and whether there is the need to acquire additional entitlement.

A detailed review is often required periodically and may also be required annually where close management of the take is required (for example, where complex dewatering and re-injection operations are undertaken, or in areas where high value receptors may be impacted upon).

D.7 Performance criteria and trigger levels

Following the trend analysis, a summary of exceedance against trigger levels (and evaluation of performance criteria) should be provided. The discussion should include an assessment of the cause of the trigger level exceedance and a review of the continued appropriateness of the trigger levels.

Where trigger level exceedances have occurred in a reporting period, the proponent needs to demonstrate the appropriate investigation as per the TARP in the WMP. It is important to note that some triggers levels will act as an early warning of a potential impact, requiring investigation, whereas others will require a larger action that may include mitigation measures.

D.8 Management measures

An important part of the adaptive groundwater management approach is a review of the effectiveness of the management measures. At this stage of the compliance reporting, the proponent will review and discuss the effectiveness of the management measures, based on the monitoring data and performance measures. An outcome of this stage may be recommendations to adjust the management measure(s), implement additional measures or amend the TARP.

D.9 Water take

In regards to water take, the following should be included in the compliance report:

- Description of the methods used to estimate or measure the indirect and direct take;
- The volume of water take reported per water source, with a comparison to water entitlements;
- Proposed licensing strategy (where additional entitlement is required for future take); and,
- Reporting the take to WaterNSW for inclusion against the relevant WAL and Extraction Site Identification number (ESID) in the relevant WaterNSW database.

D.10 Review and verification

The compliance report should include a comparison of observed trends to predictions in the GIA or more recently updated review of predictions. Where the observations (that is, measured data) may differ to the predictions, a review of the impact predictions may be required and should be discussed with the department’s Water division.

As discussed in the ‘Description of the environment’ section above, an outcome of the water monitoring review may be to revise the conceptual hydrogeological model.

D.10.1 Independent audits and reviews

Certain projects require an audit of the groundwater management, specified in the project consent. These projects are typically those where the project aquifer interference activities have the potential to have adverse impacts on water source(s) and/or receptors.

Depending on the project and the CoA, independent audits may be required to be completed by an independent party endorsed by the Planning Secretary. However, this does not exclude the consultant or individual who prepared the project GIA for the EIS or other project documentation.

Where an audit occurs in a reporting period, it should be referenced in the compliance report (the audit itself does not need to be included in the compliance report).

D.11 Recommendations

Depending on the findings of the monitoring and management system review, the compliance report may include a summary of recommendations to:

- Modify to the monitoring network (for example, replacement bores where existing bores have been damaged);
- Conduct additional investigations to fill data gaps;
- Conduct follow up monitoring or maintenance work at monitoring locations;
- Update management plans; or,
- Adjust trigger levels and TARPs.

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Glossary

Term	Definition
Abstraction	The removal of water from a water store.
Allocation	The specific volume of water allocated to water access entitlements in a given water year or allocated as specified within a water resource plan.
Alluvium	Unconsolidated sediments (clays, sands, gravels and other materials) deposited by flowing water. Deposits can be made by streams on riverbeds, floodplains, and alluvial fans.
Aquifer	A geological structure, formation or group of formations; able to receive, store and transmit significant quantities of water.
Aquifer, confined	Aquifer overlain and underlain by an impermeable or almost impermeable formation.
Aquifer, unconfined	Saturated water-bearing formation which has a water table.
Baseflow	The component of streamflow supplied by groundwater discharge.
Baseline conditions	Conditions, such as groundwater level and quality spatial and temporal trends, prior to the development of a project, against which subsequent changes can be referenced.
Basic rights	Under the WM Act, an owner or occupier of a landholding is entitled to take water from a river, estuary or lake which fronts their land or from an aquifer which is underlying their land for domestic consumption and stock watering, without the need for a WAL.
Beneficial use	Referenced in the NSW Aquifer Interference Policy relating to assessment of water quality impacts. The term “beneficial use” is interchangeable with the term “environmental value” (NWQMS 2013).
Bore	A hole drilled in the ground, either lined (eg with steel or PVC) or unlined (open hole) used to access groundwater. May be used for observation of groundwater (including groundwater level or quality).
Calibration	Process of adjusting the values of model parameters within physically defensible ranges until the model performance adequately matches observed historical data from one or more locations represented by the model (ie a match is obtained that is robust and fit for purpose).
Conceptual model	Simplified representation of a real situation, described by diagrams, flow charts, governing relationships or natural laws.
Conditions of Consent	The conditions that the Department or decision-maker sets when a project is approved. The conditions control the way in which development is constructed or operates. The applicant must adhere to these conditions.

Contaminant	Substance or organism that enters, becomes concentrated in or is transported in the environment, as a by-product of human activity, where it may cause harm to humans or have other undesirable consequences for natural resources and species.
Dissolved oxygen	Actual quantity of dissolved oxygen in water which varies with temperature, salinity and turbulence.
Direct effect	Changes to the physical and/or quality aspects of groundwater as a consequence of an activity, or changes to the physical characteristics of aquifer affected by a development activity. Examples include changes in groundwater levels, changes in groundwater chemistry.
Drawdown	The decline in groundwater level compared to the original (or static) groundwater level. It is a change in groundwater level and is reported in metres.
Environmental isotopes	Isotopes are variants of the same chemical element that contain equal numbers of protons but different numbers of neutrons in their nuclei. Environmental isotopes are naturally occurring stable or radioactive isotopes used to determine groundwater age and trace groundwater provenance, recharge/discharge mechanism, and rock–water and surface water-groundwater interactions.
Evapotranspiration	Quantity of water evaporated and transpired from the soil and the vegetative cover.
Groundwater	The water contained in interconnected pores within rocks and sediments below the ground surface in the saturated zone, including perched systems above the regional water table.
Groundwater dependent ecosystems	Natural ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.
Groundwater level	The groundwater elevation in an aquifer, typically measured in a bore. In the case of an unconfined aquifer, the groundwater level is equal to the water table level.
Potentiometric surface	A surface representing the hydraulic head of groundwater in a confined aquifer.
Groundwater receptor	A receptor is a discrete, identifiably attribute or associate entity that is measurably impacted by an effect to a pathway. A groundwater receptor is a receptor that may be measurably affected by change in the groundwater pathway at the location of the receptor.
Groundwater recharge	The process which replenishes groundwater, usually by rainfall infiltrating from the ground surface to the water table and/or by surface water infiltrating to the water table from a stream. Other forms of recharge include flooding and irrigation, and artificial recharge can also occur through various means, including bore injection.

Hydraulic conductivity	A coefficient of proportionality describing the rate at which water can move through a medium.
Hydraulic connection	Degree of hydraulic interaction between aquifers, between different parts of the same aquifer, and between groundwater and surface water systems.
Hydraulic gradient	The rate of change in total head per unit distance in a given direction, the direction of the gradient is driven by the maximum rate of decrease in head.
Hydrogeochemistry	Science which deals with the chemical composition of natural groundwaters, its changes and the causes of such changes.
Hydrogeology	The study of the interrelationships of geologic materials and processes with water, especially groundwater.
Hydrostratigraphic unit	Lithology that has similar properties from the point of view of storage and transmission of groundwater. Units that store significant amounts of water and transmit this water relatively easily are called aquifers. Units that offer a high resistance to flow are called aquitards, or confining units.
Impact	Any certain and defined change to a receptor, whether adverse or beneficial, wholly or partially resulting from a direct effect of an activity (eg groundwater level decline).
Infrastructure	As defined under Division 5.2 of the EP&A Act: development for the purposes of infrastructure, including (without limitation) development for the purposes of railways, roads, electricity transmission or distribution networks, pipelines, ports, wharf or boating facilities, telecommunications, sewerage systems, stormwater management systems, water supply systems, waterway or foreshore management activities, flood mitigation works, public parks or reserves management, soil conservation works or other purposes prescribed by the regulations.
Low permeability barrier	Engineered structure to reduce the transmission of water from the receiving environment into mining areas.
Make good provisions	The requirement to ensure that third parties have access to an equivalent supply of water through enhanced infrastructure or other means, for example deepening an existing bore, funding extra pumping costs or constructing a new pipeline or bore.
Major ions	Constituents commonly present in concentrations exceeding 1.0 milligram per litre. Dissolved cations generally are calcium, magnesium, sodium, and potassium; the major anions are sulphate, chloride, fluoride, nitrate, and those contributing to alkalinity, most generally assumed to be bicarbonate and carbonate.
Minister	NSW Minister for Planning.
Mitigation	Action taken to reduce the impact that a project may have on a receptor or water source.

Mounding	The increase in groundwater level compared to the original (or static) groundwater level. It is a change in groundwater level and is reported in metres.
Nested monitoring site/bore	Two or more monitoring bores installed at one location at varying depths to allow monitoring of different hydrostratigraphic units or depth intervals.
Numerical model	Numerical approximation of a mathematical model consisting of a set of equations that can be solved by a computer.
Performance measures	Also referred to as assessment criteria and/or trigger levels. Values / limits assigned to indicators that are used to identify deviations in predictions and early warning system of potential impacts, possibly identifying the need for management or remedial actions.
pH	Value that represents the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Phreatophytes	Plants with deep root systems that access groundwater i.e. groundwater dependent.
Porous rock	Material containing interstices that are usually connected and which above a certain scale may be considered continuous with respect to its hydraulic properties.
Porosity	The proportion of open space within a rock or deposit, comprised of intergranular space, pores, vesicles and fractures.
Pressure head	Height of a column of static water that can be supported by the static pressure at a point.
Project approval	Includes: • development consent for State significant development; and, • infrastructure approval for State significant infrastructure.
Proponent	The person or entity seeking approval for a State significant project, or acting on an approval for a State significant project, including any associated entities that have been engaged to assist with project delivery.
Redox potential	Index giving a quantitative measure for the oxidation or reduction potential of an environment.
Salinity	Concentration of dissolved salts in water.
Saturated zone	The soil and geological layers below the land surface where all spaces between soil/sediment/rock particles are filled with water. It encompasses all the soil and geological layers below the water table.
SEARs	The Secretary’s Environmental Assessment Requirements that set out clear expectations on the level of assessment required for each relevant matter which must be addressed by an proponent in an EIS.

Secretary	The Secretary of the NSW Department of Planning and Environment.
Senescence	Biological aging, gradual deterioration of functional characteristics (cellular or whole organism).
Sensitivity	The degree to which numerical model outputs are affected by changes in selected input parameters.
Stakeholder	Any person or group with an interest in, or the potential to be affected by, a project.
Standpipe	A non-pumping bore, generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface.
Storage parameters	Specific yield: The amount of water that a unit volume of saturated permeable rock will yield when drained by gravity. Storativity: The amount of water that a unit volume of saturated permeable rock will release from storage per unit decline in hydraulic head.
Stratigraphy	The branch of geology that is concerned with the order and relative position of the strata of the earth's crust.
Stygofauna	Aquatic animals found in groundwater; sometimes used as a synonym of stygobite.
Surface water	Water that flows over or is stored on the surface of the earth that includes: water in a watercourse, lake or wetland and any water flowing over or lying on land: after having precipitated naturally or after having risen to the surface naturally from underground.
Total Dissolved Solids	Total weight of dissolved constituents in a water sample per unit volume or unit weight of the water.
Total Suspended Solids	Total weight of suspended constituents in a water sample per unit volume or unit weight of the water.
Uncertainty	A state of lack of confidence to exactly describe the current or future condition of a system when limited knowledge of that system is available. Uncertainty is often categorised into two main types (AGMG; Barnett et al. 2012): • deficiency in our knowledge of the natural world (including the effects of error in measurements); and, • failure to capture the complexity of the natural world (or what we know about it) in a model. Formal definition from AS/NZS ISO 310000:2009: Uncertainty is the state, even partial, of deficiency of information related to the understanding or knowledge of an event, its consequence, or its likelihood.
Unsaturated zone	The soil between the land surface and the regional water table in which the pore space contains both air and water.

Vadophytic	Plants that depend solely on moisture held within the soil profile are known as vadophytes and are not groundwater dependent
Water balance	The flow of water into and out of, and changes in the storage volume of, a surface water system, groundwater system, catchment or specified area over a defined period of time.
Water quality	The physical, chemical and biological characteristics of water. Water quality compliance is usually assessed by comparing these characteristics with a set of reference standards. Common standards used are those for drinking water, safety of human contact and the health of ecosystems.
Water resource	All natural water (surface water or groundwater) and alternative water sources, such as recycled or desalinated water, that has not yet been abstracted or used.
Water sharing plan	A legislated plan that establishes rules for managing and sharing water between ecological processes and environmental needs of the respective water source (river/aquifer). It manages water access licences, water allocation and trading, water extraction, operation of dams, management of water flows, and use and rights of different water users.
Water source	In NSW, water source means the whole or any part of: • One or more rivers, lakes or estuaries, or • One or more places where water occurs on or below the surface of the ground (including overland flow water flowing over or lying there for the time being), and, • Includes the coastal waters of the State. (NSW Water Management Act 2000 definition).
Water table	The surface between the unsaturated and saturated zones of the subsurface at which the hydrostatic pressure is equal to that of the atmosphere.
Water table, perched	Hydrostratigraphic formations that form localized bodies of groundwater. It occurs above the regional water table and is separated from the underlying body of groundwater by an unsaturated zone as a result of a discontinuous layer of low hydraulic conductivity.

Water take	Take water from a water resource means to remove water from, or to reduce the flow of water in or into, the water resource including by any of the following means: • Pumping or siphoning water from the water resource; • Stopping, impeding or diverting the flow of water in or into the water resource; • Releasing water from the water resource if the water resource is a wetland or lake; • Permitting water to flow from the water resource if the water resource is a well or watercourse; and includes storing water as part of, or in a way that is ancillary to, any of the processes or activities referred to in paragraphs (a) to (d). (Commonwealth Water Act 2007 definition).
Wetland	An area of land whose soil is saturated with moisture either permanently or intermittently. Wetlands are typically highly productive ecosystems. They include areas of marsh, fen, parkland and open water. Open water can be natural or artificial; permanent or temporary; static or flowing; and fresh, brackish or salty.

Appendix A

SSD / SSI requirement by project type

Project type	Petroleum, including Coal Seam Gas (CSG)
Groundwater investigations (baseline data)	

Requirements[1]	• Detailed groundwater investigations, including (but not limited to):
	  ○ Groundwater monitoring network installed to target all identified groundwater sources that have the potential to be affected by the development, at a spatial density and coverage that is based on an initial desktop review and conceptual understanding of groundwater system, a risk assessment and gap analysis (vertical and spatial coverage).
	  ○ Estimates of hydraulic properties (hydraulic conductivity and storage properties) for lithology to be encountered by and overlying the development, measured at a number of test locations (spatially and vertically) across the development area, using a range of appropriate testing methods (such as rising and falling head (slug) tests, packer tests, pumping tests, core tests). Presentation of this data, including test locations on a map, is also required.
	    ▪ Collation of data collected and recorded by others, including:
	    ▪ Data collected by other exploration companies at monitoring bores or CSG exploration wells.
	    ▪ Government monitoring network.
	    ▪ Bore census surveys to collect additional information from existing third-party users, including confirming details of construction, depth, pumping rate, reliance, groundwater quality.
	• Mapping and consideration of geological structures, including assessment of influence on groundwater flow.
	• Ground-truthing and ecological assessment of high priority groundwater dependent ecosystems (including springs) mapped in the Water Sharing Plan(s) and BoM GDE Atlas, including assessment of water reliance and resilience, as well as assessment of the source of the water that ecosystem relies on.
	• Discussion with local Aboriginal community to identify culturally significant sites that rely on water, as well as an assessment of the source of the water.
	• Baseline groundwater level/pressure monitoring in hydrostratigraphic units where the water affecting activities will occur and in units that have the potential to be affected (for example, overlying units), with monitoring over at least a two-year period. The monitoring frequency should be suitable to detect groundwater level response to climate (rainfall, evapotranspiration) and existing water affecting activities. The monitoring data should be sufficient to allow assessment of vertical gradients and connection between hydrostratigraphic units.
	• Baseline groundwater quality sampling from monitoring bores, analysed preferably by National Association of Testing Authorities (NATA) certified laboratory for a comprehensive suite including major ions, dissolved metals, salinity (as electrical conductivity), trace metals, dissolved gases, nutrients and hydrocarbons with sufficient frequency to establish potential seasonal variation (for example, quarterly). Presentation of QA/QC is also required.
	• Assessment of potential surface water-groundwater interaction, including streamflow monitoring to estimate baseflow (where applicable).

Common constraints/ challenges	• Installation of monitoring bores and/or collection of baseline monitoring data may be constrained by land access approval. It is recommended that the proponent begin consultation with the department's Water division, local council, local community and local Aboriginal community in the early stages of the project. • Installation of deep monitoring bores to gas field specification can be a constraint. • Where vibrating wire piezometers are used for groundwater pressure monitoring, robust quality assurance methods are required during the installation of the instruments. Vibrating wire piezometer pressure data should be routinely verified, and ideally, interpreted in conjunction with data from open standpipe bores.
Groundwater impact assessments	

Requirements[1]	The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development is a statutory committee of leading scientists that independently advises government regulators on the impacts that coal seam gas and large coal mining development may have on Australia's water resources. The IESC have developed a number of information guidelines and explanatory notes on:
	• The preparation of development proposals.
	• Uncertainty analysis – Guidance for numerical modelling within a risk management framework.
	• Assessing groundwater dependent ecosystems.
	• Deriving site-specific guideline values for physico-chemic.al parameters and toxicants.
	In addition to the IESC requirements:
	• Detailed conceptual hydrogeological model(s) including description and conceptual illustration of:
	  o Hydrostratigraphy;
	  o Geological structures and influence on groundwater flow;
	  o The water table elevation and groundwater flow directions prior to and during operations and post-development;
	  o Potentiometric surface and groundwater flow directions in confined aquifers prior to and during operations and post-development;
	  o Vertical gradients;
	  o Identified groundwater dependent ecosystems and/or culturally significant sites, including dependence on groundwater;
	  o Other groundwater users;
	  o Surface water-groundwater interaction;
	  o Multiple conceptual diagrams to illustrate the understanding;
	  o Groundwater recharge and discharge zones; and,
	  o Water balance.
	• Analytical or numerical modelling consistent with the expectations of the NSW Aquifer Interference Policy, the IESC and industry best practice (Australian Groundwater Modelling Guidelines (Barnett et al 2012) and IESC guidance notes on uncertainty analysis).

	• Peer review of numerical groundwater modelling. • Consideration of all stages of the development (construction, operation and closure). • Assessment of potential water quality effects/contamination as a result of the development. • Assessment of subsidence effects. • Assessment of potential changes to hydraulic properties of adjacent lithology, potential creating enhanced connection between the development and overlying groundwater sources and/or surface water and other receptors. • Presentation of a range of potential effects on groundwater quantity and associated impacts on receptors, using uncertainty analysis. • Clear documentation of assumptions used to conduct the assessment (for example the numerical modelling) such that any change to the assumptions would change the predicted impacts. • Documentation of avoidance and mitigation measures. • Assessment of impacts against the Aquifer Interference Policy minimal impact considerations and identification of make good provisions, if required.
Things to consider	The proposed developed will need consider the requirements of the Environmental Protection and Biodiversity Conservation Act 1997 (EPBC Act), including assessment of the level of impact on a water resource and other matters of national environmental significance (MNES).
Post-approvals reporting (including WMP)	
Requirements[1]	• Groundwater monitoring and modelling program developed in consultation with the department's Water division and EPA. • Selection of appropriate trigger levels (quality and quantity), reflecting agreed environmental and cultural values and management objectives. For example, where there is the potential for impact on shallow groundwater and connected surface water and/or springs, it is recommended that monitoring is conducted at, and groundwater elevation/pressure triggers assigned to, monitoring bores installed in a hydrostratigraphic unit between the depressurised zone and overlying groundwater source(s). Changes in groundwater elevation/pressure detected in this zone would act as an early warning of potential impact. • Trigger action response plan developed in consultation with the department's Water division. • Produced Water Management Plan where water is brought to the surface in the course of prospecting operations (including flowback water produced following fracture stimulation activities). • Secure sufficient water entitlement in a water access licence(s) prior to the take occurring. • Metering and recording of all groundwater intercepted and moved around the operation. • Reporting of all water take (direct and indirect) in the compliance reporting, including groundwater intercepted. Water take volumes should also be provided to WaterNSW. • Monitoring of subsidence/ground movement, considering and linked to groundwater monitoring and evaluation of predicted impacts.

	• Review and verify model predictions from the EIS stage on a regular basis, as agreed with the department's Water division. • Reporting of monitoring trends with comparison to predictions. • Comprehensive review of monitoring data, considering surface water quality, groundwater quality, groundwater elevations, receptor bioindicators and subsidence monitoring. • Evaluation of the management measures documented in the water management plan, including make good provisions.
Things to consider	Subsidence observed outside of predictions should trigger a subsidence notification report comprising: • Comparison of observations against predictions and performance targets established in the WMP; • Details of additional hydraulic testing undertaken to assess enhanced hydraulic conductivity and storage parameters resulting from the subsidence; • Review of conceptual and groundwater model parameters; • Comprehensive review of groundwater elevation monitoring, surface water quality and groundwater quality; • Re-evaluation of any impacts to overlying shallow aquifers and surface water bodies and groundwater receptors; and • Proposed remedial work (eg pressure cementing of resulting voids).
	Review of the key assumptions and factors that the impact assessment relies on (including the conceptual hydrogeological model). Changes to these key assumptions may change the predicted impacts. For example, the impact assessment may have been based on a predicted maximum subsidence of 0.2 metres or limited extent of fracturing above the target coal seams, limiting vertical connection between groundwater sources and shallower sources, including surface water. During operations, if subsidence monitoring identifies greater than estimated movement and/or the height of fracturing is revised, groundwater compliance reports should review the implications on the water environment and predicted impacts. These changes may require an update the predicted impacts at identified receptors and/or adjustments to water entitlements held by the proponent.

1 – Not an exhaustive list. Proponents should use the information presented in the Guideline, including conducting a risk assessment to identify knowledge gaps and risk areas.

Example conceptual hydrogeological diagrams

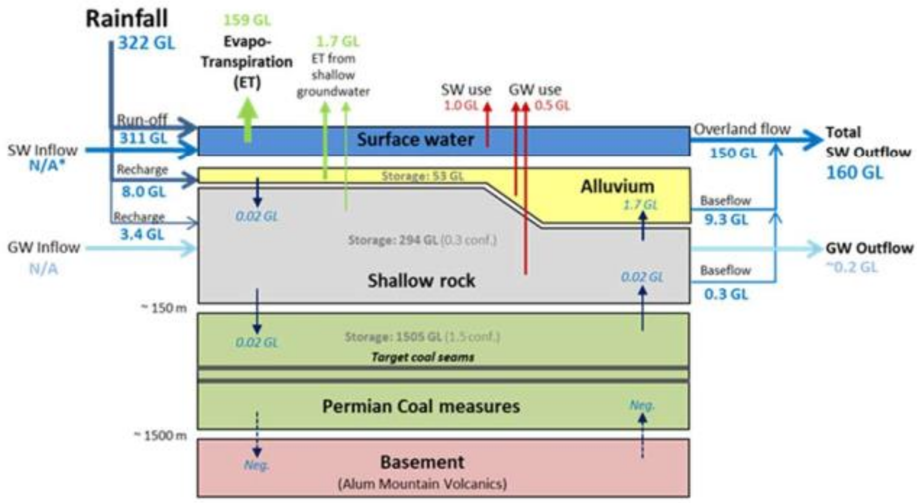


Figure A-1 Annual water balance for the Gloucester Basin baseline condition (Parsons Brinckerhoff 2015)

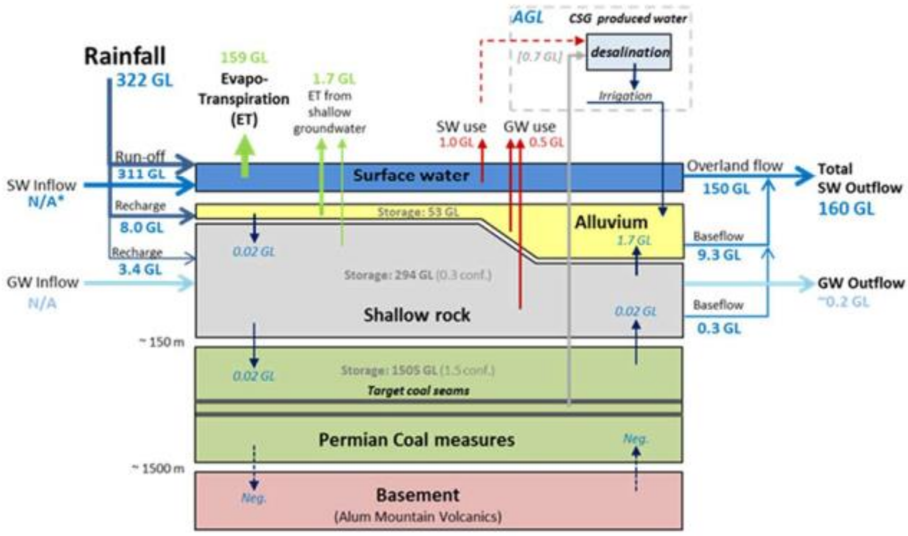


Figure A-2 Annual water balance for the Gloucester Basin – future development (Parsons Brinckerhoff 2015)

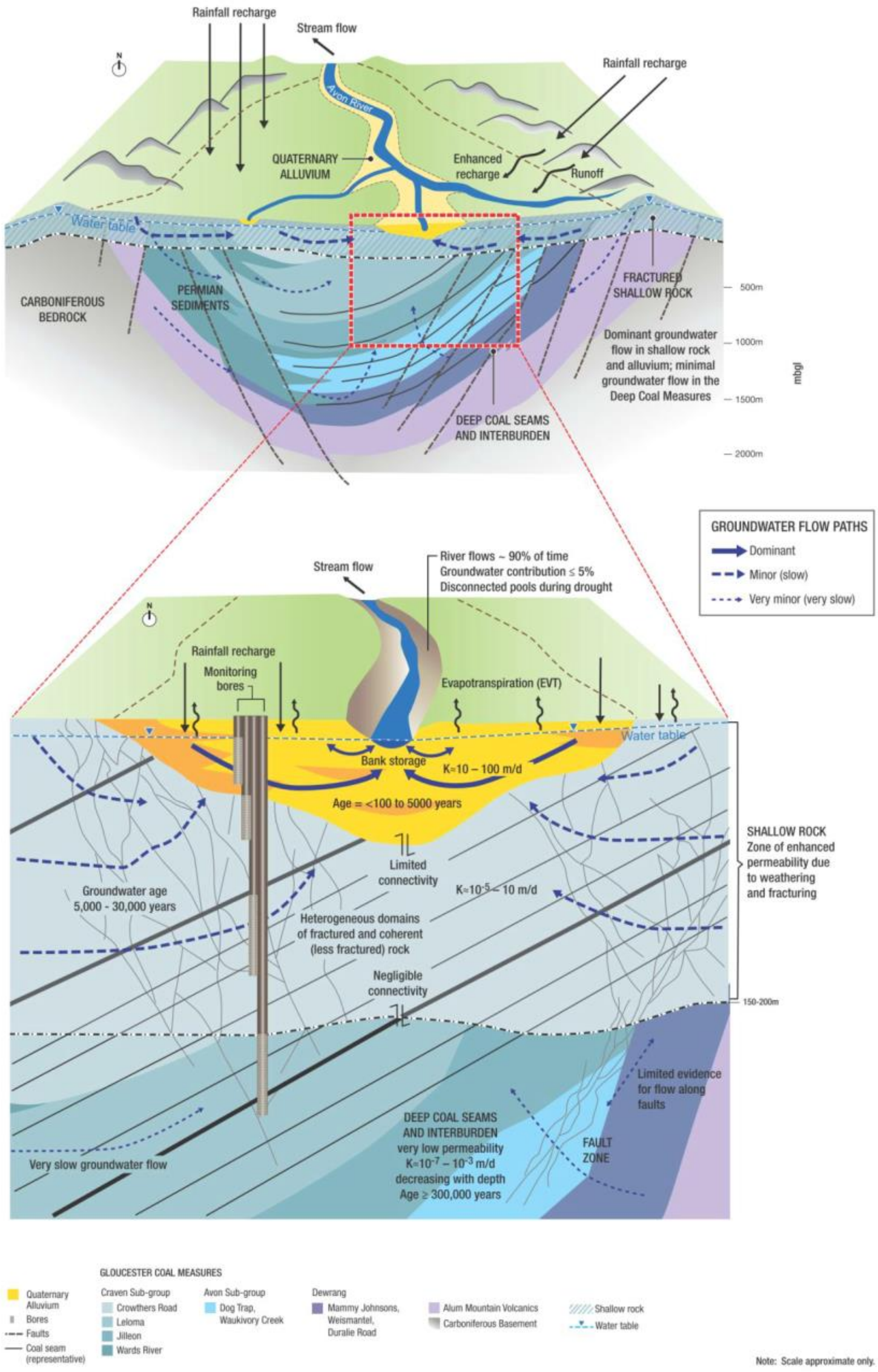


Figure A-3 Conceptual model of flow processes within the Gloucester Basin hydrogeological units (Parsons Brinckerhoff 2015)

Reference list

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A 2012, *The Australian Groundwater Modelling Guidelines*, National Water Commission.

Parsons Brinkerhoff 2015, *Updated Conceptual Hydrogeological Model of the Gloucester Basin*. Prepared for AGL Upstream Investments Pty Ltd, 17 November 2015. Document number 2200556A-WAT-REP-001 RevE.

<table>
<tr><th>Project type</th><th>Dredge mining</th></tr>
<tr><td colspan="2">Groundwater investigations (baseline data)</td></tr>
<tr><td>Requirements</td><td>
Water table elevation data (reported both as depth (in metres) below a reference level such as ground surface and elevation as metres above Australian Height Datum (mAHD)) at a minimum of three monitoring bores (drilled and constructed as per the requirements for the Minimum Construction Requirements for Water Bores in Australia (NUDLC 2020)) located around the proposed dredging operation to assess hydraulic gradients.
Monitoring of groundwater elevations with time, ideally providing two years of monitoring.
Estimates of hydraulic properties (hydraulic conductivity as a minimum) for lithology to be encountered by and adjacent to the project location.
Establish environmental and cultural values.
Mapping of acid sulfate soils or sulfidic clays/sands (usually in tidal rivers and surrounding areas at locations within 3 metres of current sea level).
Groundwater quality sampling from monitoring bores, analysed preferably by National Association of Testing Authorities (NATA) certified laboratory for major ions, dissolved metals, salinity (as electrical conductivity), nutrients and hydrocarbons with sufficient frequency to establish potential seasonal variation (for example, quarterly). Presentation of QA/QC is also required.
</td></tr>
<tr><td>Common constraints/ challenges</td><td></td></tr>
<tr><td colspan="2">Groundwater impact assessments</td></tr>
<tr><td>Requirements[1]</td><td>
Description of the site geology including stratigraphic column.
Conceptual hydrogeological model(s) including description and conceptual illustration of:

The water table elevation and groundwater flow directions prior to and during and following operations;
Mapped groundwater dependent ecosystems and/or culturally significant sites (using information presented in the relevant Water Sharing Plan(s) and BoM GDE Atlas);
Bore census of existing bore users within appropriate distance of the site (as agreed with the department’s Water division); and,
Hydrostratigraphic cross-section orientated through the site.

Use of analytical modelling methods to estimate dewatering requirements for any excavation and the maximum water table drawdown within the predicted area of influence of the water affecting activities.
Assessment of water quality risks associated with acid sulfate soils, material rejected back to the dredge pond.
Consideration of construction, operation and post-development impacts.
Reporting of all assumptions used to predict water table drawdown (including extent) and take (direct and indirect).
Demonstrate a pathway to secure adequate water access licence entitlement for the maximum predicted take for each water source, and/or description of exemptions.
</td></tr>
</table>

	• Assessment of cumulative impacts (for example, other quarries, mines, etc in the area).
Things to consider	• Commercial and recreational vessel use of the waterway affected by the dredging; and, • Local water quality objectives for groundwater receptors.
Post-approvals reporting (including WMP)	
Requirements[1]	• Groundwater monitoring program developed in consultation with the department's Water division and EPA. • Development of an Acid Sulfate Management Plan • Trigger action response plan developed in consultation with the department's Water division and EPA. • Secure sufficient water entitlement in a water access licence(s) prior to the take occurring. • Metering and recording of all groundwater intercepted and moved around the operation. • Reporting of all water take (direct and indirect) in the compliance reporting, including groundwater intercepted and abstracted regardless of whether it is actively pumped. This is required for each water source, preferably reported in a table format. Water take volumes should also be provided to WaterNSW. • List of all licences held for the operation, including water access licences and environmental protection licences, and any exemptions. • Reporting of monitoring trends (water quality and levels) with comparison to predictions.
Things to consider	

<table>
<tr><th>Project type</th><th>Open cut mining</th></tr>
<tr><td colspan="2">Groundwater investigations (Baseline data)</td></tr>
<tr><td>Requirements[1]</td><td>

Detailed groundwater investigations, including (but not limited to):

Groundwater monitoring network installed to target all identified groundwater sources that have the potential to be affected by the development, at a spatial density and coverage that is based on an initial desktop review and conceptual understanding of groundwater system, a risk assessment and gap analysis (vertical and spatial coverage). The monitoring network should include bores installed to the full depth of the proposed excavation.
Estimates of hydraulic properties (hydraulic conductivity and storage properties) for lithology to be encountered by and overlying the development, measured at a number of test locations (spatially and vertically) across the development area, using a range of appropriate testing methods (such as rising and falling head (slug) tests, packer tests, pumping tests, core tests). Presentation of this data, including test locations on a map, is also required.
Collation of data collected and recorded by others, including:

Data collected by other mining or exploration companies at exploration drill holes and/or monitoring bores.
Government monitoring network.
Bore census surveys to collect additional information from existing third-party users, including confirming details of construction, depth, pumping rate, reliance, groundwater quality.

Mapping and consideration of geological structures, including assessment of influence on groundwater flow.
Ground-truthing and ecological assessment of high priority groundwater dependent ecosystems (including springs) mapped in the Water Sharing Plan(s) and BoM GDE Atlas, including assessment of water reliance and resilience, as well as assessment of the source of the water that ecosystem relies on.
Discussion with local Aboriginal community to identify culturally significant sites that rely on water, as well as an assessment of the source of the water.
Baseline groundwater level monitoring in hydrostratigraphic units where the water affecting activities will occur and in units that have the potential to be affected, with monitoring preferred to be over a two-year period. The monitoring frequency should be suitable to detect groundwater level response to climate (rainfall, evapotranspiration) and existing water affecting activities. The monitoring data should be sufficient to allow assessment of vertical and lateral variations.
Baseline groundwater quality sampling from monitoring bores, analysed preferably by National Association of Testing Authorities (NATA) certified laboratory for a comprehensive suite including major ions, dissolved metals, salinity (as electrical conductivity), trace metals, nutrients and hydrocarbons with sufficient frequency to establish potential seasonal variation (for example, quarterly). Presentation of QA/QC is also required.

</td></tr>
</table>

	• Assessment of potential surface water-groundwater interaction, including streamflow monitoring to estimate baseflow (where applicable) and use of standpipe to monitor shallow groundwater levels and assess whether watercourse is a losing or gaining system.
Common constraints / challenges	Interception of groundwater in hard rock lithology is typically associated with fracturing that can be due to geological structures such as faults, shear zones and/or intrusions. As a result, drilling of bores for exploration or water supply purposes can be challenging. Some may not intercept fractures and be low yielding and others may intercept fractures capable of moderate to high yields. Costs associated with drilling programs can be high. Conducting hydraulic testing in both higher permeability and lower permeability areas/ depths allows estimates of a range of hydrogeological properties. In addition, where bores are installed in low permeability lithology/sections, it can take time for groundwater to flow into and stabilise in the newly drilled bore. Sufficient time is required to allow groundwater levels to stabilise.
Groundwater impact assessments	

Requirements[1]	• Detailed conceptual hydrogeological model(s) including description and conceptual illustration of:
	  ○ Hydrostratigraphy;
	  ○ Geological structures and influence on groundwater flow;
	  ○ The water table elevation and groundwater flow directions prior to and during operations and post-development;
	  ○ Potentiometric surface and groundwater flow directions in confined aquifers prior to and during operations and post-development;
	  ○ Identified groundwater dependent ecosystems and/or culturally significant sites, including dependence on groundwater;
	  ○ Other groundwater users;
	  ○ Surface water-groundwater interaction;
	  ○ Multiple conceptual diagrams to illustrate the understanding;
	  ○ Groundwater recharge and discharge zones; and,
	  ○ Water balance, including a description of site water demands, water disposal methods (e.g. Volume and frequency of any water discharges), water supply infrastructure and water storage structures.
	• Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan. Assessment of associated impacts must also be included.
	• Fir for purpose modelling consistent with the expectations of the NSW Aquifer Interference Policy and industry best practice (Australian Groundwater Modelling Guidelines (Barnett et al 2012)).
	• Peer review of numerical groundwater modelling.
	• Details of water proposed to be taken (indirect and direct) from each groundwater source as defined by the relevant Water Sharing Plan and demonstration that the predicted water takes will be appropriately licensed.
	• Consideration of all stages of the development (construction, operation and closure).

	• Final landform assessment, including final void management, predicted post-mining water takes and impacts and rehabilitation measures. • Assessment of cumulative impacts considering other surrounding approved and proposed mining developments. • Assessment of potential water quality effects/risk of leachates from water storages, waste emplacement areas, and tailing storage areas as a result of the development. • Assessment of potential acid rock drainage issues related to presence of potential acid forming (PAF) material and/or acid sulfate soils. • Presentation of a range of potential effects on groundwater quantity and associated impacts on receptors, using uncertainty analysis. • Clear documentation of assumptions used to conduct the assessment (for example the numerical modelling) such that any change to the assumptions would change the predicted impacts. • Proposed surface and groundwater monitoring activities and methodologies. • Proposed management of surplus water. • Documentation of avoidance and mitigation measures. • Assessment of impacts against the Aquifer Interference Policy minimal impact considerations and identification of make good provisions, if required.
Things to consider	Final void pit lake recovery is often very slow and are often predicted to have high salinity. Final voids can be sinks, throughflow pits or sources. The potential impacts and risks associated with these should be considered in the impact assessment. Post-mining impacts to be managed and groundwater inflows (indirect water take) to be licensed long after the development operations.
Post-approvals reporting (including WMP)	
Requirements[1]	• Groundwater monitoring and modelling program developed in consultation with the department's Water division and EPA. • Trigger action response plan developed in consultation with the department's Water division. • Selection of appropriate trigger levels (quality and quantity), reflecting agreed environmental and cultural values and management objectives. • Secure sufficient water entitlement in a water access licence(s) prior to the take occurring. • Metering and recording of all groundwater intercepted and moved around the operation. • Reporting of all water take (direct and indirect) in the compliance reporting, including groundwater intercepted. Water take volumes should also be provided to WaterNSW. • Ensure sufficient water entitlement is in place for ongoing post closure take. • Review and verify model predictions from the EIS stage on a regular basis, as agreed with the department's Water division. • Reporting of monitoring trends with comparison to predictions.

	• Comprehensive review of monitoring data, considering surface water quality, groundwater quality, groundwater elevations, receptor bioindicators and subsidence monitoring. • Evaluation of the management measures documented in the water management plan, including make good provisions.
Things to consider	Review of the key assumptions and factors that the impact assessment relies on (including the conceptual hydrogeological model and water affecting activities). Changes to these key assumptions may change the predicted impacts.

Example conceptual hydrogeological diagrams

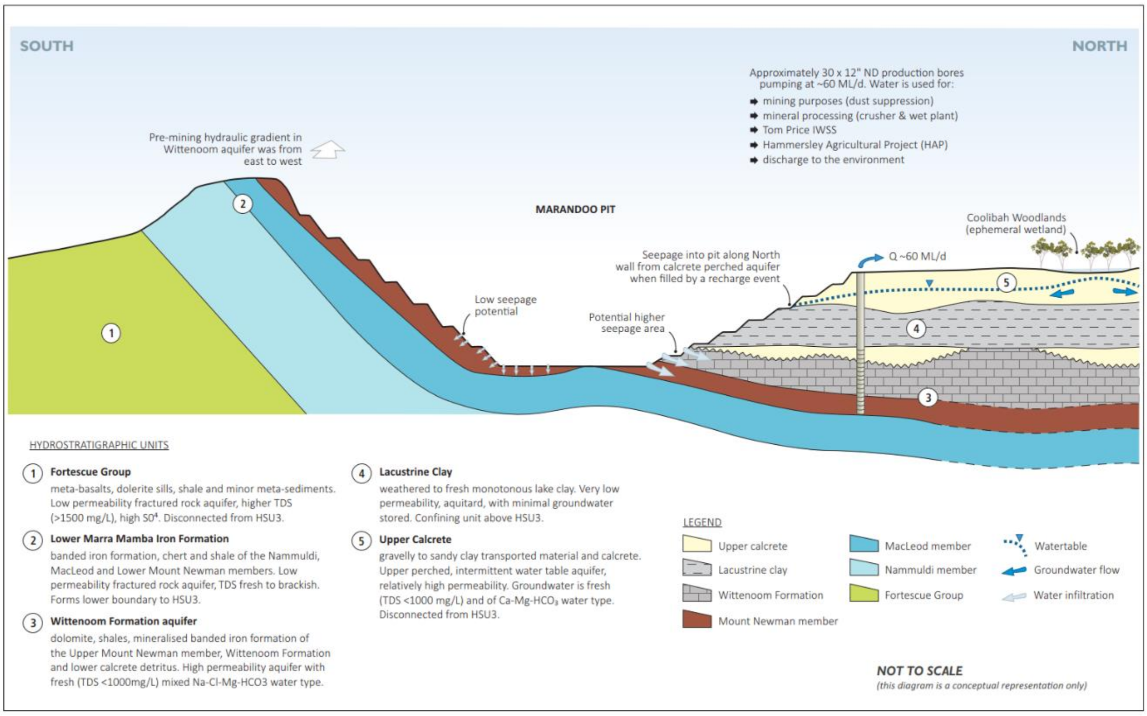


Figure A-4 Example conceptual hydrogeological model (EMM, not published)

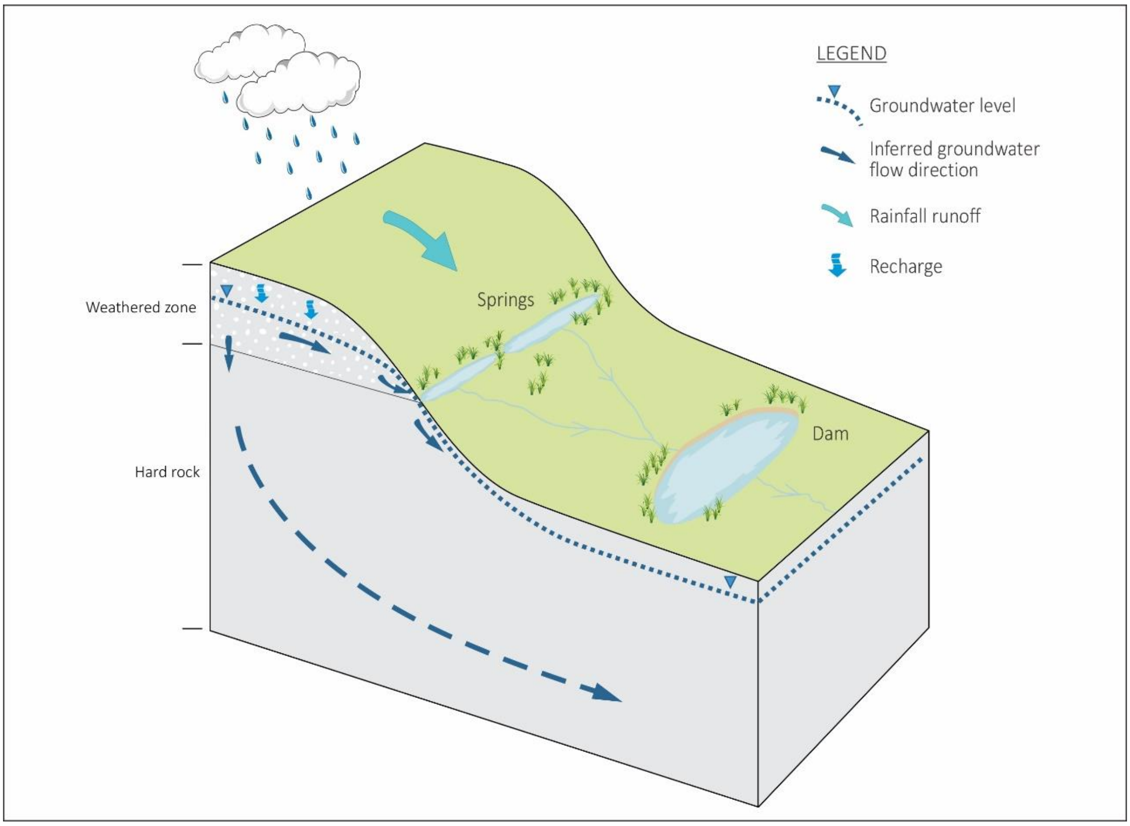


Figure A-5 Example outcrop/break of slope spring conceptual diagram – McPhillamys Gold Project (EMM 2020)

Reference list

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A 2012, *The Australian Groundwater Modelling Guidelines*, National Water Commission.

EMM Consulting Pty Ltd (EMM) 2020, McPhillamys Gold Project, Surface water – groundwater interaction assessment. Prepared for LFB Resources NL, September 2020. Reference J180395 SW-GW RP1.

<table>
<tr><th>Project type</th><th>Quarries</th></tr>
<tr><td colspan="2">Groundwater investigations (baseline data)</td></tr>
<tr><td>Requirements [1]</td><td>Water table elevation data (reported both as depth (in metres) below a reference level such as ground surface and elevation as metres above Australian Height Datum (mAHD)) at a minimum of three monitoring bores (drilled and constructed as per the requirements for the Minimum Construction Requirements for Water Bores in Australia (NUDLC 2020)) located around the proposed quarry to assess hydraulic gradients.
Monitoring of groundwater elevations with time, ideally providing two years of monitoring.
Estimates of hydraulic properties (hydraulic conductivity as a minimum) for lithology to be encountered by and adjacent to quarry.
Use of geological and structural mapping to interpret potential controls on groundwater flow directions (including recharge and discharge).
Groundwater quality sampling from monitoring bores, analysed preferably by National Association of Testing Authorities (NATA) certified laboratory for major ions, dissolved metals, salinity (as electrical conductivity) with sufficient frequency to establish potential seasonal variation (for example, quarterly). Presentation of QA/QC is also required.</td></tr>
<tr><td>Common constraints/ challenges</td><td>Unless the quarry is excavating unconsolidated material such as sand, often the lithology is described as hard rock and has limited hydraulic conductivity, as such, it can take time for groundwater to flow into and stabilise in newly drilled bores. Sufficient time is required to allow groundwater levels to stabilise.
Proponents should follow standard methods for groundwater sampling and analysis, including documentation of QA/QC protocols. This will ensure collection of representative, repeatable and high integrity water samples are collected and submitted for laboratory analysis.
Proponents must use regularly calibrated water quality meters for taking field measurements and must provide evidence of calibration records. A suitably quality person must conduct sampling in accordance with the Geoscience Australia guidelines (Sundaram et al 2009). Sample transport to the laboratory must follow documented chain-of-custody procedures and occur within prescribed holding times.</td></tr>
<tr><td colspan="2">Groundwater impact assessments</td></tr>
<tr><td>Requirements[1]</td><td>Description of the site geology including stratigraphic column.
Conceptual hydrogeological model(s) including description and conceptual illustration of:
The water table elevation and groundwater flow directions prior to and during quarry operations (at greatest depth);
Mapped groundwater dependent ecosystems and/or culturally significant sites (using information presented in the relevant Water Sharing Plan(s) and BoM GDE Atlas);
Bore census of existing bore users within appropriate distance of the quarry site (as agreed with the department’s Water division); and,
Hydrostratigraphic cross-section orientated through the quarry and perpendicular to the strike of any mapped major geological structures.</td></tr>
</table>

	• Maps and diagrams showing the planned quarry design (deepest quarry elevation). • Use of modelling (analytical methods may be sufficient) to estimate maximum water table drawdown within the predicted area of influence of the quarry. • Calculated groundwater intercepted by the quarry, presented on an annual basis, per water source. • Reporting of all assumptions used to predict water table drawdown (including extent) and take (direct and indirect). • Demonstrate a pathway to secure adequate water access licence entitlement for the maximum predicted take for each water source. • Assessment of potential water quality effects related to blasting, sewage, vehicle wash facilities, fuel storage, or leachates from disturbed rocks and soil (for example acid sulfate soils). • Consideration of the construction, operation and closure stages of the development. • Assessment of cumulative impacts (for example, other quarries, mines, etc in the area).
Things to consider	Proponents need to demonstrate if the quarry will intercept the water table. If intercepted, the requirements of the Aquifer Interference Policy apply. If there is insufficient field and publicly available data to confirm the depth to the water table, the proponent is encouraged to use analytical methods (as a minimum) to estimate the water table elevation.
Post-approvals reporting (including WMP)	
Requirements [1]	• Groundwater monitoring program developed in consultation with the department's Water division. • Trigger action response plan developed in consultation with the department's Water division. • Secure sufficient water entitlement in a water access licence(s) prior to the take occurring. • Metering and recording of all groundwater intercepted and moved around the operation. • Description of water balance, including dependence of off-site water sources, water management and wastewater storage. • Reporting of all water take (direct and indirect) in the compliance reporting, including groundwater intercepted and abstracted regardless of whether it is actively pumped or allowed to seep back or evaporate. This is required for each water source, preferably reported in a table format. Water take volumes should be provided to WaterNSW. • List of all licences held for the operation, including water access licences and environmental protection licences, and any exemptions. • Reporting of monitoring trends with comparison to predictions.
Things to consider	• Quarry operators should follow standard methods for groundwater sampling and analysis, including documentation of QA/QC protocols. This will ensure collection of representative, repeatable and high integrity water samples are collected and submitted for laboratory analysis. • Quarry operators must use regularly calibrated water quality meters for taking field measurements and must provide evidence of calibration records. A suitably

	quality person must conduct sampling in accordance with the Geoscience Australia guidelines (Sundaram et al 2009). Sample transport to the laboratory must follow documented chain-of-custody procedures and occur within prescribed holding times. • Ensure access to and maintenance of groundwater monitoring bores. • Ensure sufficient water entitlement is in place for ongoing post closure take.

1 – Not an exhaustive list. Proponents should use the information presented in the Guideline, including conducting a risk assessment to identify knowledge gaps and risk areas.

Example conceptual hydrogeological diagram

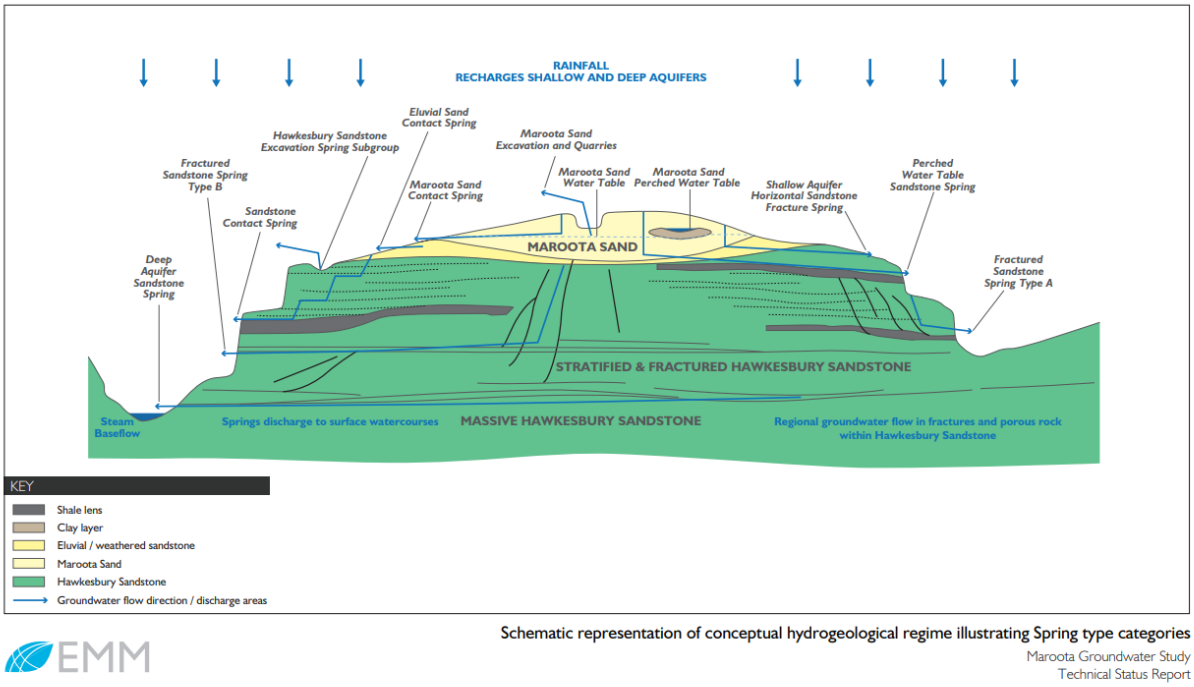


Figure A-6 Conceptual hydrogeological regime illustrating spring type categories (EMM 2018)

Reference list

EMM Consulting Pty Ltd (EMM) 2018, Maroota Extractive Industry Groundwater Study. Prepared for Department of Industry – Water, November 2018. Reference J17329RP1.

National Uniform Drillers Licensing Committee (NUDLC) 2020, *Minimum Construction Requirements for Water Bores in Australia*; Fourth edition, Australian Government National Water Commission.

Sundaram B, Feitz A, Caritat P de, Plazinska A, Brodie R, Coram J and Ransley T 2009, Groundwater Sampling and Analysis – A Field Guide. Geoscience Australia, Record 2009/27 95 pp

SSD\SSI Project type	**Tunnels**
Groundwater investigations (Baseline data)	

Requirements[1]	• Detailed groundwater investigations, including (but not limited to):
	    ○ Groundwater monitoring network installed to target all identified groundwater sources that have the potential to be affected by the development, at a spatial density and coverage that is based on an initial desktop review and conceptual understanding of groundwater system, a risk assessment and gap analysis (vertical and spatial coverage).
	    ○ Estimates of hydraulic properties (hydraulic conductivity and storage properties) for lithology to be encountered by and overlying the development, measured at a number of test locations (spatially and vertically) across the development area. Justification of testing method, presentation of test data, including test locations on a map, and discussion and interpretation of outcomes is also required. Consideration of alternative interpretations is also encouraged.
	    ○ Bore census surveys to collect additional information from existing third-party users, including confirming details of construction, depth, pumping rate, reliance, groundwater quality.
	• Mapping and consideration of geological structures, including assessment of influence on groundwater flow.
	• Geotechnical investigations undertaken for tunnel design comprise extensive geological, structural and hydrogeological information and should be utilised for the GIA, including the development of the conceptual hydrogeological model.
	• Ground-truthing and ecological assessment of high priority groundwater dependent ecosystems (including springs) mapped in the Water Sharing Plan(s) and BoM GDE Atlas, including assessment of water reliance and resilience, as well as assessment of the source of the water that ecosystem relies on.
	• Discussion with local Aboriginal community to identify culturally significant sites that rely on water, as well as an assessment of the source of the water.
	• Baseline groundwater level monitoring (typically two years) in hydrostratigraphic units where the water affecting activities will occur and in units that have the potential to be affected (for example, overlying units). The monitoring frequency should be suitable to detect groundwater level response to climate (rainfall, evapotranspiration) and existing water affecting activities. The monitoring data should be sufficient to allow assessment of vertical gradients and connection between hydrostratigraphic units.
	• Acid sulfate soils and soil salinity surveys.
	• Baseline groundwater quality sampling from monitoring bores (typically over two years), analysed preferably by National Association of Testing Authorities (NATA) certified laboratory for a comprehensive suite including major ions, dissolved metals, salinity (as electrical conductivity), trace metals, nutrients and hydrocarbons with sufficient frequency to establish

	potential seasonal variation (for example, quarterly). Presentation of QA/QC is also required. • Assessment of potential surface water-groundwater interaction, including streamflow monitoring to estimate baseflow (where applicable and typically over two years).
Common constraints/ challenges	• Timing of geotechnical investigations may not align with the groundwater studies, limiting data that can used in the groundwater investigations. • Due to the large area that tunnels can often cover, which may vary from urban land to National Parks, baseline monitoring can be constrained by land access challenges. • Where vibrating wire piezometers are used for groundwater pressure monitoring, robust quality assurance methods are required during the installation of the instruments. Vibrating wire piezometer pressure data should be routinely verified, and ideally, interpreted in conjunction with data from open standpipe bores.
Groundwater impact assessments	

Requirements[1]	• Description of the site geology including stratigraphic column.
	• Conceptual hydrogeological model(s) including description and conceptual illustration of:
	  o Hydrostratigraphy;
	  o Geological structures and influence on groundwater flow;
	  o The water table elevation and groundwater flow directions prior to and during excavation and post-construction;
	  o Potentiometric surface and groundwater flow directions in confined aquifers prior to and during excavation and post-construction;
	  o Vertical gradients;
	  o Identified groundwater dependent ecosystems and/or culturally significant sites (aboriginal and non-aboriginal), including dependence on groundwater;
	  o Other groundwater users;
	  o Surface water-groundwater interaction;
	  o Graphics to illustrate the understanding including cross-sections orientated perpendicular to the tunnel in areas of high concern, such as where tunnels ‘daylight’, intercept geological structures, where there is potential to affect high value GDEs or where productive aquifers will be intercepted by the tunnel;
	  o Groundwater recharge and discharge zones.
	• Fit for purpose modelling (most likely numerical modelling) consistent with the expectations of the NSW Aquifer Interference Policy and industry best practice (Australian Groundwater Modelling Guidelines (Barnett et al 2012)
	• Independent peer review of numerical groundwater modelling.
	• Evaluation of dewatering requirements and predicted seepages, impact of dewatering on groundwater receptors and proposed management of surplus water.
	• Details of water proposed to be taken (indirect and direct) from each groundwater source as defined by the relevant Water Sharing Plan and demonstration that the predicted water takes will be appropriately licensed.

	• Prediction of saline water intrusion for tunnels located near the coast or harbour. • Assessment of potential changes to hydraulic properties of adjacent lithology, potential creating enhanced connection / preferential hydraulic pathways between the development and surface water and other receptors that could result from subsidence or excavation (e.g. blasting). • Assessment of cumulative impacts on the water environment. • Proposed surface and groundwater monitoring activities and methodologies. • Proposed management of surplus water. • Subsidence assessment, particularly above the tunnel alignment, public transport stations and cross-passages. • Documentation of avoidance and mitigation measures. • Assessment of impacts against the Aquifer Interference Policy minimal impact considerations and identification of make good provisions, if required.
Things to consider	Where data gaps continued from the groundwater investigations stage into the groundwater impact assessment stage, the proponent must list all assumptions made to predict changes in groundwater quality and quantity.
Post-approvals reporting (including WMP)	
Requirements[1]	• Groundwater monitoring program developed in consultation with the department's Water division. • Development of an Acid Sulfate Management Plan in consultation with the department's Water division and EPA. • Trigger action response plan developed in consultation with the department's Water division. • Secure sufficient water entitlement in a water access licence(s) prior to the take occurring. • Metering and recording of all groundwater intercepted and moved around the operation. • Reporting of all water take (direct and indirect) in the compliance reporting, including groundwater intercepted. Water take volumes to be provided to WaterNSW. • Monitoring of subsidence / ground movement, considering and linked to groundwater monitoring and evaluation of predicted impacts. • Review and verify model predictions from the EIS stage on a regular basis, as agreed with the department's Water division. • Reporting of monitoring trends with comparison to predictions. • Comprehensive review of monitoring data, considering surface water quality, groundwater quality, groundwater elevations, receptor bioindicators and subsidence monitoring. • Evaluation of the management measures documented in the water management plan, including make good provisions.

Things to consider	Risk of abrupt subsidence during excavation (for example loss of tunnel boring machine confinement pressure). Ensure sufficient water entitlement is in place for ongoing take of groundwater from unlined tunnels.

1 – Not an exhaustive list. Proponents should use the information presented in the Guideline, including conducting a risk assessment to identify knowledge gaps and risk areas.

Example conceptual hydrogeological diagrams

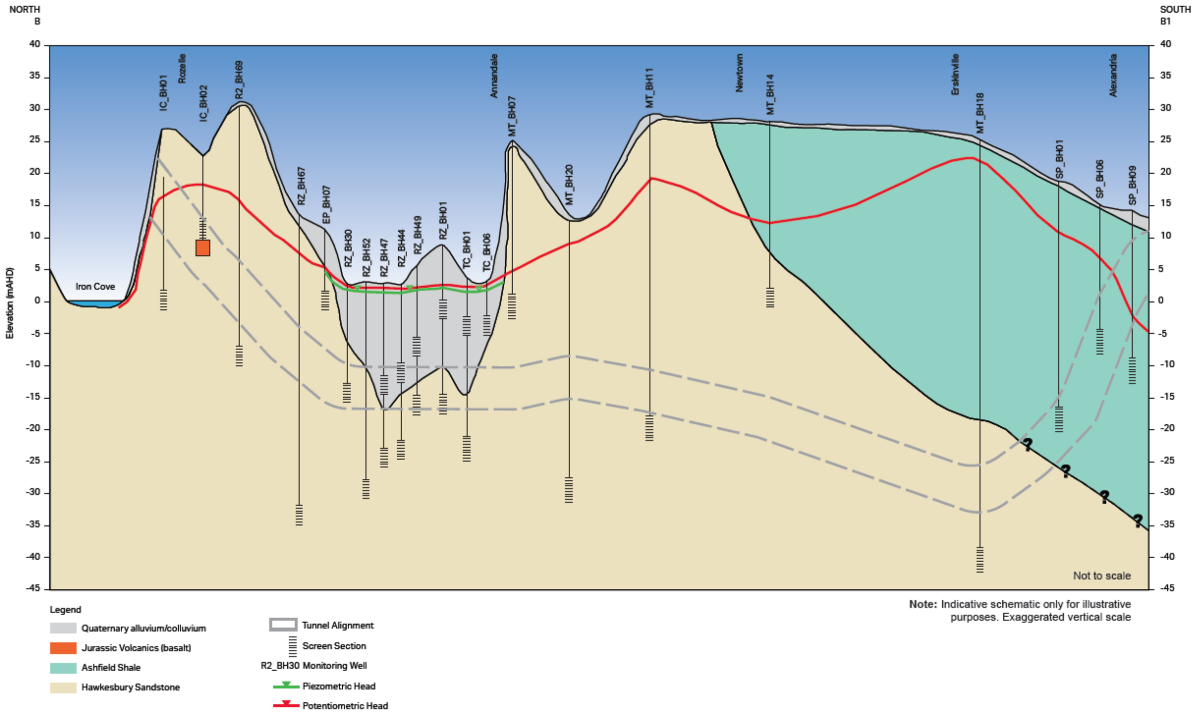


Figure A-7 **Geological cross-section along M4-M5 tunnel alignment (AECOM 2017)**

Reference list

AECOM Australia Pty Ltd (AECOM) 2017, WestConnex – M4-M5 Link Environment Impact Statement. Appendix T. Technical working paper: Groundwater.

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A 2012, *The Australian Groundwater Modelling Guidelines*, National Water Commission.

Project type	Underground coal mines & large coal mines
Groundwater investigations (baseline data)	

Requirements[1]	• Detailed groundwater investigations, including (but not limited to):
	  ○ Groundwater monitoring network installed to target all identified groundwater sources that have the potential to be affected by the development, at a spatial density and coverage that is based on an initial desktop review and conceptual understanding of groundwater system, a risk assessment and gap analysis (vertical and spatial coverage).
	  ○ Estimates of hydraulic properties (hydraulic conductivity and storage properties) for lithology to be encountered by and overlying the development, measured at a number of test locations (spatially and vertically) across the development area, using a range of appropriate testing methods (such as rising and falling head (slug) tests, packer tests, pumping tests, core tests). Presentation of this data, including test locations on a map, is also required.
	  ○ Collation of data collected and recorded by others, including:
	    ▪ Data collected by other mining or exploration companies at exploration drill holes and/or monitoring bores.
	    ▪ Government monitoring network.
	    ▪ Bore census surveys to collect additional information from existing third-party users, including confirming details of construction, depth, pumping rate, reliance, groundwater quality.
	• Mapping and consideration of geological structures, including assessment of influence on groundwater flow.
	• Ground-truthing and ecological assessment of high priority groundwater dependent ecosystems (including springs) mapped in the Water Sharing Plan(s) and BoM GDE Atlas, including assessment of water reliance and resilience, as well as assessment of the source of the water that ecosystem relies on.
	• Discussion with local Aboriginal community to identify culturally significant sites that rely on water, as well as an assessment of the source of the water.
	• Baseline groundwater level/pressure monitoring in hydrostratigraphic units where the water affecting activities will occur and in units that have the potential to be affected (for example, overlying units), with monitoring over at least a two-year period. The monitoring frequency should be suitable to detect groundwater level response to climate (rainfall, evapotranspiration) and existing water affecting activities. The monitoring data should be sufficient to allow assessment of vertical gradients and connection between hydrostratigraphic units.
	• Baseline groundwater quality sampling from monitoring bores, analysed preferably by National Association of Testing Authorities (NATA) certified laboratory for a comprehensive suite including major ions, dissolved metals, salinity (as electrical conductivity), trace metals, dissolved gases, nutrients and hydrocarbons with sufficient frequency to establish potential seasonal variation (for example, quarterly). Presentation of QA/QC is also required.
	• Assessment of potential surface water-groundwater interaction, including streamflow monitoring to estimate baseflow (where applicable) and use of

	standpipe(s) to monitor shallow groundwater levels and assess whether watercourse is a losing or gaining system.
Common constraints/ challenges	• Proponents should follow standard methods for groundwater sampling and analysis, including documentation of QA/QC protocols. This will ensure collection of representative, repeatable and high integrity water samples are collected and submitted for laboratory analysis. • Proponents must use regularly calibrated water quality meters for taking field measurements and must provide evidence of calibration records. A suitably quality person must conduct sampling in accordance with the Geoscience Australia guidelines (Sundaram et al 2009). Sample transport to the laboratory must follow documented chain-of-custody procedures and occur within prescribed holding times. • Where vibrating wire piezometers are used for groundwater pressure monitoring, robust quality assurance methods are required during the installation of the instruments. Vibrating wire piezometer pressure data should be routinely verified, and ideally, interpreted in conjunction with data from open standpipe bores.
Groundwater impact assessments	

Requirements[1]	The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development is a statutory committee of leading scientists that independently advises government regulators on the impacts that coal seam gas and large coal mining development may have on Australia's water resources. The IESC have developed a number of information guidelines and explanatory notes on:
	• The preparation of development proposals
	• Uncertainty analysis – Guidance for numerical modelling within a risk management framework
	• Assessing groundwater dependent ecosystems
	• Deriving site-specific guideline values for physico-chemical parameters and toxicants
	In addition to the IESC requirements:
	• Detailed conceptual hydrogeological model(s) including description and conceptual illustration of:
	    ○ Hydrostratigraphy;
	    ○ Geological structures and influence on groundwater flow;
	    ○ The water table elevation and groundwater flow directions prior to and during operations and post-development;
	    ○ Potentiometric surface and groundwater flow directions in confined aquifers prior to and during operations and post-development;
	    ○ Vertical gradients;
	    ○ Identified groundwater dependent ecosystems and/or culturally significant sites, including dependence on groundwater;
	    ○ Other groundwater users;
	    ○ Surface water-groundwater interaction;
	    ○ Multiple conceptual diagrams to illustrate the understanding;
	    ○ Groundwater recharge and discharge zones; and,

	◦ Water balance, including a description of site water demands, water disposal methods (e.g. volume and frequency of any water discharges), water supply infrastructure and water storage structures. • Demonstration that water for the construction and operation stages of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan. • Fit for purpose modelling (in most cases numerical modelling) consistent with the expectations of the NSW Aquifer Interference Policy, the IESC and industry best practice (Australian Groundwater Modelling Guidelines (Barnett et al 2012) and IESC guidance notes on uncertainty analysis). • Independent peer review of numerical groundwater modelling. • Details of water proposed to be taken (direct and indirect) from each groundwater source as defined by the relevant Water Sharing Plan and demonstration that the predicted water takes will be appropriately licensed. • Consideration of all stages of the development (construction, operation and closure). • Final landform assessment, including final void management, predicted post-mining water takes and impacts and rehabilitation measures. • Assessment of cumulative impacts considering other surrounding approved and proposed mining developments. • Assessment of potential water quality effects/risk of leachates from emplacement/tailing storage areas as a result of the development. • Assessment of potential acid rock drainage issues related to presence of potential acid forming (PAF) material and/or acid sulfate soils. • Assessment of subsidence effects, particularly above longwalls and pillars (for underground mines). • Assessment of potential changes to hydraulic properties of adjacent lithology, potential creating enhanced connection between the development and surface water and other receptors. Including a risk assessment of induced fracturing redirecting saline waters to streams, river and other shallow water sources and receptors. • Presentation of a range of potential effects on groundwater quantity and associated effects on receptors, using uncertainty analysis. • Clear documentation of assumptions used to conduct the assessment (for example the numerical modelling) such that any change to the assumptions would change the predicted impacts. • Proposed surface and groundwater monitoring activities and methodologies. • Proposed management of surplus water. • Documentation of avoidance and mitigation measures. • Assessment of impacts against the Aquifer Interference Policy minimal impact considerations and identification of make good provisions, if required.
Things to consider	• The proposed developed will need consider the requirements of the Environmental Protection and Biodiversity Conservation Act 1997 (EPBC Act), including assessment of the level of impact on a water resource and other matters of national environmental significance (MNES). • Subsidence assessment and management plan must be considered, including assessment of the likely conventional and non-conventional subsidence

	effects and impacts of the development, and the potential consequences of these effects on water sources. • Design of underground mining should avoid placing longwall and pillars directly under groundwater receptors.
Post-approvals reporting (including WMP)	
Requirements[1]	• Groundwater monitoring and modelling program developed in consultation with the department's Water division and EPA. • Selection of appropriate trigger levels (quality and quantity), reflecting agreed environmental and cultural values and management objectives. For example, where there is the potential for impact on shallow groundwater and connected surface water and/or springs, it is recommended that monitoring is conducted at, and groundwater elevation/pressure triggers assigned to, monitoring bores installed in a hydrostratigraphic unit between the depressurised zone and overlying groundwater source(s). Changes in groundwater elevation/pressure detected in this zone would act as an early warning of potential impact. • Trigger action response plan developed in consultation with the department's Water division. • Secure sufficient water entitlement in a water access licence(s) prior to the take occurring. • Metering and recording of all groundwater intercepted and moved around the operation. • Reporting of all water take (direct and indirect) in the compliance reporting, including groundwater intercepted. Water take volumes to be provided to WaterNSW. • Monitoring of subsidence/ground movement, considering and linked to groundwater monitoring and evaluation of predicted impacts. • Specialist monitoring of the bulkhead integrity and pillar stability as part of the water management plan and subsidence management plan for the project to identify whether future irregular and unpredictable subsidence (resulting from periodic support failure) will likely have an impact on groundwater availability for licensed users, receptors and the potential for aquifer damage. • Review and verify model predictions from the EIS stage on a regular basis, as agreed with the department's Water division. • Reporting of monitoring trends with comparison to predictions. • Comprehensive review of monitoring data, considering surface water quality, groundwater quality, groundwater elevations, receptor bioindicators and subsidence monitoring. • Evaluation of the management measures documented in the water management plan, including make good provisions.
Things to consider	Subsidence observed outside of predictions should trigger a subsidence notification report comprising: • Comparison of observations against predictions and performance targets established in the WMP; • Details of additional hydraulic testing undertaken to assess enhanced hydraulic conductivity and storage parameters resulting from the subsidence; • Review of conceptual and groundwater model parameters;

	• Comprehensive review of groundwater elevation monitoring, surface water quality and groundwater quality; • Re-evaluation of any impacts to overlying shallow aquifers and surface water bodies and groundwater receptors; and, • Proposed remedial work (e.g. pressure cementing of resulting voids).
	Review of the key assumptions and factors that the impact assessment relies on (including the conceptual hydrogeological model). Changes to these key assumptions may change the predicted impacts. For example, the impact assessment may have been based on a predicted maximum subsidence of 0.2 metres or limited extent of fracturing above the target coal seams, limiting vertical connection between groundwater sources and shallower sources, including surface water. During operations, if subsidence monitoring identifies greater than estimated movement and/or the height of fracturing is revised, groundwater compliance reports should review the implications on the water environment and predicted impacts. These changes may require an update the predicted impacts at identified receptors and/or adjustments to water entitlements held by the proponent.
	Ensure sufficient water entitlement is in place for ongoing take post-closure

1 – Not an exhaustive list. Proponents should use the information presented in the Guideline, including conducting a risk assessment to identify knowledge gaps and risk areas.

Example conceptual hydrogeological diagrams

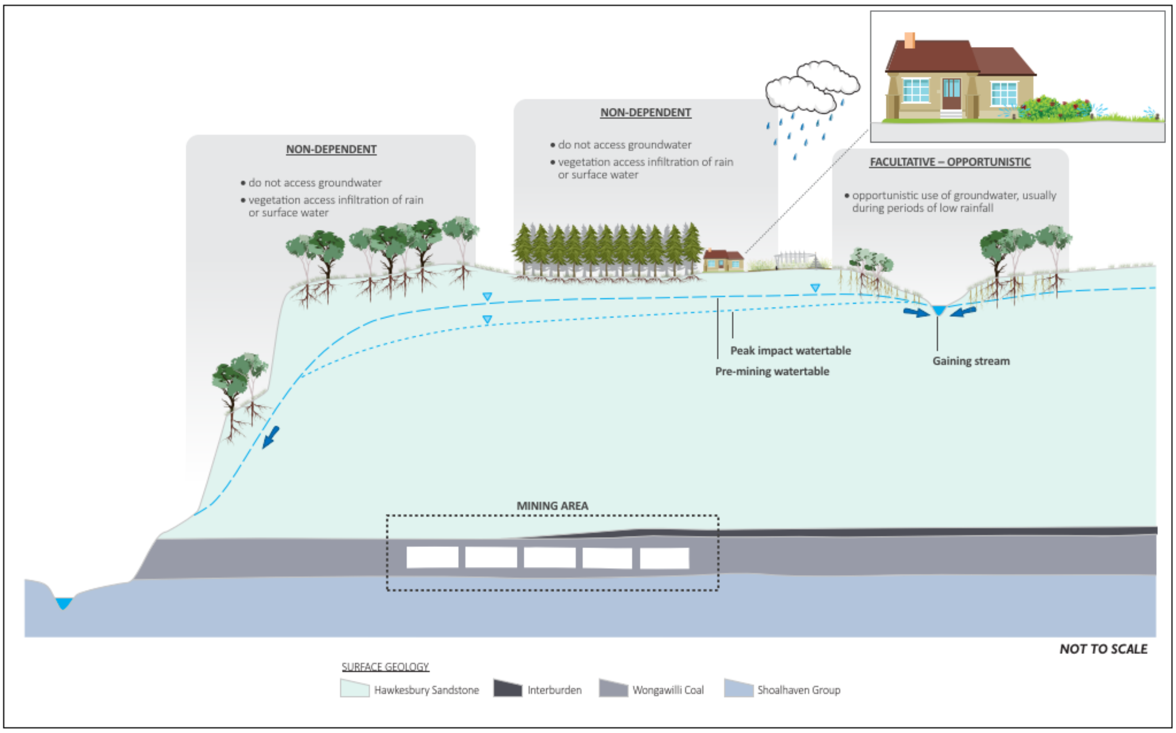


Figure A-8 **Conceptual diagram for surface vegetation interaction with groundwater – Hawkesbury Sandstone outcrop areas (EMM 2020)**

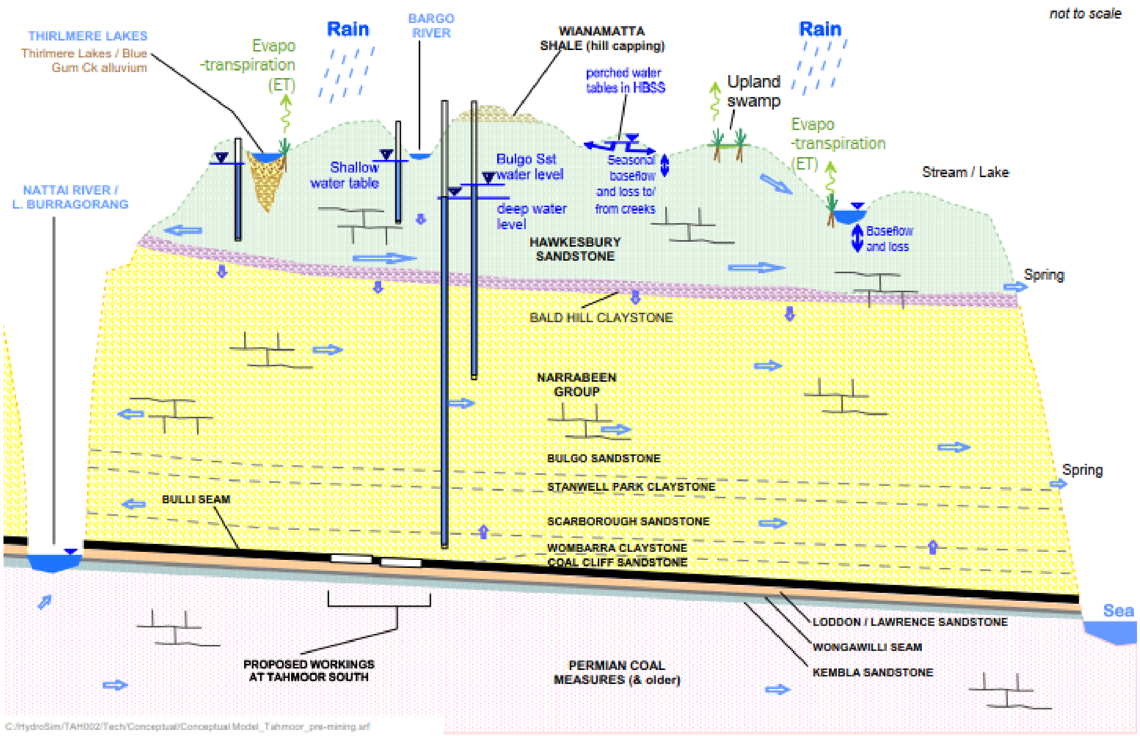


Figure A-9 **Hydrogeological conceptual model: pre-mining at Tahmoor South (HydroSimulations 2018)**

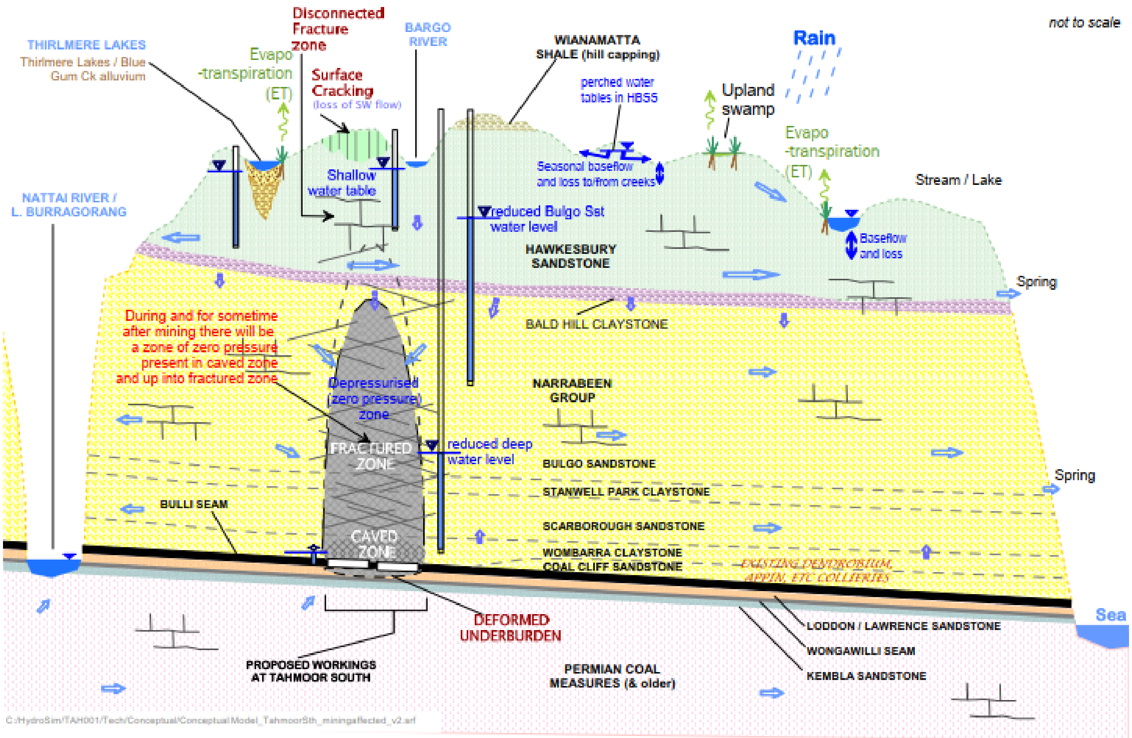


Figure A-10 Hydrogeological conceptual model: post-mining at Tahmoor South (HydroSimulations 2018)

Reference list

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A 2012, *The Australian Groundwater Modelling Guidelines*, National Water Commission.

EMM Consulting Pty Ltd (EMM) 2020, Hume Coal and Berrima Rail Project, Groundwater dependence assessment for cultural heritage landscapes and gardens prepared in response to recommendations R16 and R19 in the Independent Planning Commission Assessment report dates 27 May 2019. Prepared for Hume Coal Pty Ltd, April 2020. Reference J12055.

HydroSimulations 2018, Tahmoor South Project EIS: Groundwater Assessment. Prepared for Tahmoor Coal Pty Ltd, December 2018. Reference TAH0004, HS2018/52.

Project type	Underground mining in hard rock
Groundwater investigations (baseline data)	

Requirements[1]	• Detailed groundwater investigations, including (but not limited to):
	  ○ Groundwater monitoring network installed to target all identified groundwater sources that have the potential to be affected by the development, at a spatial density and coverage that is based on an initial desktop review and conceptual understanding of groundwater system, a risk assessment and gap analysis (vertical and spatial coverage). The monitoring network should include bores installed to the full depth of the proposed excavation.
	  ○ Estimates of hydraulic properties (hydraulic conductivity and storage properties) for lithology to be encountered by and overlying the development, measured at a number of test locations (spatially and vertically) across the development area, using a range of appropriate testing methods (such as rising and falling head (slug) tests, packer tests, pumping tests, core tests). Presentation of this data, including test locations on a map, is also required.
	  ○ Collation of data collected and recorded by others, including:
	    ▪ Data collected by other exploration companies at monitoring bores or CSG exploration wells.
	    ▪ Government monitoring network.
	    ▪ Bore census surveys to collect additional information from existing third-party users, including confirming details of construction, depth, pumping rate, reliance, groundwater quality.
	• Mapping and consideration of geological structures, including assessment of influence on groundwater flow.
	• Geotechnical investigations targeting geological structures (e.g. faults and fracturing systems) or lithologies (e.g. karst) and their hydraulic connectivity with overlying aquifers, surface water or groundwater receptors.
	• Ground-truthing and ecological assessment of high priority groundwater dependent ecosystems (including springs) mapped in the Water Sharing Plan(s) and BoM GDE Atlas, including assessment of water reliance and resilience, as well as assessment of the source of the water that ecosystem relies on.
	• Discussion with local Aboriginal community to identify culturally significant sites that rely on water, as well as an assessment of the source of the water.
	• Baseline groundwater level/pressure monitoring in hydrostratigraphic units where the water affecting activities will occur and in units that have the potential to be affected (for example, overlying units), with monitoring over at least a two-year period. The monitoring frequency should be suitable to detect groundwater level response to climate (rainfall, evapotranspiration) and existing water affecting activities. The monitoring data should be sufficient to allow assessment of vertical gradients and connection between hydrostratigraphic units.
	• Baseline groundwater quality sampling from monitoring bores, analysed preferably by National Association of Testing Authorities (NATA) certified laboratory for a comprehensive suite including major ions, dissolved metals, salinity (as electrical conductivity), trace metals, nutrients and hydrocarbons

	with sufficient frequency to establish potential seasonal variation (for example, quarterly). Presentation of QA/QC is also required. • Assessment of potential surface water-groundwater interaction, including streamflow monitoring to estimate baseflow (where applicable) and use of standpipe to monitor shallow groundwater levels and assess whether watercourse is a losing or gaining system.
Challenges	Interception of groundwater in hard rock lithology is typically associated with fracturing that can be due to geological structures such as faults, shear zones and/or intrusions. As a result, drilling of bores for exploration or water supply purposes can be challenging. Some may not intercept fractures and be low yielding and others may intercept fractures capable of moderate to high yields. Costs associated with drilling programs can be high. Conducting hydraulic testing in both higher permeability and lower permeability areas/depths allows estimates of a range of hydrogeological properties. In addition, where bores are installed in low permeability lithology/sections, it can take time for groundwater to flow into and stabilise in the newly drilled bore. Sufficient time is required to allow groundwater levels to stabilise.
Groundwater impact assessments	

Requirements[1]	• Detailed conceptual hydrogeological model(s) including description and conceptual illustration of:
	  ○ Hydrostratigraphy;
	  ○ Geological structures and influence on groundwater flow;
	  ○ The water table elevation and groundwater flow directions prior to and during operations and post-development;
	  ○ Potentiometric surface and groundwater flow directions in confined aquifers prior to and during operations and post-development;
	  ○ Vertical gradients;
	  ○ Identified groundwater dependent ecosystems and/or culturally significant sites, including dependence on groundwater;
	  ○ Other groundwater users;
	  ○ Surface water-groundwater interaction;
	  ○ Multiple conceptual diagrams to illustrate the understanding;
	  ○ Groundwater recharge and discharge zones; and,
	  ○ Water balance, including a description of site water demands, water disposal methods (eg volume and frequency of any water discharges), water supply infrastructure and water storage structures.
	• Fit for purpose modelling (in most cases numerical modelling) consistent with the expectations of the NSW Aquifer Interference Policy and industry best practice (Australian Groundwater Modelling Guidelines (Barnett et al 2012)).
	• Independent peer review of numerical groundwater modelling.
	• Details of water proposed to be taken (indirect and direct) from each groundwater source as defined by the relevant water sharing plan and demonstration that the predicted water takes will be appropriately licensed.
	• Demonstration that water for the construction and operation stages of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan.

	• Consideration of all stages of the development (construction, operation and closure). • Assessment of dewatering requirements, impact of dewatering on groundwater receptors and proposed management of surplus water. • Final landform assessment, including final void management, predicted post-mining water takes and impacts and rehabilitation measures. • Assessment of cumulative impacts considering other surrounding approved and proposed mining developments. • Assessment of potential water quality effects/contamination as a result of the development, for examples leachates from emplacement/tailing storage areas as a result of the development. • Assessment of potential subsidence effects. • Assessment of potential changes to hydraulic properties of adjacent lithology, potential creating enhanced connection/preferential hydraulic pathways between the development and surface water and other receptors that could result from subsidence or mining activities (e.g. blasting). • Presentation of a range of potential effects on groundwater quantity and associate effects on receptors, using uncertainty analysis. • Clear documentation of assumptions used to conduct the assessment (for example the numerical modelling) such that any change to the assumptions would change the predicted impacts. • Proposed surface and groundwater monitoring activities and methodologies. • Documentation of avoidance and mitigation measures. • Assessment of impacts against the Aquifer Interference Policy minimal impact considerations and identification of make good provisions, if required.
Things to consider	• Underground mining in hard rock often requires blasting which can result in connective cracking. Thorough geological investigations and impact assessment are recommended to manage this potential risk. • Subsidence assessment and management plan must be considered, including assessment of the likely conventional and non-conventional subsidence effects and impacts of the development, and the potential consequences of these effects on water sources.
Post-approvals reporting (including WMP)	
Requirements[1]	• Groundwater monitoring and modelling program developed in consultation with the department's Water division and EPA. • Trigger action response plan developed in consultation with the department's Water division. • Selection of appropriate trigger levels (quality and quantity), reflecting agreed environmental and cultural values and management objectives. • Secure sufficient water entitlement in a water access licence(s) prior to the take occurring. • Metering and recording of all groundwater intercepted and moved around the operation. • Reporting of all water take (direct and indirect) in the compliance reporting, including groundwater intercepted. Water take volumes to be provided to WaterNSW.

	• Monitoring of subsidence/ground movement, considering and linked to groundwater monitoring and evaluation of predicted impacts. • Review and verify model predictions from the EIS stage on a regular basis, as agreed with the department's Water division. • Reporting of monitoring trends with comparison to predictions. • Comprehensive review of monitoring data, considering surface water quality, groundwater quality, groundwater elevations, receptor bioindicators and subsidence monitoring. • Evaluation of the management measures documented in the water management plan, including make good provisions.
Things to consider	Review of the key assumptions and factors that the impact assessment relies on (including the conceptual hydrogeological model and water affecting activities). Changes to these key assumptions may change the predicted impacts. Ensure sufficient water entitlement is in place for ongoing take post-closure.

1 – Not an exhaustive list. Proponents should use the information presented in the Guideline, including conducting a risk assessment to identify knowledge gaps and risk areas.

Example conceptual hydrogeological diagrams

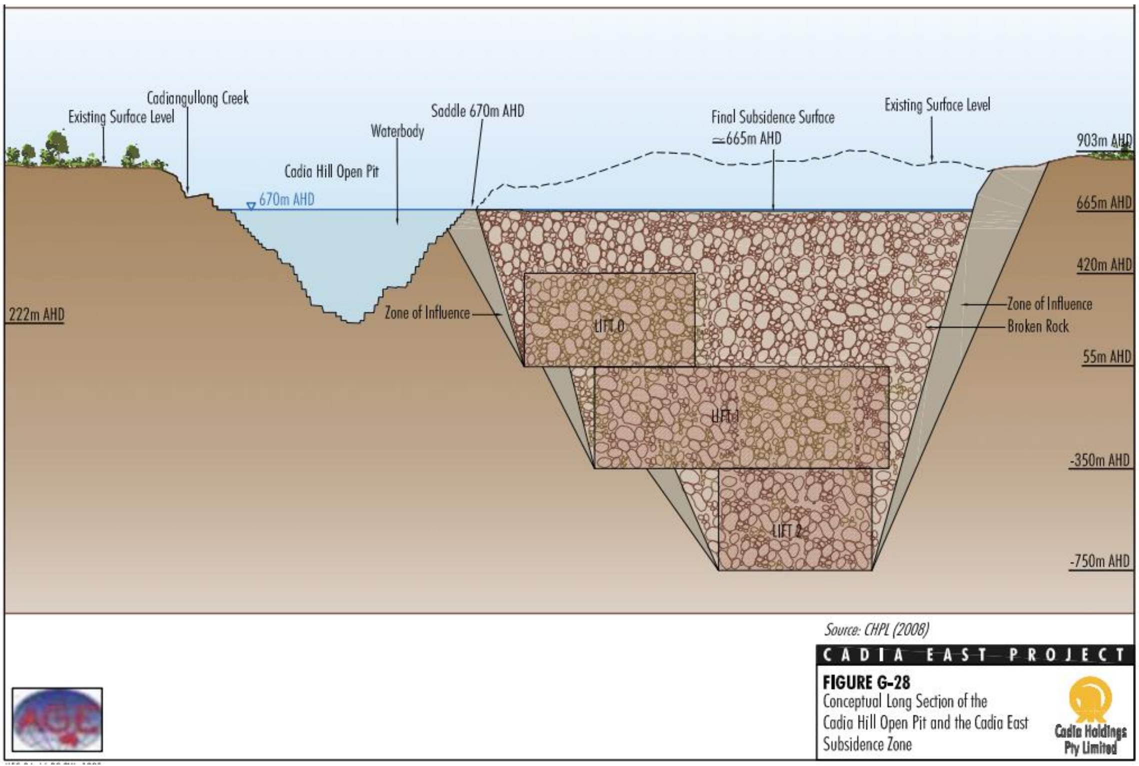


Figure A-11 **Conceptual long section of the Cadia Hill Open Pit and the Cadia East Subsidence Zone (AGE 2009)**

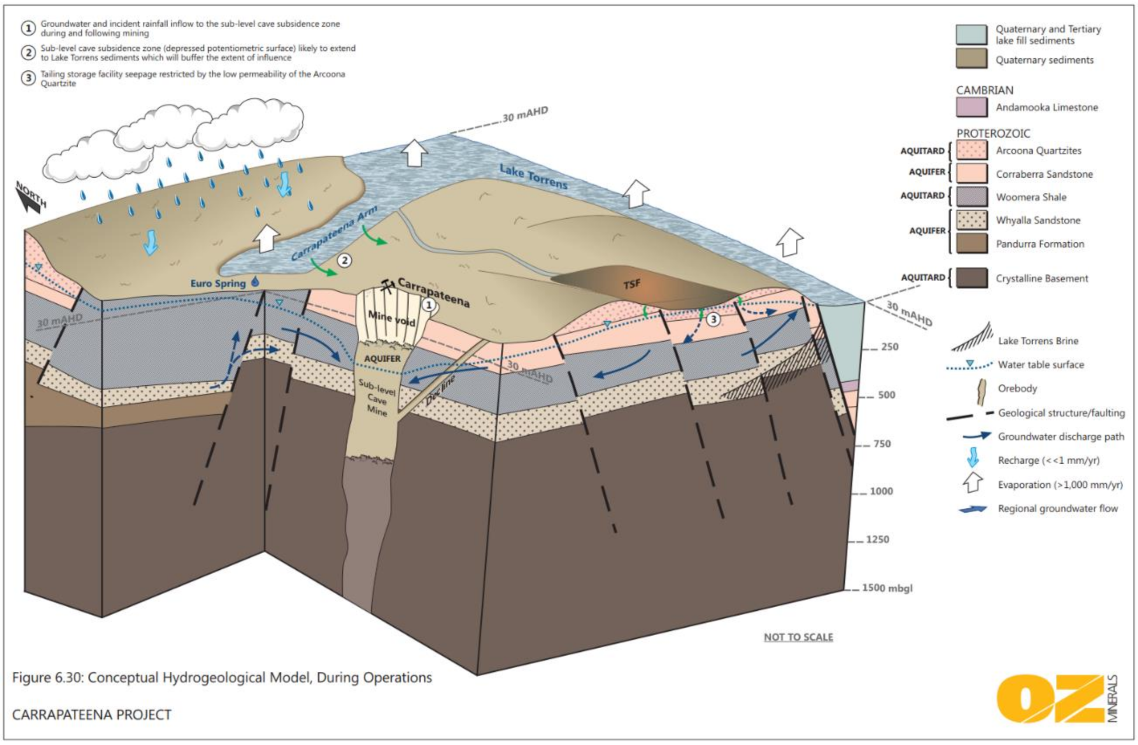


Figure A-12 **Conceptual hydrogeological model (during operations) for the Carrapateena Project (OZL 2017)**

Reference list

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) 2009, Cadia East Project Environment Impact Statement. Appendix G. Groundwater Assessment Report. Prepared by AGE for Cadia Holdings Pty Ltd.

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A 2012, *The Australian Groundwater Modelling Guidelines*, National Water Commission.

OZ Minerals Ltd 2017, Carrapateena Project Mining Lease Proposal and Miscellaneous Purposes Licence Management Plans, May 2017.

Project type	Land development (for projects such as buildings, waste management sites, water treatment facilities)
Groundwater investigations (Baseline data)	

Requirements	• Detailed groundwater investigations, including (but not limited to):
	  ○ Groundwater monitoring network installed to target all identified groundwater sources that have the potential to be affected by the development, at a spatial density and coverage that is based on an initial desktop review and conceptual understanding of groundwater system, a risk assessment and gap analysis (vertical and spatial coverage). The monitoring network should include bores installed to the full depth of the proposed excavation.
	  ○ Estimates of hydraulic properties (hydraulic conductivity and storage properties) for lithology to be encountered by and overlying the development, measured at a number of test locations (spatially and vertically) across the development area, using a range of appropriate testing methods (such as rising and falling head (slug) tests, packer tests, pumping tests, core tests). Presentation of this data, including test locations on a map, is also required.
	• Ground-truthing and ecological assessment of high priority groundwater dependent ecosystems (including springs) mapped in the Water Sharing Plan(s) and BoM GDE Atlas, including assessment of water reliance and resilience, as well as assessment of the source of the water that ecosystem relies on.
	• Baseline groundwater level monitoring in hydrostratigraphic units where the water affecting activities will occur and in units that have the potential to be affected, with monitoring preferred to be over a two-year period. The monitoring frequency should be suitable to detect groundwater level response to climate (rainfall, evapotranspiration) and existing water affecting activities. The monitoring data should be sufficient to allow assessment of vertical and lateral variations.
	• Baseline groundwater quality sampling from monitoring bores, analysed preferably by National Association of Testing Authorities (NATA) certified laboratory for a comprehensive suite including major ions, dissolved metals, salinity (as electrical conductivity), trace metals, nutrients and hydrocarbons with sufficient frequency to establish potential seasonal variation (for example, quarterly). Presentation of QA/QC is also required.
	• Assessment of potential surface water-groundwater interaction, including streamflow monitoring to estimate baseflow (where applicable) and use of standpipe to monitor shallow groundwater levels and assess whether watercourse is a losing or gaining system.

Common constraints / challenges	Conducting hydraulic testing in both higher permeability and lower permeability areas/ depths allows estimates of a range of hydrogeological properties. In addition, where bores are installed in low permeability lithology/sections, it can take time for groundwater to flow into and stabilise in the newly drilled bore. Sufficient time is required to allow groundwater levels to stabilise.
Groundwater impact assessments	

Requirements	• Detailed conceptual hydrogeological model(s) including description and conceptual illustration of:
	  ○ Hydrostratigraphy;
	  ○ The water table elevation and groundwater flow directions prior to and during operations and post-development;
	  ○ Potentiometric surface and groundwater flow directions in confined aquifers prior to and during operations and post-development;
	  ○ Where applicable, identified groundwater dependent ecosystems and/or culturally significant sites, including dependence on groundwater;
	  ○ Other groundwater users;
	  ○ Surface water-groundwater interaction;
	  ○ Multiple conceptual diagrams to illustrate the understanding;
	  ○ Groundwater recharge and discharge zones; and,
	  ○ Water balance, including a description of site water disposal methods (e.g. volume and frequency of any water discharges).
	• Demonstration that water taken during the construction of the development can be appropriately authorised in accordance with the operating rules of any relevant Water Sharing Plan. Assessment of associated impacts must also be included.
	• Demonstration that water taken during the occupation of the development if watertightness cannot be achieved can be appropriately authorised in accordance with the operating rules of any relevant Water Sharing Plan. Assessment of associated impacts must also be included.
	• Simple or complex modelling consistent with the expectations of the NSW Aquifer Interference Policy and industry best practice (Australian Groundwater Modelling Guidelines (Barnett et al 2012)).
	• Independent peer review of to groundwater model for projects seeking approval under Part 4, Division 4.1 of the EP&A Act.
	• Details of water proposed to be taken (indirect and direct) from each groundwater source as defined by the relevant Water Sharing Plan and demonstration that the predicted water takes will be appropriately licensed.
	• Consideration of all stages of the development (construction, operation and closure).
	• Description of the design and construction of the development to prevent ongoing impacts to groundwater systems.
	• Assessment of cumulative impacts considering other surrounding approved and proposed developments.
	• Assessment of potential water quality effects as a result of the development (e.g. induced salt water intrusion or induced migration of contamination from nearby sources).
	• Assessment of possible acidification related to presence of potential or actual acid sulfate soils.
	• Presentation of a range of potential effects on groundwater quantity and associated impacts on receptors, using uncertainty analysis.
	• Clear documentation of assumptions used to conduct the assessment (for example the numerical modelling) such that any change to the assumptions would change the predicted impacts.

	• Proposed surface and groundwater monitoring activities and methodologies. • Proposed management of surplus water if higher than predicted inflows are encountered. • Documentation of avoidance and mitigation measures. • Assessment of impacts against the Aquifer Interference Policy minimal impact considerations and identification of make good provisions, if required.
Things to consider	If watertightness of the completed development cannot be achieved, the cone of depression development can be very slow and often does not impact on surrounding receptors for some time. The final voids can be sinks that draw in contamination and saline water, depending on the development location. The potential impacts and risks associated with these on both the environment and on the development should be considered in the impact assessment. Post-development impacts to be managed and groundwater inflows (indirect water take) to be licensed long after the project is completed.
Post-approvals reporting (including DMP)	
Requirements	• Groundwater monitoring and modelling program developed in consultation with the department's Water division and EPA. • Secure sufficient water entitlement in a water access licence(s) prior to any groundwater take occurring. • Metering and recording of all groundwater intercepted and pumped. • Reporting of all water take (direct and indirect) in the compliance reporting, including groundwater intercepted. Water take volumes should also be provided to WaterNSW. • Ensure sufficient water entitlement is in place for ongoing post completion take. • Review and verify model predictions from the EIS stage on a regular basis, as agreed with the department's Water division. • Reporting of monitoring trends with comparison to predictions. • Comprehensive review of monitoring data, considering surface water quality, groundwater quality, groundwater elevations, receptor bioindicators and ground surface settlement monitoring. • Evaluation of the management measures documented in the water management plan, including make good provisions.
Things to consider	Review of the key assumptions and factors that the impact assessment relies on (including the conceptual hydrogeological model and water affecting activities). Changes to these key assumptions may change the predicted impacts.

Reference list

Department of Planning, Industry and Environment, 2021. Minimum requirements for building site groundwater investigations and reporting – information for developers and consultants. Report PUB20/940, prepared by NSW Department of Planning, Industry and Environment, Water Group. January. ISBN 978-1-76058-419-1.

Appendix B

Aquifer interference assessment framework

Department of Primary Industries
Office of Water

AQUIFER INTERFERENCE ASSESSMENT FRAMEWORK

Assessing a proposal against the NSW Aquifer Interference Policy – step by step guide

Note for proponents

This is the basic framework which the NSW Office of Water uses to assess project proposals against the **NSW Aquifer Interference Policy (AIP).**

The NSW Aquifer Interference Policy can be downloaded from the NSW Office of Water website (www.water.nsw.gov.au under Water management > Law and policy > Key policies > Aquifer interference).

While you are not required to use this framework, you may find it a useful tool to aid the development of a proposal or an **Environmental Impact Statement (EIS)*.***

We suggest that you summarise your response to each AIP requirement in the tables following and provide a reference to the section of your EIS that addresses that particular requirement. Using this tool can help to ensure that all necessary factors are considered, and will help you understand the requirements of the AIP.

Table 1. Does the activity require detailed assessment under the AIP?

	Consideration	Response
1	Is the activity defined as an aquifer interference activity?	If **NO,** then no assessment is required under the AIP. If **YES,** continue to Question 2.
2	Is the activity a defined minimal impact aquifer interference activity according to section 3.3 of the AIP?	If **YES**, then no further assessment against this policy is required. Volumetric licensing still required for any water taken, unless exempt. If **NO**, then continue on for a full assessment of the activity.

Note for proponents

Section 3.2 of the AIP defines the framework for assessing impacts. These are addressed here under the following headings:

1. Accounting for or preventing the take of water
2. Addressing the minimal impact considerations
3. Proposed remedial actions where impacts are greater than predicted.

1. Accounting for, or preventing the take of water

Where a proposed activity will take water, adequate arrangements must be in place to account for this water. It is the proponent's responsibility to ensure that the necessary licences are held. These requirements are detailed in Section 2 of the AIP, with the specific considerations in Section 2.1 addressed systematically below.

Where a proponent is unable to demonstrate that they will be able to meet the requirements for the licensing of the take of water, consideration should be given to modification of the proposal to prevent the take of water.

Table 2. Has the proponent:

	AIP requirement	Proponent response	NSW Office of Water comment
1	Described the water source(s) the activity will take water from?		
2	Predicted the total amount of water that will be taken from each connected groundwater or surface water source on an annual basis as a result of the activity?		
3	Predicted the total amount of water that will be taken from each connected groundwater or surface water source after the closure of the activity?		
4	Made these predictions in accordance with Section 3.2.3 of the AIP? (refer to Table 3, below)		
5	Described how and in what proportions this take will be assigned to the affected aquifers and connected surface water sources?		
6	Described how any licence exemptions might apply?		
7	Described the characteristics of the water requirements?		
8	Determined if there are sufficient water entitlements and water allocations that are able to be obtained for the activity?		

	AIP requirement	Proponent response	NSW Office of Water comment
9	Considered the rules of the relevant water sharing plan and if it can meet these rules?		
10	Determined how it will obtain the required water?		
11	Considered the effect that activation of existing entitlement may have on future available water determinations?		
12	Considered actions required both during and post-closure to minimize the risk of inflows to a mine void as a result of flooding?		
13	Developed a strategy to account for any water taken beyond the life of the operation of the project?		
Will uncertainty in the predicted inflows have a significant impact on the environment or other authorised water users? If **YES,** items 14-16 must be addressed.			
14	Considered any potential for causing or enhancing hydraulic connections, and quantified the risk?		
15	Quantified any other uncertainties in the groundwater or surface water impact modelling conducted for the activity?		
16	Considered strategies for monitoring actual and reassessing any predicted take of water throughout the life of the project, and how these requirements will be accounted for?		

Table 3. Determining water predictions in accordance with Section 3.2.3 (complete one row only – consider both during and following completion of activity)

	AIP requirement	Proponent response	NSW Office of Water comment
1	**For the Gateway process**, is the estimate based on a simple modelling platform, using suitable baseline data, that is, fit-for-purpose?		
2	**For State Significant Development or mining or coal seam gas production**, is the estimate based on a complex modelling platform that is: • Calibrated against suitable baseline data, and in the case of a **reliable water source,** over at least two years? • Consistent with the Australian Modelling Guidelines? • Independently reviewed, robust and reliable, and deemed fit-for-purpose?		
3	In all other processes, estimate based on a desk-top analysis that is: • Developed using the available baseline data that has been collected at an appropriate frequency and scale; and • Fit-for-purpose?		

Other requirements to be reported on under Section 3.2.3

Table 4. Has the proponent provided details on:

	AIP requirement	Proponent response	NSW Office of Water comment
1	Establishment of baseline groundwater conditions?		
2	A strategy for complying with any water access rules?		
3	Potential water level, quality or pressure drawdown impacts on nearby basic landholder rights water users?		
4	Potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources?		
5	Potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems?		
6	Potential for increased saline or contaminated water inflows to aquifers and highly connected river systems?		
7	Potential to cause or enhance hydraulic connection between aquifers?		
8	Potential for river bank instability, or high wall instability or failure to occur?		
9	Details of the method for disposing of extracted activities (for coal seam gas activities)?		

2. Addressing the minimal impact considerations

Note for proponents

Section 3.2.1 of the AIP describes how aquifer impact assessment should be undertaken.

1. Identify all water sources that will be impacted, referring to the water sources defined in the relevant water sharing plan(s). Assessment against the minimal impact considerations of the AIP should be undertaken for each ground water source.
2. Determine if each water source is defined as 'highly productive' or 'less productive'. If the water source is named in then it is defined as highly productive, all other water sources are defined as less productive.
3. With reference to pages 13-14 of the Aquifer Interference Policy, determine the sub-grouping of each water source (eg alluvial, porous rock, fractured rock, coastal sands).
4. Determine whether the predicted impacts fall within Level 1 or Level 2 of the minimal impact considerations defined in Table 1 of the AIP, for each water source, for each of water table, water pressure, and water quality attributes. The tables below may assist with the assessment. There is a separate table for each sub-grouping of water source – only use the tables that apply to the water source(s) you are assessing, and delete the others.
5. If unable to determine any of these impacts, identify what further information will be required to make this assessment.
6. Where the assessment determines that the impacts fall within the Level 1 impacts, the assessment should be 'Level 1 – Acceptable'
7. Where the assessment falls outside the Level 1 impacts, the assessment should be 'Level 2'. The assessment should further note the reasons the assessment is Level 2, and any additional requirements that are triggered by falling into Level 2.
8. If water table or water pressure assessment is not applicable due to the nature of the water source, the assessment should be recorded as 'N/A – reason for N/A'.

Table 5. Minimal impact considerations – *example tables*

Aquifer	**Alluvial aquifer**	
Category	**Highly Productive**	
Level 1 Minimal Impact Consideration		**Assessment**
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic post-water sharing plan variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.		
Water pressure A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the base of the water source to a maximum of a 2 metre decline, at any water supply work. **OR**, for the Lower Murrumbidgee Deep Groundwater Source: A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the top of the relevant aquifer to a maximum of a 3 metre decline, at any water supply work.		
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity. No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. No mining activity to be below the natural ground surface within 200 metres laterally from the top of high bank or 100 metres vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a reliable water supply. Not more than 10% cumulatively of the three dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200 metres laterally from the top of high bank and 100 metres vertically beneath a highly connected surface water source that is defined as a reliable water supply.		

Aquifer	**Coastal sands**
Category	**Highly Productive**

Level 1 Minimal Impact Consideration	**Assessment**
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	
Water pressure A cumulative pressure head decline of not more than a 2 metre decline, at any water supply work.	
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	

Aquifer	Porous Rock – except Great Artesian Basin
Category	Highly Productive
Level 1 Minimal Impact Consideration	**Assessment**
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic ‘post-water sharing plan’ variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	
Water pressure A cumulative pressure head decline of not more than a 2 metre decline, at any water supply work.	
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	

<table>
<tr><th>Aquifer</th><th>Porous Rock – Great Artesian Basin – Eastern Recharge and Southern Recharge</th></tr>
<tr><th>Category</th><th>Highly Productive</th></tr>
</table>

Level 1 Minimal Impact Consideration	Assessment
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic ‘post-water sharing plan’ variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	
Water pressure Less than 0.2 metre cumulative variation in the groundwater pressure, allowing for typical climatic ‘post-water sharing plan’ variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. A cumulative pressure level decline of not more than 15 metres, allowing for typical climatic ‘post-water sharing plan’ variations. The cumulative pressure level decline of no more than 10% of the 2008 pressure level above ground surface at the NSW State border, as agreed between NSW and Queensland.	
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	

Aquifer	Porous Rock – Great Artesian Basin – Surat, Warrego and Central
Category	Highly Productive

Level 1 Minimal Impact Consideration	Assessment
Water table NOT APPLICABLE	
Water pressure Less than 0.2 metre cumulative variation in the groundwater pressure, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. A cumulative pressure level decline of not more than 30 metres, allowing for typical climatic 'post-water sharing plan' variations. The cumulative pressure level decline of no more than 10% of the 2008 pressure level above ground surface at the NSW State border, as agreed between NSW and Queensland.	
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	

Aquifer	Fractured Rock
Category	Highly Productive

Level 1 Minimal Impact Consideration	Assessment
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: • high priority groundwater dependent ecosystem; or • high priority culturally significant site; listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	
Water pressure A cumulative pressure head decline of not more than a 2 metre decline, at any water supply work.	
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	

Aquifer	Alluvial
Category	Less productive

Level 1 Minimal Impact Consideration	Assessment
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work unless make good provisions apply	
Water pressure A cumulative pressure head decline of not more than 40% of the 'post-water sharing plan' pressure head above the base of the water source to a maximum of a 2 metre decline, at any water supply work.	
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity. No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. No mining activity to be below the natural ground surface within 200 metres laterally from the top of high bank or 100 metres vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a 'reliable water supply'.	

Aquifer	Porous rock or fractured rock
Category	**Less productive**

Level 1 Minimal Impact Consideration	Assessment
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic ‘post-water sharing plan’ variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	
Water pressure A cumulative pressure head decline of not more than a 2 metre decline, at any water supply work.	
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	

3. Proposed remedial actions where impacts are greater than predicted.

Note for proponents

Point 3 of section 3.2 of the AIP provides a basic framework for considerations to consider when assessing a proponent's proposed remedial actions.

Table 6. Has the proponent:

	AIP requirement	Proponent response	NSW Office of Water comment
1	Considered types, scale, and likelihood of unforeseen impacts *during operation*?		
2	Considered types, scale, and likelihood of unforeseen impacts *post closure*?		
3	Proposed mitigation, prevention or avoidance strategies for each of these potential impacts?		
4	Proposed remedial actions should the risk minimization strategies fail?		
5	Considered what further mitigation, prevention, avoidance or remedial actions might be required?		
6	Considered what conditions might be appropriate?		

4. Other considerations

Note for proponents

These considerations are not included in the assessment framework outlined within the AIP, however are discussed elsewhere in the document and are useful considerations when assessing a proposal.

Table 7: Has the proponent:

	AIP requirement	Proponent response	NSW Office of Water comment
1	Addressed how it will measure and monitor volumetric take? (page 4 of the AIP)		
2	Outlined a reporting framework for volumetric take? (page 4 of the AIP)		

More information

www.water.nsw.gov.au

Disclaimer:

This is a draft document produced as a guide for discussion, and to aid interpretation and application of the NSW Aquifer Interference Policy (2012). All information in this document is drawn from that policy, and where there is any inconsistency, the policy prevails over anything contained in this document.
Any omissions from this framework do not remove the need to meet any other requirements listed under the Policy.

The information contained in this publication is based on knowledge and understanding at the time of writing (August 2018). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of the Department of Primary Industries or the users independent adviser.

Published by the NSW Department of Primary Industries.

Reference 12279.1

Appendix C

AIP fact sheets 1 to 7

C1 Fact Sheet 1 – Groundwater and aquifers

Department of Primary Industries
Office of Water

NSW AQUIFER INTERFERENCE POLICY | FACT SHEET 1

Groundwater and aquifers

August 2013

What is groundwater?

Groundwater is the water contained within rocks and sediments below the ground's surface in the saturated zone.

Groundwater occurs everywhere below the ground but the ability to get the water out of the ground (called 'yield') and the salinity of the water can vary widely depending on the geology and the amount of recharge a groundwater system receives. Recharge is the movement of water into a groundwater system from rainfall, overland flow, other groundwater sources, irrigation, streams or other sources.

What is a groundwater system?

A groundwater system is any type of saturated sequence of rocks or sediments that has similar hydrogeological characteristics and is in hydraulic connection. The characteristics can range from low yielding and high salinity water to high yielding and low salinity water.

What is an aquifer?

The term 'aquifer' is **commonly** understood to mean a groundwater system that can yield useful volumes of groundwater. This also implies that the water is of good enough quality to be used for purposes such as irrigating crops or for town or stock drinking water. Aquifers are not underground rivers or streams.

For the purposes of the Aquifer Interference Policy the term 'aquifer' has the same meaning as 'groundwater system' and includes low yielding and saline systems.

Why protect groundwater?

Groundwater is an important resource for many towns, industries and irrigators who rely on groundwater extraction to support their activities. Also, many landholders rely on groundwater for domestic and stock use. Groundwater is also important for the environment, as it supports some ecosystems and provides baseflow to rivers.

Over-extraction or contamination of groundwater can have serious, long-term and sometimes permanent impacts on the groundwater system. This may ultimately reduce the volume and quality of water available for the users and ecosystems that depend on this groundwater.

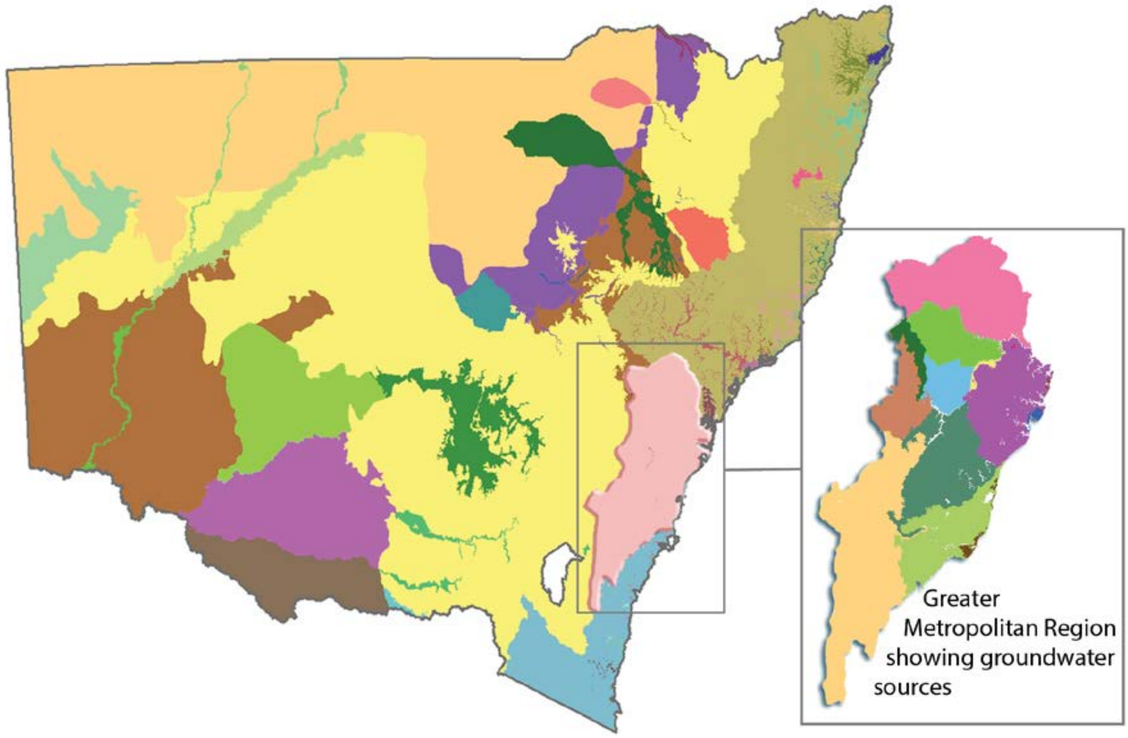
Groundwater is part of the water sharing plans

In New South Wales groundwater is managed at the 'water source' scale under the rules in a water sharing plan. Water sharing plans are being developed to apply to all of the water extracted in the State. Water sharing plans are created by the *Water Management Act 2000* and at present 95% of NSW is covered by 70 water sharing plans (Figure 1). These plans manage both surface water and groundwater that is used by irrigators, the environment, industry, towns and communities. A groundwater source can include a number of aquifers and groundwater systems.

Water sharing plans aim to:

- clarify the rights of the environment, basic landholder rights users, town water suppliers and other licensed users
- define the long-term average annual extraction limit (LTAAEL) for water sources
- set rules to manage impacts of extraction
- facilitate the trading of water between users.

Figure 1 Water sharing plans that include groundwater



Note: this map only shows the uppermost water sharing plan in an area. Other water sharing plans underlie many of these. More information on all water sharing plans and their groundwater sources is available at www.water.nsw.gov.au under Water-management/Water-sharing-plans/Plans-commenced.

How is groundwater divided up and managed?

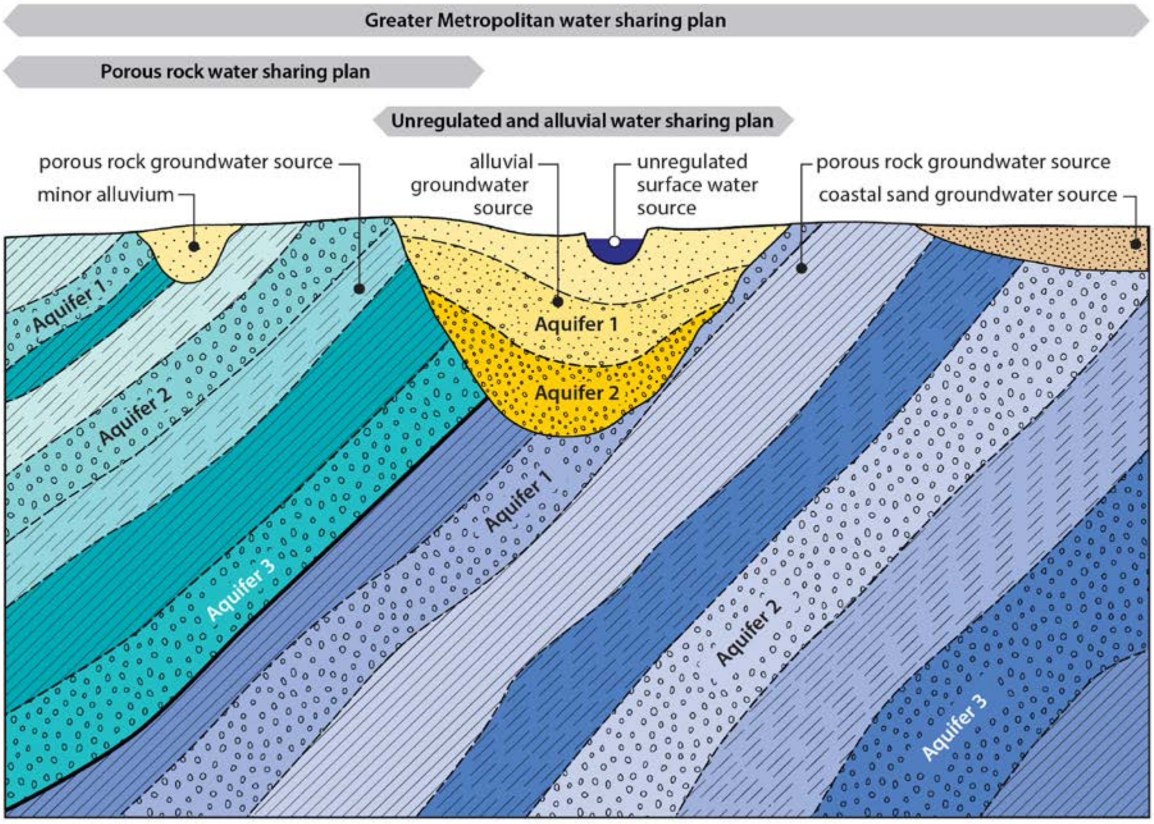
Groundwater sources are divided into four broad hydrogeological types:

- **alluvial** – unconsolidated sediments
- **coastal sand** – unconsolidated sediments
- **porous rock** – consolidated sedimentary rocks
- **fractured rock** – igneous and metamorphic rocks.

Each of these systems are hydrogeologically quite different from each other. For example, they have different rates of recharge, groundwater flow, yield and water quality.

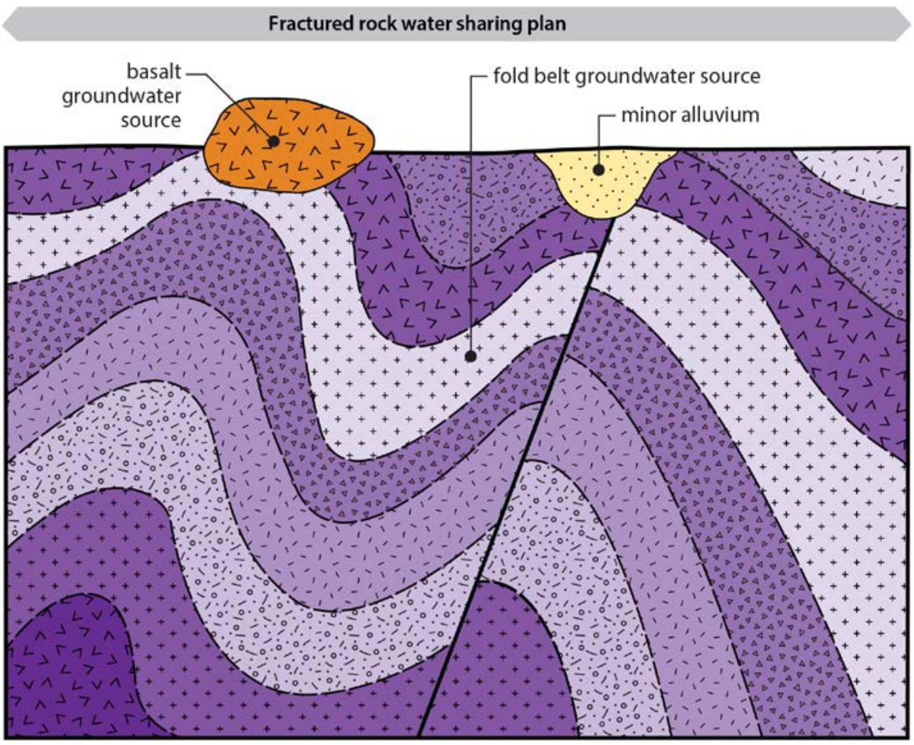
For management purposes, geological sequences that are hydrogeologically similar may be grouped together and defined as a groundwater source (Figure 2). For example, all of the unconsolidated sediments in the Lower Namoi (Narrabri, Gunnedah and Cubbaroo Formations) are grouped into the Lower Namoi Groundwater Source.

Figure 2 Generic example of water sources included in water sharing plans



Some parts of geological basins and provinces are divided into separate groundwater sources because they are hydrogeologically different. For example, the Young Granite forms part of the Lachlan Fold Belt but has been classed as a separate groundwater source because of its generally better water quality and higher yields (Figure 3).

Figure 3 Generic example of a fractured rock water sharing plan and its groundwater sources



In other cases, groundwater systems are divided by surface water catchment into separate groundwater sources for administrative purposes even though they belong to the same geological basin or province and are hydrogeologically very similar. For example, the Kanmantoo Fold Belt has been divided by the Murray-Darling Basin catchment boundary into the Kanmantoo Fold Belt North Western and Kanmantoo Fold Belt Murray-Darling Basin Groundwater Sources.

Where groundwater sources overlie one another causing part or all of a groundwater source to be buried (either horizontally or subvertically), they are termed ‘fully buried’ or ‘partly buried’. For example, the Gunnedah-Oxley Murray-Darling Basin Groundwater Source is a partly buried water source.

Water sharing plans can cover one or more of the groundwater sources in an area, and can also include the surface water in that area. For example, the Hunter Unregulated and Alluvial Water Sharing Plan covers, among others, the Hunter Regulated River Alluvial Water Source and the Merriwa River Water Source.

Glossary

Alluvium – sedimentary deposits made by rivers or streams or found on alluvial fans, floodplains etc that consist of gravel, sand, silt and clay.

Brackish water – water that has a salinity between 3000 and 7000mg/L total salts, but is not as salty as seawater.

Consolidated sedimentary rock – a rock formed by sediment deposited in layers then being consolidated for example sandstone and siltstone.

Geological sequence – a sequence of rocks or sediments occurring in chronological order.

Hydraulic connection – a path or conduit allowing fluids to be connected. The degree to which a groundwater system can respond hydrologically to changes in hydraulic head.

Hydrogeology – the study of underground water including the geology of water-bearing rocks, and the chemistry, physics and movement of groundwater.

Igneous rock – rocks which have solidified from a molten mass.

Metamorphic rock – consolidated rocks that have been altered from their original structure and composition by pressure and heat.

Permeability – the measure of the ability of earth materials to transmit a fluid.

Recharge – Infiltration of water from rainfall, overland flow, irrigation, streams or other sources into the groundwater system.

Saturated zone – area below the water table where all soil spaces, pores, fractures and voids are filled with water.

Sedimentary rock – rock formed by layers of sediment.

Unconsolidated sediment – particles of gravel, sand, silt or clay size that are not bound or hardened by mineral cement, pressure, or thermal alteration of the grains.

Water sharing plan – a plan made under the *Water Management Act 2000*. These plans set out the rules for sharing water between the environment and water users within whole or part of a water management area or water source (taken from *Macro water sharing plans – the approach for groundwater* published by NSW Office of Water).

Water table – the depth at which soil spaces, pores, fractures and voids in rock become completely saturated with water.

More information

www.water.nsw.gov.au

Published by the NSW Department of Primary Industries

Jobtrack 12268_F1

C2 Fact Sheet 2 – An overview of the Aquifer Interference Policy

Department of Primary Industries
Office of Water

NSW AQUIFER INTERFERENCE POLICY | FACT SHEET 2

An overview of the Aquifer Interference Policy

August 2013

The NSW Aquifer Interference Policy was released in September 2012 and applies across the State. It explains the water licensing and impact assessment processes for aquifer interference activities under the *Water Management Act 2000* and other relevant legislation.

There are three key parts to the policy:

1. All water taken must be properly accounted for.
2. The activity must address minimal impact considerations for impacts on water table, water pressure and water quality.
3. Planning for measures in the event that the actual impacts are greater than predicted, including making sure that there is sufficient monitoring in place.

Water licensing

Water licences are required to account for the water taken from groundwater and surface water sources through aquifer interference activities. This is to ensure that the amount of water taken from each water source does not exceed the extraction limit set in a water sharing plan. These extraction limits are set to ensure that water is available in each water source for the environment and other water users, including domestic and stock users, irrigators, town water suppliers and various industries – including mining and coal seam gas.

A water licence is required whether water is taken for consumptive use e.g. irrigation, or whether it is taken incidentally by the aquifer interference activity. For example, dewatering of groundwater to allow mining to occur or during building construction requires a water licence even where that water is not being used consumptively as part of the activity's operation.

Assessment of water impacts

The Aquifer Interference Policy details the way the NSW Office of Water will assess aquifer interference projects to determine their potential impacts on water resources. It also explains the information and modelling that proponents will need to provide to enable the impacts to be assessed.

The assessment criteria are called '**minimal impact considerations'** and include impacts on water table levels, water pressure levels and water quality in different types of groundwater systems. Impacts on connected alluvial aquifers and surface water systems are also considered, as well as the impacts on other water-dependent assets. These include impacts on water supply bores, groundwater-dependent ecosystems and culturally significant sites that are groundwater-dependent.

Thresholds are set in the Policy so that the impacts of both an individual activity and the cumulative impacts of a number of activities within each water source can be considered.

Figure 1 Mound spring and associated ecosystem at Lake Peery, western NSW (photo Neal Foster)

Role of the Minister for Primary Industries

When an assessment has been done, the NSW Office of Water or the Minister for Primary Industries will provide advice to the Gateway Panel, the Department of Planning and Infrastructure or the Division of Resources and Energy, depending on the phase or location of the project.

Gateway panel

The gateway process will involve a panel which is intended to provide a tailored mechanism to assess the potential impacts of these proposals on strategic agricultural land and resources. It will provide a rigorous and independent assessment of the potential impacts of a project on agricultural land and water resources before a development application can be lodged.

Benefits to NSW

Both the community and project proponents now have a better understanding of the detailed considerations in the assessment of the water-related impacts of each project. The assessment of potential impacts on water resources is occurring with greater clarity and transparency than in the past.

More information

www.water.nsw.gov.au

Published by the Department of Primary Industries

Jobtrack 12268_F2

C3 Fact Sheet 3 – Accounting for water

Department of Primary Industries
Office of Water

NSW AQUIFER INTERFERENCE POLICY | FACT SHEET 3

Accounting for water

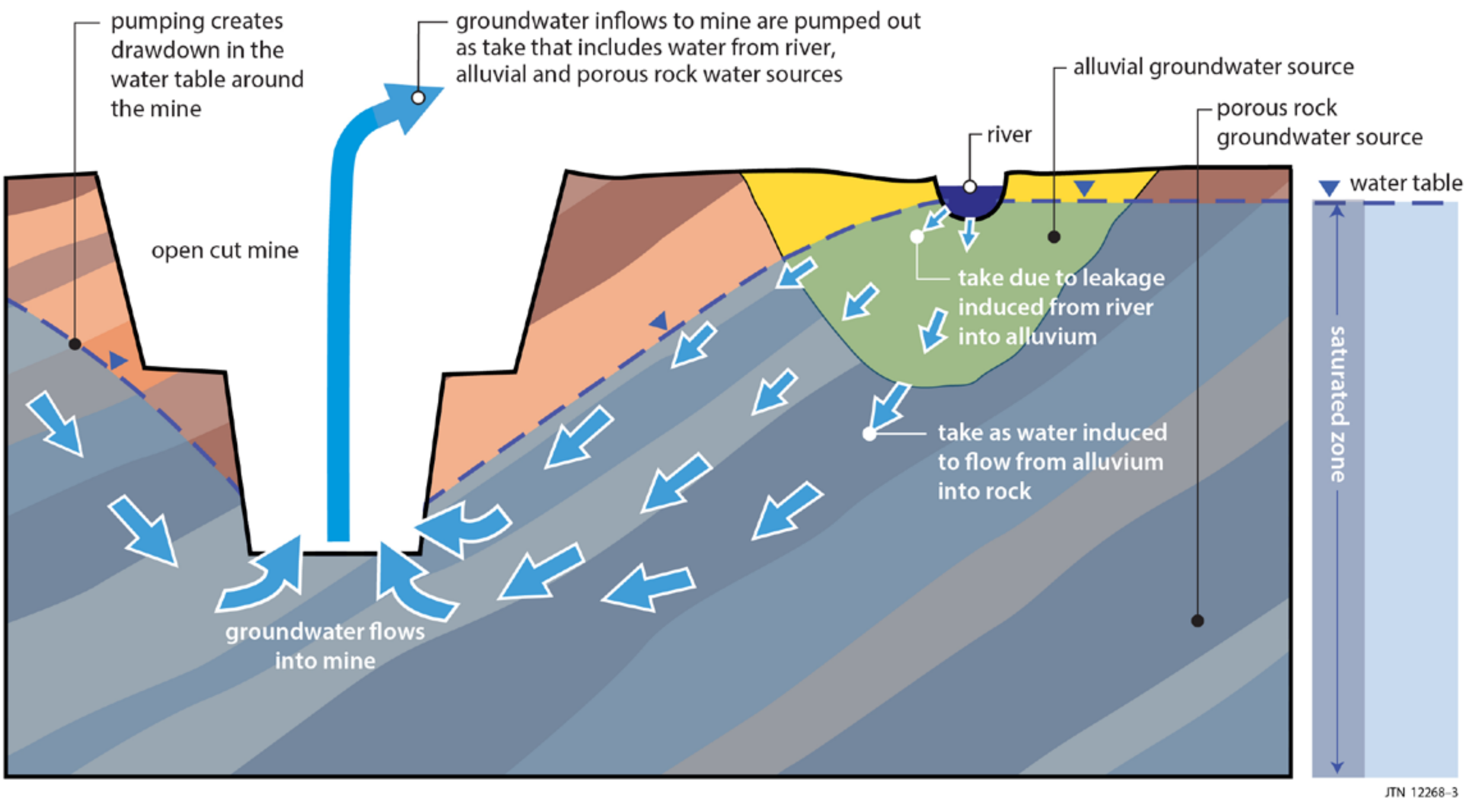
August 2013

What is the take of water?

Water can be taken directly from a groundwater or surface water source, usually via a pump or bore. It can also be taken indirectly, for instance when it is induced to flow from another connected groundwater or surface water source by an aquifer interference activity such as mining.

Water can be taken from connected surface water systems (for example lakes, wetlands or rivers) or from connected groundwater systems and must be licensed by the NSW Office of Water.

Example of take from several connected water sources due to mine dewatering



Accounting for the water taken through aquifer interference activities

All water taken from a water source by an aquifer interference activity, regardless of its quality, needs to be accounted for within the long term average extraction limit specified for that water source. The extraction limit for each water source is specified in a water sharing plan.

The processes for obtaining licences under the *Water Management Act 2000*, the licence type and the volumes held are all important for ensuring that aquifer interference activities hold adequate entitlement to cover the take of water from each affected water source.

Aquifer interference activities may induce flow from adjacent or overlying groundwater sources to the groundwater source in which they are operating. They can also induce flow from connected surface water sources. Separate water licences are required to account for water taken through these activities from all the affected water sources.

The total volume of water to be taken from each water source as a result of an aquifer interference activity needs to be determined before project approval can be granted and any licences obtained to take this amount of water. Once the activity commences the take must be measured and reported.

Type of water licence required

An aquifer access licence is required for all water taken from a groundwater source unless an exemption applies. Where an aquifer interference activity is taking water from a groundwater source, and that take of groundwater is causing the movement of water into that groundwater source from an adjacent, overlying or underlying groundwater source, separate aquifer access licences are required for the groundwater source and for each of the adjacent, overlying or underlying groundwater sources.

For water taken from surface water sources directly or indirectly as a result of the aquifer interference activity a regulated river access licence and/or an unregulated river access licence is required. If an aquifer interference activity is indirectly taking water from an unregulated river, the water must be returned to that river when flows are below the level where other water users are not permitted to pump. This level is specified in the relevant water sharing plan for that unregulated river.

Obtaining a water licence

The volume of water being extracted for consumptive use in most water sources in NSW has reached its limit and licences for new and extended development can only be obtained through the water trading market from an existing licence holder.

Where a water source has not reached its limit and there is unassigned water, which is the case in some groundwater sources, a controlled allocation order for the issue of new aquifer access licences can be made. Unassigned groundwater occurs where the long term average annual extraction limit is greater than current water requirements. Current water requirements are the sum of licensed volumes plus groundwater to meet basic landholder rights.

Controlled allocation orders

A controlled allocation order is made under section 65 of the *Water Management Act 2000* and involves an auction, tender or other process specified in the order.

The NSW Office of Water will review potential demand for new aquifer access licences in groundwater sources with unassigned water from time to time and determine if there is a need to make a controlled allocation order. More information on controlled allocations is available at www.water.nsw.gov.au

How are the volumes calculated?

Proponents are required to provide their estimates of all volumes of water likely to be taken from any water source both during the time the activity is occurring and after it stops. The minimum requirements for estimating this volume are:

- **At the gateway stage** – estimates based on a simple modelling platform
- **For State Significant Projects not going through a gateway panel** – estimates based on a complex modelling platform
- **For all other aquifer interference activities** – estimates based on a desk-top analysis.

In all cases the Minister for Primary Industries must be satisfied that the analysis/modelling is appropriate for the purposes of properly estimating the water that will be taken from each water source and the likely impacts.

Gateway process

The gateway process will involve a panel which is intended to provide a tailored mechanism to assess the potential impacts of these proposals on strategic agricultural land and resources. It will provide a rigorous and independent assessment of the potential impacts of a project on agricultural land and water resources before a development application can be lodged.

Further details on modelling requirements are in section 3.2.3 of the Aquifer Interference Policy.

More information

www.water.nsw.gov.au

Published by the Department of Primary Industries

Jobtrack 1268_F3

C4 Fact Sheet 4 – Assessing the impacts

Department of Primary Industries
Office of Water

NSW AQUIFER INTERFERENCE POLICY | FACT SHEET 4

Assessing the impacts

December 2013

Assessing the impacts on aquifers and associated water dependent assets is a key element of the NSW Aquifer Interference Policy, along with accounting for water and managing the risks. The Policy provides clear and objective considerations to allow proponents, Government and the community to assess these impacts.

Impact assessment criteria

The Aquifer Interference Policy includes a set of **minimal impact considerations** for assessing the impacts of all aquifer interference activities, including those regulated under the *Water Management Act 2000,* the *Water Act 1912*, and those decided under other legislation.

All NSW groundwater sources have been categorised as being either highly productive or less productive, based on the general character of the water source meeting or not meeting the criteria of 1500 mg/L total dissolved solids and a bore yield rate of greater than 5 L/s. This categorisation applies to a whole groundwater source as it is defined in a water sharing plan, not to the specific groundwater conditions at a particular location. The minimal impact considerations for the highly productive groundwater sources are different to those for the less productive groundwater sources.

Thresholds for minimal impact considerations have been developed for each groundwater source in NSW. The thresholds relate to impacts on groundwater table and pressure, and to groundwater and surface water quality.

Water table

The water table assessment examines the actual height of groundwater in parts of groundwater sources that are not confined by overlying rocks or sediments.

Water pressure

The water pressure assessment describes the pressure of the groundwater in parts of groundwater sources that are confined by overlying rocks or sediments, and is therefore under pressure. The change in water pressure is described in height. This height corresponds to the height that water would rise to if a bore was connected into that part of the groundwater system.

Water quality

The water quality assessment examines whether a change to any water quality parameter would change the water quality enough to potentially impact on current and future uses. The assessment also considers whether the activity will increase the salinity of groundwater or any highly connected surface water.

Levels of impact

The outcome of the assessment is either a Level 1 impact, which is considered acceptable, while a Level 2 impact requires further studies to assess whether a project will prevent the long-term viability of a dependent ecosystem or significant site, or needs other arrangements to mitigate the impacts.

Estimating impacts

Where an aquifer interference activity might have significant impacts on water sources or their dependent ecosystems or on other authorised water users, then predictions of these impacts should be made.

Proponents of an aquifer interference activity are required to provide estimates of all quantities of water that are likely to be taken from any water source during and following the end of the activity, and to make predictions of all impacts associated with the activity. This will assist in assessing whether the predicted impacts of the proposal are acceptable.

All take volumes and impacts are to be determined using desktop analysis or modelling, depending on the scale and nature of the activity.

Minimum impact considerations in highly productive groundwater sources

The following diagrams have been developed to assist in interpreting the minimal impact considerations for aquifer interference activities in highly productive groundwater sources.

Figure 1 Alluvial and Coastal Sand Groundwater Sources (general) - maximum impact considered acceptable on the water table.

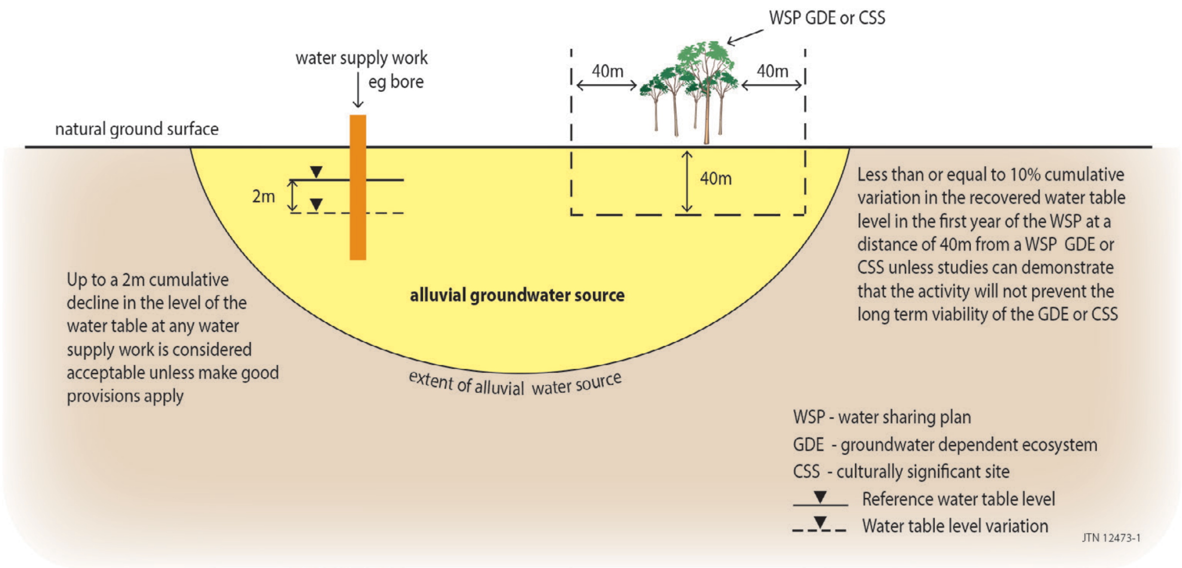


Figure 2 Alluvial Groundwater Sources* (general) - maximum impact considered acceptable on water pressure
*excluding the Lower Murrumbidgee Deep Groundwater Source

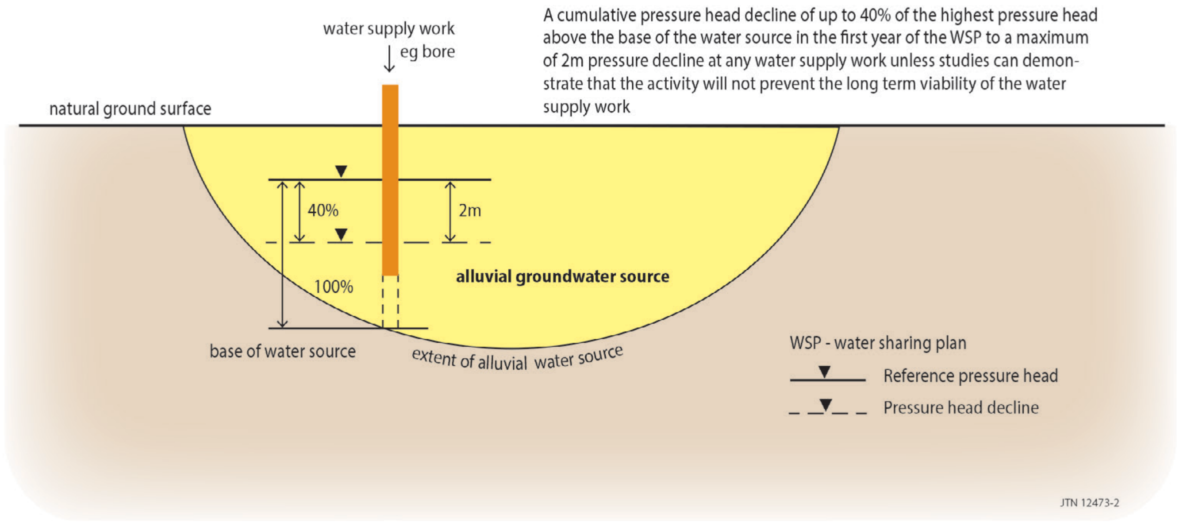


Figure 3 Alluvial Groundwater Sources - maximum impact considered acceptable on water quality.

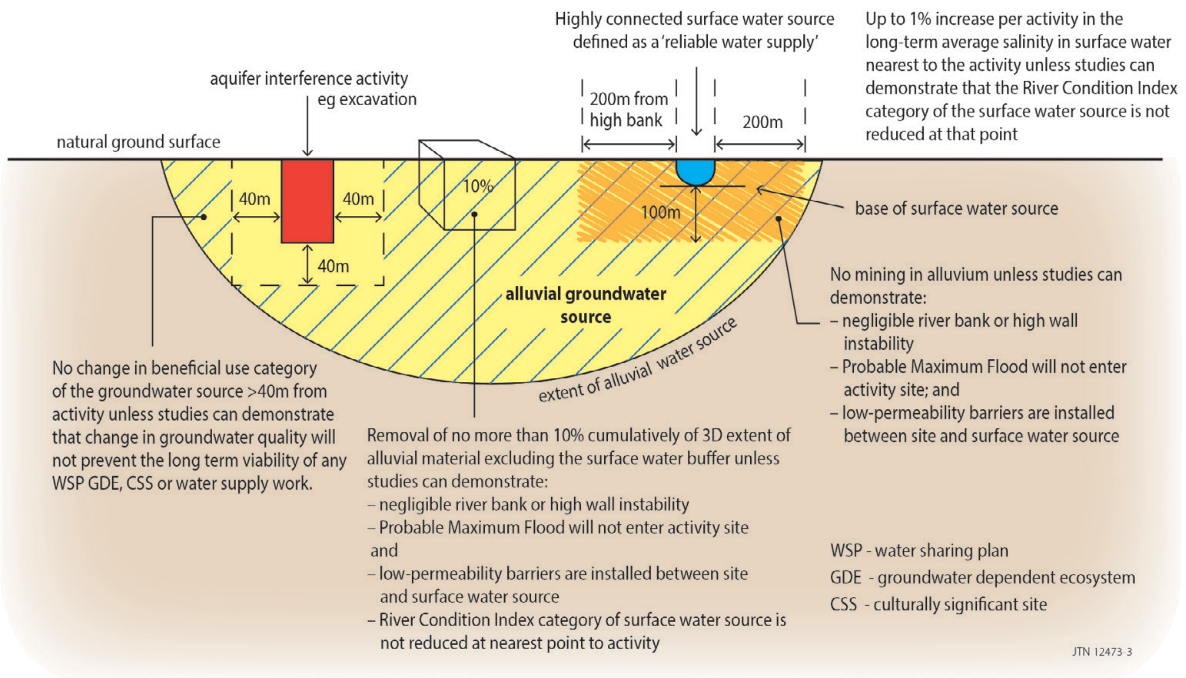


Figure 4 Porous and Fractured Rock Groundwater Sources (general) - maximum impacts considered acceptable on the water table.

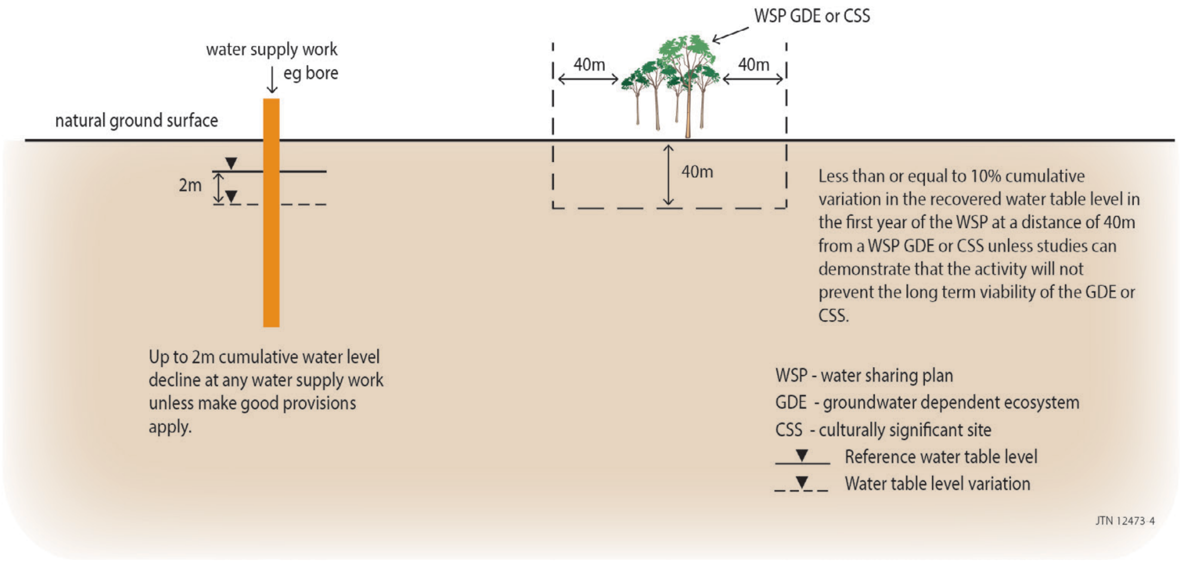


Figure 5 Coastal Sand, Porous Rock* and Fractured Rock Groundwater Sources (general) - maximum impacts considered acceptable on water pressure. *excluding the GAB groundwater sources (Fig 6)

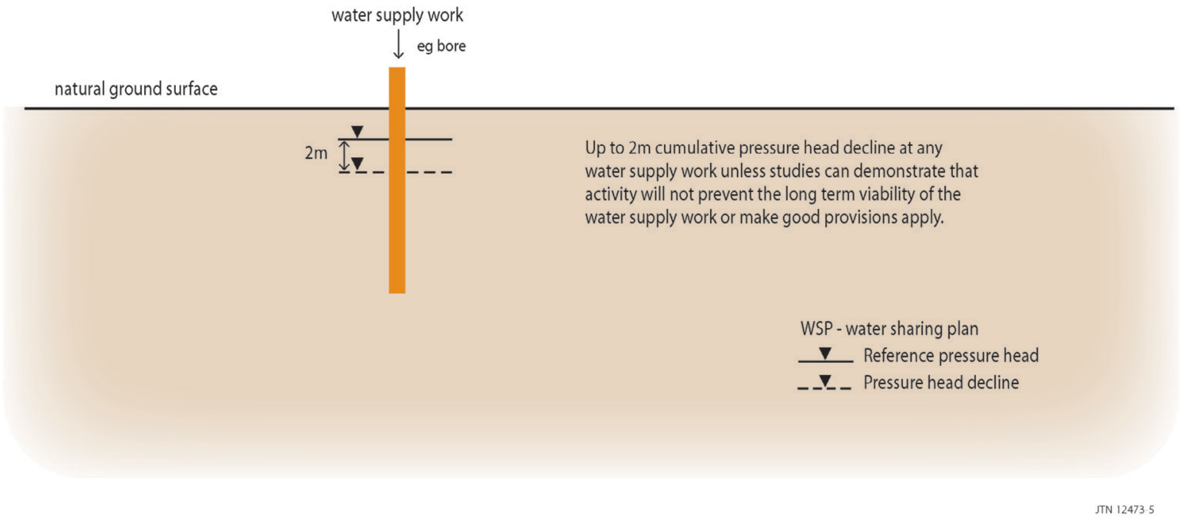


Figure 6 Porous Rock Great Artesian Basin Groundwater Sources - maximum impacts considered acceptable on water pressure.

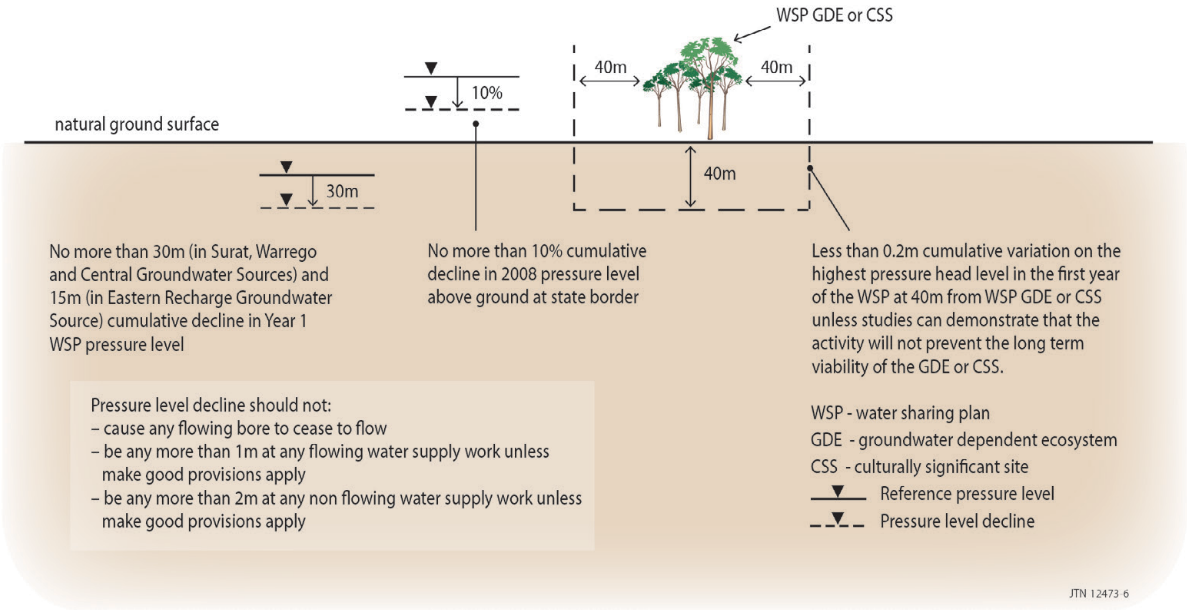
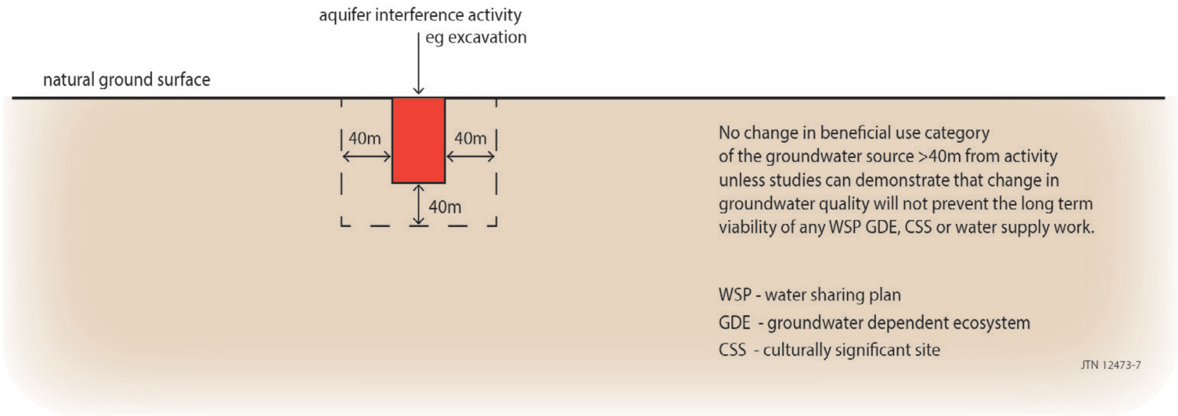


Figure 7 Coastal Sand, Porous Rock and Fractured Rock Groundwater Sources - maximum impacts considered acceptable on water quality.



Glossary

Beneficial use category – a general categorisation of groundwater uses based on water quality and the presence or absence of contaminants as defined in *Macro water sharing plans – the approach for groundwater* (NSW Office of Water, 2011).

GDE – Groundwater Dependent Ecosystem. Any ecosystem that uses groundwater at any time or for any duration in order to maintain its composition and condition (Serov P, Kuginis L, Williams J.P., May 2012, *Risk assessment guidelines for groundwater dependent ecosystems, Volume 1 – The conceptual framework*, NSW Department of Primary Industries, Office of Water, Sydney).

Make good provisions – the requirement to ensure third parties have access to an equivalent supply of water through enhanced infrastructure or other means for example deepening an existing bore, funding extra pumping costs or constructing a new pipeline or bore.

Minimal impact considerations – factors that need to be assessed to determine the potential effect of aquifer interference activities on groundwater and its dependent assets.

RCI – River Condition Index. This is a spatial tool used to measure and monitor the long term trend of river condition, but also reports on instream values and risk to instream values from extraction and geomorphic disturbance. Further details can be found at www.water.nsw.gov.au > Water management > Monitoring > Catchments.

Reliable water supply – rainfall of 350mm or more per annum (9 out of 10 years); or a regulated river, or unregulated rivers where there are flows for at least 95% of the time (ie the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers; or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5L/s and total dissolved solids of less than 1,500 mg/L (as defined by Strategic Regional Land Use Plans).

Salinity – the concentration of sodium chloride or other dissolved minerals in water, usually expressed in EC units or milligrams of total dissolved solids per litre. Conversion factor is 0.64 mg/l TDS = 1000 μS/cm = 1 dS/m.

Water source – the whole or any part of:

- one or more rivers, lakes or estuaries, or
- one or more places where water occurs naturally on or below the surface or the ground

and includes the coastal waters of the State (as defined in the *Water Management Act 2000*).

More information

www.water.nsw.gov.au

Published by the Department of Primary Industries

Jobtrack 12268_F4.3

C5 Fact Sheet 5 – Risk mitigation

Department of Primary Industries
Office of Water

NSW AQUIFER INTERFERENCE POLICY | FACT SHEET 5

Risk mitigation

August 2013

Assessment and management of risk is one of the three key elements of the NSW Aquifer Interference Policy, along with accounting for water and considering impacts on aquifers. The Policy provides for up front assessment, ongoing monitoring, and development of mitigation strategies.

This fact sheet will focus on the Office of Water's assessment of an activity that requires approval under the *Environmental Planning and Assessment Act 1979*.

What is required by the Aquifer Interference Policy?

No assessment or prediction of the impacts of any future activity will be totally accurate. This applies to any project plan in any sphere of life. The Aquifer Interference Policy sets out a stepwise approach for proponents and the Office of Water to consider when assessing the risks of an aquifer interference activity.

What are the risks?

Consider where the main uncertainties are in the proponent's predictions, and what the impacts could be if any of the predictions were not correct, both during the operational phase, or following completion of the aquifer interference activity.

What strategies are in place to minimise these risks?

Once the risks and uncertainties are understood, the proponent must develop strategies to minimise these risks. These may include measures to avoid or prevent the risk arising in the first place, for example through modifying the activity or project design. The proponent may also develop strategies to mitigate these risks, such as acquiring additional water licences, or exploring possible offsets.

Proposed remedial actions

The proponent develops contingency plans and remedial measures in case impacts are greater than predicted, and the risk minimisation strategies fail. This allows assessment of how these risks can be managed if they arise, and ensures that plans are developed in consultation with relevant regulatory authorities, and are ready to be implemented rapidly if they are needed.

Ensuring appropriate conditions

The Aquifer Interference Policy requires that appropriate conditions are placed on an approval, including:

- details of an effective monitoring program through all phases of the activity
- details of the required devices or methods for measuring water that is taken by the activity
- details of appropriate reporting and notification procedures
- details of the contingency plans or remedial measures to be employed where it is found that take by, or impacts from the activity are not in accordance with the licensing and approval requirements of the Policy.

The importance of modelling in risk mitigation

In order to predict what future impacts might be, and where the risks lie, the modelling approach is very important. Modelling is the most reliable way of predicting what will happen to a groundwater or surface water system in the future.

The Aquifer Interference Policy sets out some basic minimum requirements that are expected of a proponent when they predict what impacts their activity will have on water sources and associated water dependent assets.

For higher risk activities, such as mining and gas extraction, the Office of Water requires the estimates to be based on a complex modelling platform that is consistent with the *Australian Groundwater Modelling Guidelines* (National Water Commission, 2012) and is independently peer-reviewed and determined to be robust, reliable and fit-for-purpose.

This approach to modelling allows the proponent, the Government and the community to understand where the biggest risks lie, and what the main uncertainties in the predictions are.

The Government will often require these models to be updated throughout the life of a project as additional information is obtained. This reduces uncertainties, and may provide an early warning if any additional risks arise.

Monitoring actual impacts

In order to understand how accurate the predictions were, the Government will require ongoing monitoring and reporting to ensure that the impacts are within the range predicted. A monitoring plan will be developed to provide the best information in relation to the biggest risks, and main areas of uncertainty.

For example, if a community is concerned about impacts on a high value aquifer that is above a deeper aquifer where an aquifer interference activity is occurring, then monitoring may focus mainly on the high value aquifer, to make sure that any impacts are detected as early as possible.

Trigger levels will be set, meaning that if the actual impacts start to get bigger than predicted, then the contingency plans developed up front can be put into place before the impacts become unmanageable.

Security deposits and penalties

While the most important consideration for the Government is to prevent adverse and unforseen impacts from occurring, it is also important that there is a backup should things go wrong.

The Aquifer Interference Policy addresses the issue of security deposits to assign the risk of unforseen and ongoing impacts to the proponent of an aquifer impact activity, and not other water users or the environment.

Also, there are significant penalties for offences under the *Water Management Act 2000*. These include up to $1.1 million for individuals, $2.2 million for corporations, and individuals can face prison for up to two years.

These financial arrangements have a two-fold effect of providing a strong incentive to a proponent to ensure that they manage a project to the required standard and do not understate the risks, and also providing the Government with the financial means to ensure remediation should it be required.

More information

www.water.nsw.gov.au

Published by the Department of Primary Industries

Jobtrack 12268_F5

C6 Fact sheet 6 – How the Aquifer Interference Policy is applied

NSW AQUIFER INTERFERENCE POLICY | FACTSHEET 6

How the Aquifer Interference Policy is applied

August 2013

The NSW Aquifer Interference Policy was released in September 2012 following a detailed development and review process, building on the work and expertise of the Office of Water, other Government agencies, industry, and the community. It has been implemented since that time.

What does the Aquifer Interference Policy do?

The Aquifer Interference Policy describes objectively the requirements for a proponent when designing a project, and developing an environmental impact assessment. It also describes how the NSW Government, through the Minister for Primary Industries and the Office of Water, will assess and regulate aquifer interference activities.

When is it used?

The Aquifer Interference Policy applies to all aquifer interference activities both during and after an activity. The following sections explain how it is used at different times.

Development of a project

It is recommended that developers refer closely to the Aquifer Interference Policy during the design and development of a project. The Policy helps to understand whether an activity includes an aquifer interference activity, the relative risk of some types of activities, and provides guidance to allow the project design to minimise potential impacts on aquifers. It also describes obligations in relation to aquifer interference activities.

At the Gateway stage of a proposal on biophysical strategic agricultural land

Where a proposal is assessed by a Gateway Panel, the Minister for Primary Industries is required to provide advice to the Panel that includes an assessment of the potential impacts of an aquifer interference activity against the minimal impact considerations of the Aquifer Interference Policy, as well as the rules of any relevant water sharing plan.

The Panel may provide conditions to the proponent to ensure they properly address the requirements of the Aquifer Interference Policy during the detailed design and assessment of their proposal.

During assessment and review of a proposal

When assessing a proposal for an activity seeking approval under the *Environmental Planning and Assessment Act 1979*, the Office of Water will undertake a detailed assessment against the requirements of the Aquifer Interference Policy, described below under *Key Considerations*.

The Office of Water uses a systematic assessment framework to ensure that a consistent, rigorous, and clear approach is used in each assessment. This assessment framework is available on the Office of Water's website at www.water.nsw.gov.au.

Throughout the life of an activity

Proponents and Government will monitor an activity according to agreed standards throughout the life of an activity. The Aquifer Interference Policy describes requirements for conditions of approval, including measurement and monitoring, reporting, contingency plans and remedial measures where the impacts are not in accordance with requirements of the Policy.

After an activity finishes

The Aquifer Interference Policy clearly stipulates that impacts and water taken following the completion of an activity must be planned for and appropriately managed. The Policy outlines how to deal with perpetual inflow volumes, and also addresses the requirement for security deposits to ensure that the Government has the financial capacity to remediate any impacts greater than predicted during the development and assessment of a project.

Key considerations

The Aquifer Interference Policy follows an ‘account for, mitigate, avoid/prevent, and remediate’ approach. When assessing a proposal, the Office of Water will broadly address the following key considerations.

Account for water taken

The proponent will be required to demonstrate that they can obtain the necessary water licences in order to account for water taken for the life of a project as well as any ongoing take. They also need to demonstrate how they will be able to meet any applicable rules under the relevant water sharing plan(s).

Where the proponent is unable to meet these requirements, they will be required to demonstrate that the project has been designed in such a way to prevent the take of any water beyond what they can obtain licences for.

Address impacts on aquifers

The Aquifer Interference Policy describes minimal impact considerations for water pressure, water table, and water quality, for a range of different types of aquifers. The proponent is required to address these, and the Office of Water will assess the proposal against these considerations.

These considerations detail a range of different impacts, such as what level of drawdown to another bore is considered acceptable until “make good” arrangements will be required, what impacts on groundwater dependent ecosystems are considered acceptable, and whether impacts on water quality will change the beneficial use category of a water source.

Contingency planning where impacts are greater than predicted

The proponent is expected up-front to develop contingency plans and remedial measures if impacts are greater than predicted. This includes an assessment of what the risks are. This allows Government and the community to understand the risks, how they can be managed if they arise, and will also ensure that plans are developed and ready to implement rapidly should unforseen impacts arise.

Frequently asked questions

Does the Policy apply state wide?

Yes, the Aquifer Interference Policy applies to aquifer interference activities right across NSW.

What if aquifer interference approvals under the *Water Management Act 2000* haven’t commenced?

The Policy is used to guide proponents and the Office of Water in assessing proposed aquifer interference activities, regardless of the legislation that applies to regulate the activity. Activities that will require an aquifer interference approval if that part of the *Water Management Act 2000* commences, will generally be regulated under the *Water Act 1912* until that time.

It also provides guidance to the Office of Water when assessing applications for water access licences, and to other government decision makers, such as the Minister for Planning and Infrastructure or his/her delegate, when determining a proposal that includes an aquifer interference activity.

More information

www.water.nsw.gov.au

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C7 Fact Sheet 7 – Quarrying and extractive Industries

Department of Primary Industries
Office of Water

NSW AQUIFER INTERFERENCE POLICY | FACT SHEET 7

Quarrying and extractive industries

July 2014

This factsheet aims to assist extractive industries, such as quarrying, dredging and the extraction of sand and aggregate, to understand and comply with the NSW Aquifer Interference Policy.

The Policy was released in September 2012 and applies across NSW. It explains the water licensing, impact assessment and approval requirements for aquifer interference activities under the *Water Management Act 2000,* and other relevant legislation.

Water management in NSW

In New South Wales water is managed under the *Water Management Act 2000* and the *Water Act 1912.*

Water sharing plans are used to manage surface water and groundwater through associated water licences and approvals. Water sharing plans are in place for all inland water sources and are progressively being introduced for coastal water sources.

The purpose of water sharing plans is to protect water sources and their dependent ecosystems, whilst recognising the social and economic benefits of the sustainable and efficient use of water.

These plans set limits on the total volume of water that can be taken from each water source and specify rules for water access. Long term average annual extraction limits (LTAAELs) are set for each water source and aim to ensure that water is available for the environment and other water users, including domestic and stock users, irrigators, town water suppliers and other industries such as mining and agricultural processors.

Water licensing

Activities associated with extractive industries may take water from the groundwater sources in which they occur, and from other hydraulically connected water sources.

Aquifer interference activities taking water outside of water sharing plan areas require a licence under the *Water Act 1912*. In areas covered by water sharing plans, a water access licence is required under the *Water Management Act 2000* unless an exemption applies. The current exemptions from the requirement to hold a water access licence are specified in the *Water Management (General) Regulation 2011*.

A water licence is required regardless of whether the water is taken for consumptive use such as irrigation, or whether it is taken incidentally in the course of conducting the primary activity. For example, dewatering of groundwater to allow quarrying or sand mining to occur requires a water licence even where the extracted water is not being used consumptively as part of that industry's operation. Water licensing requirements also apply to activities that are State significant.

A licence is required for water that:

- Is extracted as entrained water within the resource
- Is dewatered to allow quarrying and resource extraction
- Flows into a void as a result of evaporation
- Is required for processing or washing
- Is required for dust suppression
- Is extracted for any other reason or purpose, whether passively or actively.

A water access licence specifies the holder's shares in the available water within the relevant water source. Separate water access licences are required to account for water taken from groundwater and surface water sources through aquifer interference activities, including quarrying and extractive industries. A licence with sufficient entitlement and water allocation must be held to account for all take of water, both during the life of the activity and for any ongoing take after the activity has ceased. Ongoing take includes the volume of groundwater inflow to voids that results due to evaporation where the void intersects the water table.

Where water is taken, a water access licence must be obtained for the correct category (eg aquifer), within the correct water source (as defined by the relevant water sharing plan), and that can be linked to the location that the water will be taken from.

These water licensing requirements are important for ensuring that the amount of water taken from a water source does not exceed the LTAAEL set in the water sharing plan.

Estimating the volumes of water that will be taken

Proponents are required to provide predictions of take during operations and after they have ceased, in order to ensure that appropriate entitlement is held to account for that take. The estimates of take should be made using modelling or analysis. The level of analysis required will depend on the nature and scale of the proposal.

Obtaining water entitlement

In areas still being managed under the *Water Act 1912* a water licence with entitlement can be obtained from the Office of Water for groundwater sources that have unassigned water. In areas being managed under the *Water Management Act 2000* water entitlement will need to be purchased on the open market. From time to time, the Office of Water will also make controlled allocation orders that allow a small portion of unassigned groundwater to be made available as new licences. Under a controlled allocation process the right to purchase water entitlement is obtained through a tender, bid or other competitive process.

Approvals

Where a water sharing plan has commenced, the water supply work approval, controlled activity approval and use approval requirements of the *Water Management Act 2000* apply. This means that all works taking water from a water source require an approval unless an exemption applies. The exception to this is where approval for a State significant development, State significant infrastructure or public priority infrastructure is given under the *Environmental Planning and Assessment Act 1979*. In this case, the approval requirements of the *Water Management Act 2000* do not apply however the NSW Office of Water will still assess the project against the provisions of the Aquifer Interference Policy and provide advice to the consent authority.

Applications for approvals will need to nominate the works from which the water will be taken. Works include bores, pumps, voids and excavations. Where an approval is given under other legislation the proponent must still nominate the works that will take water, even if no works approval is required under the *Water Management Act 2000*.

Further information in relation to approvals under the *Water Management Act 2000* can be obtained from http://www.water.nsw.gov.au/Water-Licensing/Approvals/default.aspx

Assessment of impacts

The Policy details how the NSW Office of Water will assess quarrying and extractive industry activities to determine their potential impacts on water resources. It also explains the information and modelling or analysis that proponents will need to provide to enable the impacts to be adequately assessed.

An assessment needs to be conducted before approval will be given to carry out an aquifer interference activity such as quarrying (where the water table is intersected), or to construct and use a water supply work. This involves assessment of the predicted impacts on the groundwater source, connected water sources, the users of these water sources and dependent ecosystems.

The assessment criteria for aquifer interference activities are set out in the Policy and are called 'minimal impact considerations. These considerations include impacts on water table levels, water pressure levels and water quality in different types of groundwater systems. Impacts on connected alluvial groundwater systems and surface water systems are also considered, as well as the impacts on other water-dependent assets including water supply bores, groundwater dependent ecosystems and culturally significant sites that are groundwater dependent. Rules in relevant water sharing plans also apply if an approval is being given under the *Water Management Act 2000*, for example distance conditions.

Thresholds are set in the Policy so that the impacts of both an individual activity and the cumulative impacts of more than one activity in a water source can be considered.

Monitoring and reporting

A water measurement and monitoring program should be developed to monitor and report on water levels, water quality and water take. The monitoring program should identify all users and water dependent features with the potential to be impacted by the activity. Water level and quality monitoring should be initiated prior to commencement of the activity to establish baseline conditions. The water monitoring program should include regular assessment and reporting of results to ensure that impacts are not greater than predicted. The program should also include threshold trigger levels and a response strategy in the event that trigger levels are exceeded.

New initiatives

The NSW Office of Water is developing return flow rules for groundwater that are proposed to be made under section 75 of the *Water Management Act 2000*. Under these rules, it is proposed that licence holders will receive a credit to their water allocation account for water returned to the same groundwater source from which it was taken, providing specific conditions are met.

An exemption from the requirement to hold a licence is also being developed where less than 3 ML per year is taken from a groundwater source. This will only apply where the take is not principally for the purposes of water supply or water use.

Both initiatives require amendments to be made to the Water Management (General) Regulation 2011.

This factsheet will be updated when any changes to the legislation are made.

More information

www.water.nsw.gov.au

Find more factsheets on the Aquifer Interference Policy.

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Appendix D

Regulatory overview

Environmental Planning and Assessment Act 1979

Context

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and the NSW *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) form the statutory framework for land-use planning decisions in NSW. The requirement for development consent under the EP&A Act is regulated by environmental planning instruments (EPIs), including State Environmental Planning Policies (SEPPs) and local environmental plans (LEPs).

The objects of the EP&A Act include to promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources.

Assessment pathways

Mining and Petroleum Gateway Panel

Biophysical Strategic Agricultural Land (BSAL) is land with high quality soil and water resources capable of sustaining high levels of productivity. BSAL plays a critical role in sustaining the State's agricultural industry.

The NSW Government has introduced a range of measures designed to deliver greater protection to agricultural land from the impacts of mining and coal seam gas activity, including establishing a Mining and Petroleum Gateway Panel (the Panel) to assess mining and coal seam gas impacts on BSAL and its associated water resource.

The Panel is an independent body constituted under the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* and is a sub-committee of the NSW Independent Planning Commission.

Clause 50A of the EP&A Act outlines special provisions for development applications relating to mining or petroleum development on strategic agricultural land. If a project involves a mining or petroleum development within the meaning of Part 4AA of the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*, clause 50A of the EP&A Act requires that the development application be accompanied by either:

- A "Gateway Certificate", where the development occurs on land which meets the definition of BSAL; or
- A "Site Verification Certificate" (SVC) that certifies that the land on which the proposed development is to be carried out is not BSAL.

Part 4AA of the Mining SEPP states that:

> *(1) In this Part, mining or petroleum development means:*
>
> *(a) development specified in clause 5 (Mining) of Schedule 1 to State Environmental Planning Policy (State and Regional Development) 2011, but only if:*
>
> *(i) a mining lease under the Mining Act 1992 is required to be issued to enable the development to be carried out because:*
>
> *(A) the development is proposed to be carried out outside the mining area of an existing mining lease, or*

(B) there is no current mining lease in relation to the proposed development, or

(ii) the development is for the purposes of extracting a bulk sample as part of resource appraisal or a trial mine comprising the extraction of more than 20,000 tonnes of coal or of any mineral ore…

Therefore, where an SSD project requires a new mining lease and is located on BSAL, an application for a Gateway Certificate must be submitted to the department, and the project will be referred to the Minister for Planning and Public Spaces for advice on the project's impacts under the Aquifer Interference Policy (AIP), and to the Commonwealth Independent Expert Scientific Committee (IESC) for advice on potential impacts on water resources.

Following each assessment, the Panel can issue two types of Gateway Certificate – a certificate which confirms the proposal meets the scientific criteria or a conditional certificate which may include recommendations such as further studies or modifications to the project.

Once a Gateway certificate has been issued for a project, the proponent can proceed with a development application. The development application will then be subject to a full merit assessment under the EP&A Act.

The Panel can also provide advice on request by the Minister for Planning and Public Spaces on the potential agricultural and water impacts of mining or CSG production proposals for which a development application or modification application has been lodged, or environmental assessment requirements are being prepared.

The Panel can also provide input on the Secretary's Environmental Assessment Requirements (SEARs) for projects where the time limit for issuing a Gateway Certificate has lapsed.

If an SSD project falls within the meaning of Part 4AA of the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (e.g. requires a new mining lease); however, is not located on BSAL (as verified in accordance with the *Interim protocol for site verification and mapping of biophysical strategic agricultural land (NSW Government 2013*)) then a SVC certifying this is the case will need to be applied for and obtained prior to lodgement of the development application for the project.

State significant development

Projects are classified as SSD if they are declared to be so under under the *State Environmental Planning Policy (State and Regional Development) 2011* (the SRD SEPP), and are generally projects that are important for economic, environmental or social reasons. SSD projects are assessed under Part 4, Division 4.7 of the EP&A Act, and require development consent from the Minister for Planning and Public Spaces (or delegate) or the Independent Planning Commission before they may proceed. These are generally large-scale or complex projects that may involve significant environmental impacts such as quarries, tunnels, open-cut and underground mines, and large building developments.

Assessment requirements (or SEARs) for SSD projects are issued by the Secretary of the department and include assessment of the potential impacts of the development on aquifers, watercourses, riparian land, water dependent assets, and other water users. The Secretary seeks advice and input to the SEARs from the relevant water agencies, including the department's Water division, NRAR, EPA and WaterNSW (if relevant).

The SSD assessment process is illustrated in Figure D-1.

State significant infrastructure

SSI projects includes major transport and services developments that have a wider significance and impact than just the local area. SSI includes rail and road infrastructure, water storage and treatment, wharf and boating facilities, pipelines and certain development in National Parks.

SSI is also classified under the SRD SEPP. SSI projects require development approval from the Minister for Planning and Public Spaces (or delegate). Part 5, Division 5.2 of the EP&A Act provides a streamlined approval process for the assessment and determination of SSI projects. As above for SSD projects, SSI projects are subject to the issue of SEARs.

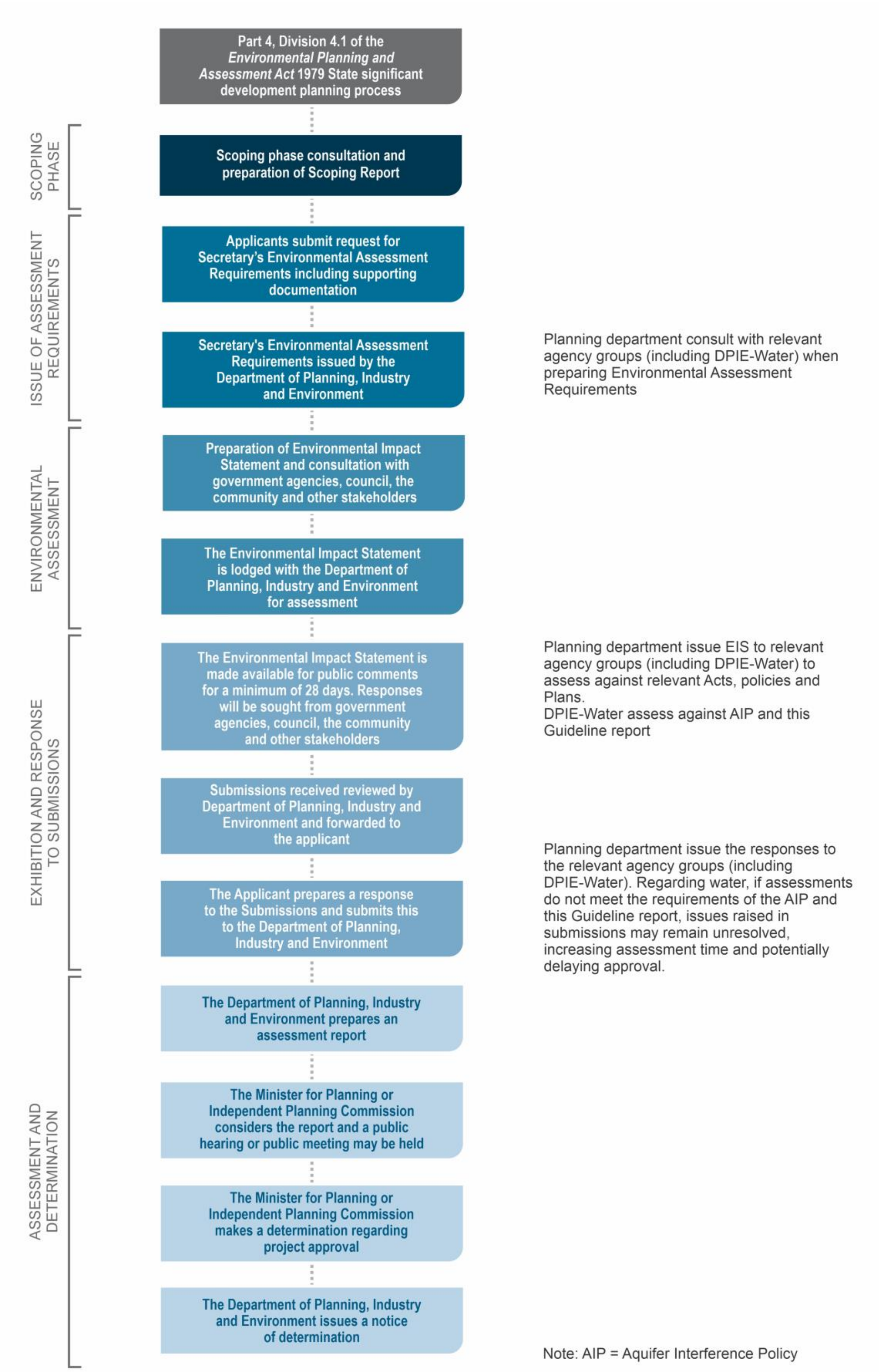

Figure D-1 SSD project assessment process under the EP&A Act

Water Management Act 2000

The Act

The WM Act is the primary legislation governing water management and licensing in NSW.

The WM Act is based on the principles of ecologically sustainable development and the need to share and manage water resources for future generations. The WM Act recognises that water management decisions must consider economic, environmental, social, cultural and heritage factors. In addition, the WM Act recognises that sustainable and efficient use of water delivers economic and social benefits to the state of NSW.

The WM Act provides for water sharing between different water users, including environmental, basic rights or existing water access licence (WAL) holders and provides security for licence holders.

The licensing provisions of the WM Act apply to those areas where a water sharing plan has commenced; it has progressively been enacted across NSW since July 2004. The licensing provisions of the WM Act become effective for any water source once a water sharing plan for that water source commences.

One of the key components of the WM Act is the separation of the water licence from the land; this facilitates opportunities for licence holders to trade water. The WM Act outlines the requirements for taking and trading water through WALs, water supply works, and water use approvals.

The WM Act is replacing the *Water Act 1912.* This transition occurs for particular water sources when a water sharing plan which applies to those water sources commences. This transition process is largely complete.

The *Water Act 1912* still applies to:

- Taking water from a water source outside water sharing plan areas;
- Construction and use of water supply works outside water sharing plan areas;
- Drainage works in all areas of NSW; and
- Aquifer interference activities in all areas of NSW.

Water Sharing Plans

Water sharing plans are statutory documents that apply to one or more water source areas. They contain the rules for sharing and managing the water resources within water source areas. Water sharing plans also set the water management vision and objectives, management rules for WALs, what water is available within the various water sources, and procedures for dealing in licences and water allocations, water supply works approvals and the extraction of water. Water sharing plans are designed to establish sustainable use and management of water resources. Each water sharing plan is in place for 10 years.

Water sharing plans describe the basis for water sharing, and document the water available and how it is shared between environmental, extractive, and other uses. The water sharing plans then outline the water available for extractive uses within different categories, such as: local water utilities, domestic and stock, basic rights, and access licences.

Aquifer Interference Policy (AIP)

Overview

The AIP was released by the NSW Government in September 2012. The purpose of the AIP is to explain the water licensing and assessment processes for aquifer interference activities under the WM Act and other relevant legislative frameworks.

The dictionary to the WM Act (under Section 91) defines an 'aquifer interference activity' as an activity involving any of the following:

- Penetration of an aquifer;
- Interference with water in an aquifer;
- Obstruction of the flow of water in an aquifer;
- Taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations; or
- Disposal of water taken from an aquifer in the course of carrying our mining or any other activity prescribed in the regulations.

The AIP clarifies the requirements for obtaining water licences for aquifer interference activities and defines considerations in assessing and providing advice on whether more than minimal impacts might occur to a key water-dependent asset.

The AIP defines water sources as being either 'highly productive' or 'less productive' based on levels of salinity and average yields from bores. The AIP then further defines water sources by their lithological character, being one of: alluvium, coastal sand, porous rock, or fractured rock.

The key requirements of the AIP are to:

- **Account for, or prevent, the take of water**. Where a proposed activity will take water from an aquifer or connected surface water source, adequate arrangements must be in place to account for this water. It is the proponent's responsibility to enable this to be estimated to a suitable level of accuracy, and to ensure necessary WALs are obtained and held.
- **Address the 'minimal impact considerations'**. Aquifer interference activities can adversely impact groundwater and connected surface water sources by decreasing groundwater pressure and/or lowering the water table; deteriorating groundwater and surface water quality either due to pollution or increases in salinity; by affecting the health or viability of a groundwater dependent ecosystem; or impacting on a culturally significant site. The AIP provides objective, measurable thresholds for considering the degree of impact an activity may have on the water table, groundwater pressure and water quality changes. The assessment criteria differ between aquifer types (for example alluvial, porous, fractured) and whether the aquifer is deemed 'highly' or 'less' productive on the basis of natural water quality and extraction yields.
- **Propose remedial actions**. Where impacts are greater than those that were predicted as part of the relevant approval, proposed remedial actions shall be specified to manage those impacts.

AIP assessment process

As part the department's Water division's role in water management, including assessing project proposals and providing advice to the Department of Planning and Environment – Planning and Assessment, the department's Water division's approach is based on the principles of "account for, mitigate, avoid/ prevent, and remediate".

The Aquifer Interference Assessment Framework is a step-by-step guide that the department's Water division use to assess project proposals against the AIP. The framework is available for proponents to use as a tool to aid the development of an EIS and is provided in Section 3 of this Guideline.

The department's Water division's assessment and subsequent advice will be based on whether a proposal demonstrates:

- A pathway to obtain necessary licences to account for the take of water from any relevant water source.

- Mitigation or avoidance strategies will be implemented to reduce the take of water to a point where it can be accounted for if licence entitlements cannot be easily obtained.
- That the proposal has been designed to limit the incidental take of water.
- Adequate arrangements will be in place to ensure that the minimal impact considerations and/or mitigation and management measures (including make good provisions) can be met (discussed further below).
- Proposed remedial actions if actual impacts are greater than those that were predicted as part of the relevant approval. This may occur where modelled predictions were inaccurate or where planned mitigation, prevention or avoidance strategies have failed.

Minimal impact considerations

The WM Act includes the concept of ensuring “no more than minimal harm” for both the granting of WALs and the granting of approvals.

The minimal impact considerations have been developed for impacts on groundwater sources, connected water sources, and their dependent ecosystems, culturally significant site and water users. The AIP minimal impact considerations process is shown in Figure D-2.

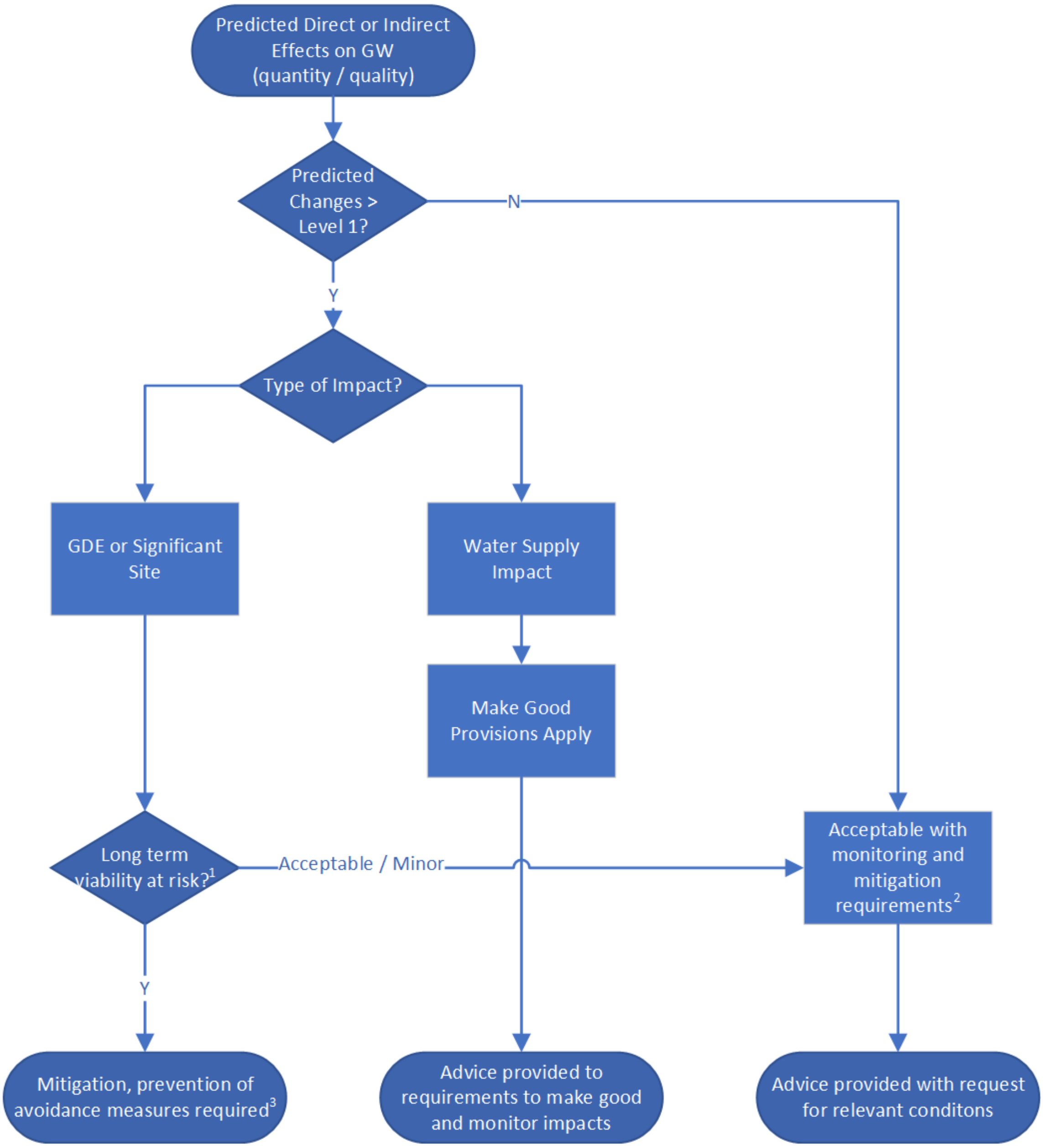

Figure D-2 AIP minimal impact considerations process (note: GDE = groundwater dependent ecosystem)

Make good provisions

AIP Fact Sheet 4 (refer Appendix C) outlines how a minimal impact is to be considered. It describes how the minimal impact criteria are applied to both a water supply work and a groundwater dependent ecosystem or culturally significant site defined in a water sharing plan. This fact sheet also defines the term 'make good provisions' for impacts on water supply works as "the requirement to ensure that third parties have access to an equivalent supply of water through enhanced infrastructure or other means, for example, deepening an existing bore, funding extra pumping costs or constructing a new pipeline or bore".

Another example of a make good provision is surrendering water access licence to account for ongoing post-closure take of water, provided water management costs and other administrative requirements are met (NOW 2013a).

Licensing

The WM Act requires water users or proponents to hold (unless exempt):

- A WAL to take water from a river, lake, dam or groundwater for irrigation, industrial, or commercial purposes;
- A water supply work approval to construct and use a water supply work, such as a pump, dam, channel or bore;
- A water use approval for a specific purpose at a particular location;
- A flood work approval for works on floodplain that diver floodwaters; and
- A controlled activity approval (CAA) to carry out work in a watercourse or within 40 metres of the bank of a river, lake of estuary, such as extracting material from a river bed, constructing a creek crossing or residential developments.

AIP Fact Sheet 3 (refer Appendix C) provides guidance regarding licensing and accounting for water. Water can be taken directly from a groundwater or surface water source, usually via a pump (in a river or an excavated area) or bore. It can also be taken indirectly when an aquifer interference activity causes water to flow from another connected groundwater or surface water source. Flows induced from other water sources also constitute take of water. In all cases, separate WALs are required to account for the take from all individual water sources.

Take of water is licensed by the source from where the water is taken.

For example, where an aquifer interference activity is taking water from a groundwater source, and this take is causing the movement of water from a connected surface water source into the groundwater source, then an access licence in the regulated or unregulated river water source is required to account for the take of water from that water source and another access licence in the groundwater source is required for the remainder of the take. This is illustrated in Figure D-3 below.

The total volume of water to be taken from each water source as a result of an aquifer interference activity needs to be estimated before project approval can be granted. A proponent is not required to hold sufficient entitlement prior to project approval; however, the proponent is required to demonstrate the licensing pathway to secure sufficient entitlement for the peak take (including documenting the proposed mechanisms to secure the entitlement, for example trade or controlled allocation orders). A proponent is required to hold sufficient entitlement prior to the take occurring.

Once the activity commences, the take must be measured and reported.

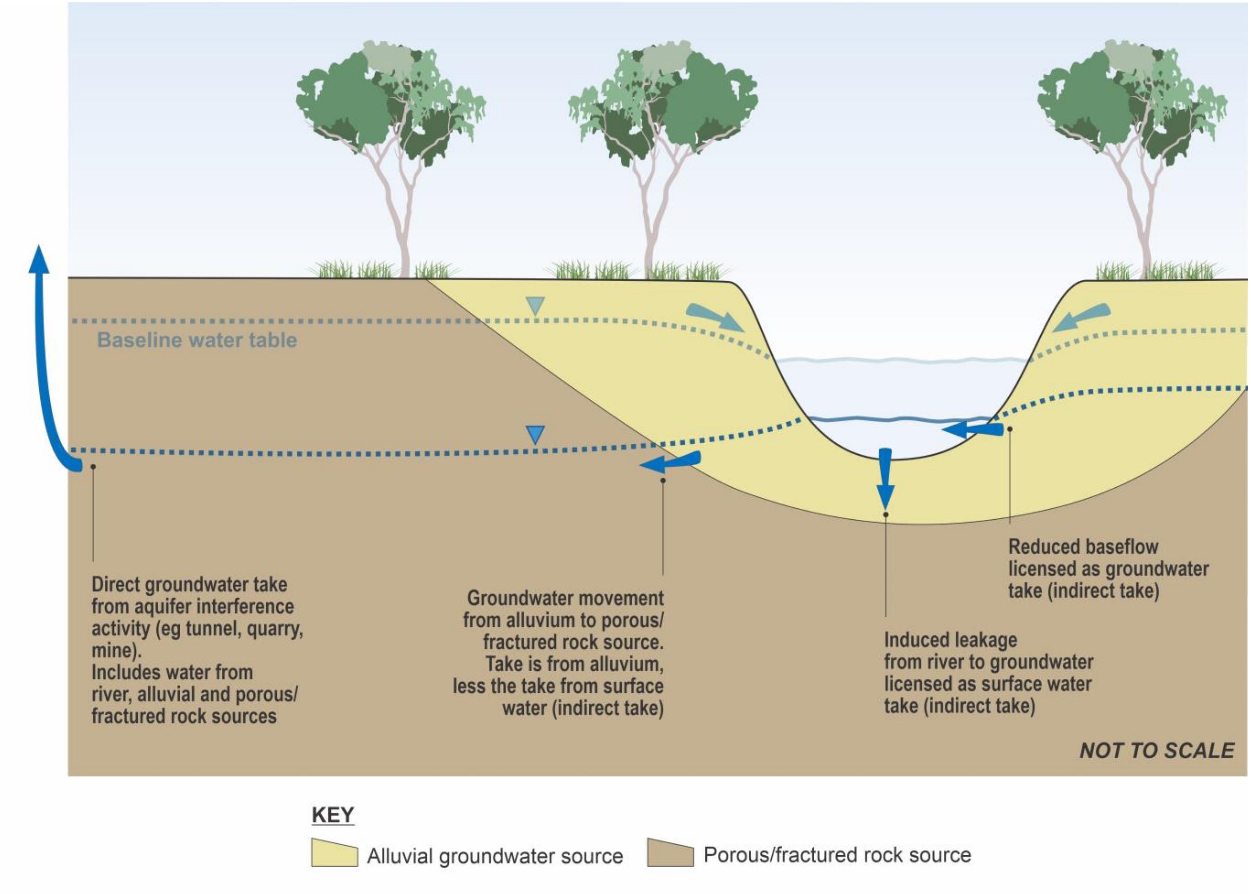

Figure D-3 Licensing requirements by source (surface water vs groundwater)

Exemptions

Exemptions from some licensing and approval requirements apply for some low-impact activities under certain conditions and mostly relevant to surface water (for example small dams on small creeks, known as harvestable rights dams). However, some exemptions do apply for some groundwater works, such as stock and domestic bores and some monitoring bores. In addition, groundwater take of 3 ML or less for aquifer interference activities, where the take is for non-consumptive purposes or supply, is exempt from requiring a WAL.

Clause 5.23 (1)(g) of the EP&A Act exempts an SSI project authorised by a development consent from requiring a water use approval under Section 89, a water management work approval under Section 90, or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act.

Under Clause 4.41(1)(g) of the EP&A Act, SSD projects are exempt from requiring a water use approval under Section 89, a water management work approval under Section 90, or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act.

The *Water Management (General) Regulation 2018* specifies exemptions for access licences and various approvals.

Metering

The WM Act also includes requirements to the use of non-urban water meters. Metering requirements are provided in the *Water Management (General) Regulation 2018* and the *NSW Non-Urban Water Metering Policy*. The rollout of the *Non-Urban Water Metering Policy* began in 2018 and will be staged over five years.

Bore dealing impact assessment

Where water is taken primarily for consumptive use from a bore or borefield, the intent is that these activities be assessed and licensing requirements applied in the same way as water supply works, for example irrigation bores. The assessment criteria of bore(s) for consumptive use differs to the AIP criteria.

The department's Water division and NRAR encourage proponents to apply for a water supply work approval for a bore(s) or borefield(s) for SSD water supply purposes prior to the lodgement of an EIS, as it:

- Allows the bore/borefield extraction limits to be established;
- The opportunity to demonstrate a strategy for a reliable water supply for the project; and
- Permits the ability for the proponent and the department's Water division to assess the cumulative impact of the project against the AIP 'minimal impact considerations' with consideration of the bore/borefield extraction limit.

Under Clause 4.41(1)(g) of the EP&A Act, SSD projects are exempt from requiring a water use approval under Section 89, a water management work approval under Section 90, or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act. This includes approval for production bores. Should the project be approved, and if a proponent already holds a WAL, the proponent can apply to amend the existing WAL to link it to a Miscellaneous Work for all works associated with the project. The 'dealing' will be referred to the department's Water division for assessment under the department's Water division's 'dealing impact assessment' process.

If a bore/borefield water supply is not resolved prior to EIS submission, there is a risk that the planned take (water supply strategy) from a bore/borefield may not be approved or a lower extraction limit may be applied to the work. Where impact criteria exceed water dealing thresholds, water extraction limits may be set lower than that required or the application may be refused. This has the potential to become a constraint for a project, as the proponent may need to scale project activities to remain within permissible volumes of water extraction.

Department of Planning and Environment – Water hydrogeological assessment of dealings and works approvals

Once an application for a dealing or a water supply work approval has been checked and accepted by either WaterNSW or NRAR, it is then referred to the department's Water division for assessment. The process for dealing with these applications is shown in Figure D-4.

Figure D-4 Simplified process for assessing groundwater dealings and new works applications

Prioritisation and approvals are based on the level of risk to the groundwater source and its dependent ecosystems. The risk categories are:

- Low risk—no further impact assessment is required and the application is approved subject to standard conditions;
- Medium risk—a simple hydraulic assessment required (analytical model); and
- High risk—a detailed hydraulic assessment required (analytical model).

The hydraulic assessment involves the analysis of expected drawdown impacts compared to the acceptable levels of impact specified for each groundwater source.

Acceptable levels of impacts are described in DoI Water (2018) and the state-wide application is summarised in Table 16 and the following text.

Table 16: Summary of criteria for acceptable level of impacts associated with bore(s)

Groundwater source	Impact on water table (unconfined aquifers)	Impact on groundwater pressure (confined and semi-confined aquifers)
Alluvial Groundwater Sources (all except below)	✓	✓
Lower Murrumbidgee (deep) and Lower Murray water sources	Not Applicable	✓ #
Lower Gwydir and Lower Namoi water sources	✓	✓
Coastal Sands Groundwater Sources (all)	✓ #	✓
Porous and Fractured Rock Groundwater Sources (all except below)	✓	✓
GAB – Eastern and Southern Recharge water sources	✓	✓ #
GAB – Surat, Warrego and Central water sources	Not Applicable	✓ #

Note: # - special criteria apply

Typically for unconfined aquifers across all types of groundwater systems the acceptable criteria are:

1. Less than 0.1 metre cumulative drawdown in the water table, 40 metres from any:
   a) high-priority, groundwater-dependent ecosystem; or
   b) high-priority, culturally significant site.
2. An additional drawdown of not more than 10% of the pre-development Total Available Drawdown (TAD) above the base of the water source to a maximum of 2 metres at any:
   a) 3rd or higher order surface water source measured at 40 metres from the high bank; or
   b) water supply works (excluding those on the same property) subject to negotiation with impacted parties.
3. (alluvium) A cumulative drawdown of not more than 10% of the pre-development TAD of the water source to a maximum of 2 metres at a distance of 200 metres from any water supply works (including the pumping bores) subject to negotiation with impacted parties.
4. (porous and fractured rock) A cumulative drawdown of no more than 10% of the pre-development TAD of the unconfined aquifer at a distance of 200 metres from any water supply works including the pumping bores.

Typically for semi-confined or confined aquifers across all types of groundwater systems the acceptable criteria are:

1. A cumulative drawdown of not more than 40% of the pre-development TAD above the base of the water source at a distance of 200 metres from any water supply works including the pumping bores.
2. An additional drawdown of not more than 10% of the pre-development TAD above the base of the water source to a maximum of 3 metres at any water supply works (excluding those on the same property), subject to negotiation with impacted parties.

Environment Protection and Biodiversity Conservation Act 1999

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action that involves a coal seam gas development or a large coal mining development requires assessment by and approval from the Commonwealth Government if the action has, will have, or is likely to have a significant impact on a water resource (‘the water trigger’) or other matter of national environmental significance.

Australian and state regulators (including NSW) who are signatories to the National Partnership Agreement seek the advice of IESC under the EPBC Act at appropriate stages of the approvals process for a coal seam gas or large coal mining development that is likely to have a significant impact on water resources. The overall objective of the National Partnership Agreement was to strengthen the regulation of coal seam gas and large coal mining development by ensuring that future decisions are informed by substantially improved science and independent expert advice.

Proponents of a coal seam gas or large coal mining development that is likely to have a significant impact on water resources are to refer the proposed action to the Commonwealth Department of Agriculture, Water and the Environment (DAWE) to determine whether the proposed action will need formal assessment and approval under the EPBC Act (that is, whether the project is a controlled action). If declared a controlled action, the project will require approval under the EPBC Act). However, it is noted that proponents can still make a referral if the action is considered unlikely to have a significant impact on a water resource or other matter of national environmental significance, for DAWE to confirm that the proposal is not a controlled action, and therefore does not need approval under the EPBC Act.

DAWE determines what is considered to be a significant impact based on the Significant Impact Guidelines 1.3 (DoE 2013). Typically, the Commonwealth Office of Water Science and the IESC will provide advice to DAWE on water related matters while NSW Government are also assessing the project.

Appendix E

Guideline checklist

Project setting (If any ‘no’ answers are recorded, then proponent to provide explanation)	
Scope of the project described (including construction, operation and closure)?	☐ Yes ☐ No
Location of project clearly identified (address and real property description, and/or lot and plan information)?	☐ Yes ☐ No
Environmental setting described (including topography, climate, the location of surface water features, biodiversity values and land use)?	☐ Yes ☐ No
Appreciation of regional and local geological setting clearly stated?	☐ Yes ☐ No
Geological structural features potentially affecting groundwater behaviour identified?	☐ Yes ☐ No
Will any project related excavation remain above the water table?	☐ Yes ☐ No
Have baseline groundwater field investigations been conducted and report provided?	☐ Yes ☐ No
Have the relevant Water Sharing Plans and relevant water sources been identified?	☐ Yes ☐ No
Has the proponent consulted with the local community, local Aboriginal community, council, Department of Planning and Environment – Water, EPA, WaterNSW and Environment, Energy and Science group within the department (where relevant) to establish cultural and environmental values of the water sources?	☐ Yes ☐ No
Receptors (If any ‘no’ answers are recorded, then proponent to provide explanation)	
Have mapped high priority groundwater dependent ecosystems, listed in the relevant Water Sharing Plans, been identified?	☐ Yes ☐ No
Has the proponent reviewed the GDE Atlas to identify any other mapped potential groundwater dependent ecosystems in the project area?	☐ Yes ☐ No

Has the proponent identified other potential groundwater dependent ecosystems out of other technical specialist analysis? Have the technical specialists used outputs from the GIA for their ecological assessment?	☐ Yes ☐ No
Have considered and identified potential culturally significant sites listed in the relevant Water Sharing Plans been identified?	☐ Yes ☐ No
Has the proponent identified third-party users in the vicinity that might be impacted identified (Registered/unregistered)?	☐ Yes ☐ No
Groundwater investigations and groundwater impact assessment (If any 'no' answers are recorded, then proponent to provide explanation)	
Groundwater elevation and flow	
Are monitoring bore locations and depths provided and appropriate based on depth and scale of proposed development?	☐ Yes ☐ No
Are measurements recorded at a frequency suitable to detect potential changes (EIS or post-approval)?	☐ Yes ☐ No
Has a bore census of existing third-party bores in the project area been completed?	☐ Yes ☐ No
Is the groundwater baseline provided sufficient (AIP requires 2 years)?	☐ Yes ☐ No
Has the proponent assessed vertical gradients between overlying water sources?	☐ Yes ☐ No
Has the proponent provided water table elevation and potentiometric surface contour plans for water sources pre-development (including consideration of wet/winter and summer/dry seasonal variations), supported by points labelled with measured groundwater elevation?	☐ Yes ☐ No
Has the proponent provided evidence of spatial and temporal assessment of groundwater elevation and flow (that is, vertical and lateral with time and seasons)?	☐ Yes ☐ No

Hydraulic properties	
Has the proponent conducted hydraulic tests at various locations across the project area? For example, slug tests, pumping tests, packer tests, core tests.	☐ Yes ☐ No
Has the proponent conducted a literature review of potential hydraulic properties for the water sources in the project area? For example, other projects in the area or textbook values.	☐ Yes ☐ No
Groundwater quality	
Has the proponent included sufficient spatial & temporal variation in groundwater quality data?	☐ Yes ☐ No
Was the potential for cross contamination of aquifers assessed sufficiently?	☐ Yes ☐ No
Is the baseline groundwater quality defined and described sufficiently with respect to the cultural and environmental values and the development?	☐ Yes ☐ No
Is quality assurance data provided?	☐ Yes ☐ No
Conceptual hydrogeological model	
Has the proponent described the hydrostratigraphic units in the project area?	☐ Yes ☐ No
Has the proponent assessed and described potential surface water-groundwater interaction?	☐ Yes ☐ No
Has the proponent considered existing water use in the area?	☐ Yes ☐ No
Has the proponent provided a graphical representation of the conceptual hydrogeological model (cross-section or three dimensional block model) to show hydrostratigraphy and other groundwater processes described above?	☐ Yes ☐ No
Has the proponent provided a graphical representation of potential groundwater dependence of GDEs within the project area?	☐ Yes ☐ No

Impact assessment (If any 'no' answers are recorded, then proponent to provide explanation)	
Is the assessment methodology commensurate with the risk and as agreed with the department's Water division? For example, analytical model versus simple numerical model vs complex numerical model?	☐ Yes ☐ No
Has the proponent completed the Aquifer Interference Assessment Framework form?	☐ Yes ☐ No
Has the proponent assessed the predicted impacts against the Aquifer Interference Policy "minimal impact considerations"?	☐ Yes ☐ No
Has the proponent assessed the predicted impacts during construction, operations and post-development?	☐ Yes ☐ No
Have the potential impacts from changes in water quality, water quantity, aquifer integrity and biological integrity of groundwater dependent ecosystems been identified and quantified?	☐ Yes ☐ No
Has the proponent assessed the potential presence of acid sulfate soils?	☐ Yes ☐ No
Has the proponent assessed the potential for generation of acid metalliferous drainage?	☐ Yes ☐ No
Has the proponent documented the predicted annual water take (per water source) on an annual basis?	☐ Yes ☐ No
Has the proponent documented the licensing pathway proposed to secure the required water entitlement for water access licence(s) for the predicted take?	☐ Yes ☐ No
Has the proponent assessed impacts on the groundwater dependent ecosystems and culturally significant sists in accordance with the Aquifer Interference Policy considerations?	☐ Yes ☐ No

Management and mitigation measures (If any 'no' answers are recorded, then proponent to provide explanation)	
Are the documented management and mitigation measures practical and measurable?	☐ Yes ☐ No
Has the proponent documented the approach to the proposed monitoring program during construction and operations?	☐ Yes ☐ No
Water management plans (If any 'no' answers are recorded, then proponent to provide explanation)	
Are the documented management and mitigation measures practical and measurable?	☐ Yes ☐ No
Does it include a review and summary of groundwater baseline data?	☐ Yes ☐ No
Has the proponent documented the approach to the proposed monitoring program during construction and operations?	☐ Yes ☐ No
Has the proponent described the methods for measuring take?	☐ Yes ☐ No
Is trigger level management applied to the correct locations?	☐ Yes ☐ No
Are trigger levels set at points that will provide timely action?	☐ Yes ☐ No
Are response actions described that will address exceedances?	☐ Yes ☐ No
Has trend analysis of monitoring data been conducted using statistical approach?	☐ Yes ☐ No
Has the proponent documented a commitment to review and verify model predictions from the EIS stage (during the project development)?	☐ Yes ☐ No

Compliance reporting (If any 'no' answers are recorded, then proponent to provide explanation)	
Has the proponent reported and assessed monitoring trends with a comparison to predictions made in the EIS stage?	☐ Yes ☐ No
Were any trigger levels exceeded during the reporting period?	☐ Yes ☐ No
Has the proponent conducted a holistic assessment of water quality and quantity when reviewing monitoring data and assessing impacts?	☐ Yes ☐ No
Has the proponent reported water take volumes (per water source) for the reporting period (ideally in a table format)?	☐ Yes ☐ No
Has the proponent compared the actual take to the take predicted as part of the EIS? Does this trigger a requirement to obtain additional water entitlement?	☐ Yes ☐ No
Are observations from other technical discipline compliance reporting considered in the water reporting? For example, implication of subsidence or ecological monitoring?	☐ Yes ☐ No

Appendix F

Standard units and terminology

Information presented in the groundwater impact assessment provided should be clear, succinct, objective and where appropriate, supported by maps and other descriptive detail. Repetitive or general non-specific data is distracting and is not relevant to the decision-making process. The use of jargon should be avoided.

Information presented in the groundwater impact assessment report and supporting groundwater investigation documentation must use consistent terminology and measurements. Table 17 lists the commonly used terms and measurements.

Table 17: Terminology and units

Term/measurement	Units to be used	Comments
Elevation	Metres Australian Height Datum (mAHD)	Surveying of bore measurement /reference points (typically top of casing) by a registered surveyor to required accuracy necessary for groundwater assessments
Depth	Metres below reference point	For a bore, the reference point should be the surveyed measurement/reference point.
	Metres below ground level	Typically, the surveyed measurement/reference point at a bore is the top of casing, which has the potential to give a false impression of depth to groundwater, which can be important for consideration of surface water-groundwater interaction and GDE reliance and access to water.
Hydraulic conductivity	Metres per day (m/day)	
Transmissivity	Square metres per day (m^2/day)	
Bore yield\pumping rate	Litres per second (L/sec)	
Take\groundwater inflows	Megalitres per year (ML/yr)	
Depth to groundwater	Metres below reference point	For a bore, the reference point should be the surveyed measurement/reference point.
Groundwater level	Metres Australian Height Datum (mAHD)	
Field pH	pH units	Requires field measurement of pH is required due to the short (6 hrs) hold time. Field water quality meters should be calibrated daily to ensure measurement accuracy.
Field electrical conductivity	Microsiemens per centimetre (µS/cm) or millisiemens per centimetre (mS/cm)	Field water quality meters should be calibrated daily to ensure measurement accuracy.
Field temperature	Degrees Celsius (°C)	

Appendix G

Consultation

Consultation with stakeholders, including the local community, council, Aboriginal community, NSW Government and Commonwealth agencies (depending on the project) will be conducted as part of the overall EIS process and will be managed through the Planning and Assessment team of the department. It is necessary for some groundwater specific consultation to occur with the department's Water division, NRAR, EPA and/or WaterNSW (depending on the project) at the following key stages of an SSD project:

- Development of the Groundwater Monitoring and Modelling Plan (GMMP), only relevant for mining or petroleum exploration projects and needed in the early stages of the project planning. The GMMP documents the proposed monitoring plan that will be implemented to obtain baseline data needed to conduct an assessment, as well as the proposed approach to future modelling for the project. This is discussed further in Part A of the Guideline. The details of the mining or petroleum development are typically preliminary and limited at this stage of the project.
- Introduction to the project, typically prior to the submission of the Scoping Report (prepared by the EIS team with inputs from technical specialists). In comparison to the consultation completed as part of the GMMP, the project is typically more advanced. For example, the proponent would have project design information, such as layout, design depth and construction and operation schedule. Requests for consultation are directed through the Planning and Assessment team. the department's Water division strongly recommends that proponents communicate with the department's Water division and NRAR early in the process to identify whether a lack of available authorisations for a water source could be a constraint to project approval.
- Prior to completion of the GIA and EIS, providing an update on the approach to the assessment and preliminary results of the assessment predictions. Requests for consultation are directed through the Planning and Assessment team.
- Following assessment and review of the GIA by the department's Water division, NRAR, EPA and/or WaterNSW. This would occur following receipt of the agency advice and if the agency advice identifies areas for improvement or clarification prior to determination. Requests for consultation are directed through the Planning and Assessment team.

Usually, the GIA will be a stand-alone document presented as an attachment to the EIS and a summary of the key aspects of the GIA will be included within the main content of the EIS. Guidance on the preparing an EIS is provided in the (then) Department of Urban Affairs and Planning (DUAP) NSW EIS guideline series (1996a, 1996b, 1996c and 2000) and the draft Environmental Impact Assessment guidelines released by the (then) Department of Planning and Environment in June 2017.