THE BASIN PLAN IMPLEMENTATION

NSW Murray-Darling Basin Porous Rock Risk Assessment

GW6 Water Resource Plan Area

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NSW Office of Environment and Heritage Atlas of NSW Wildlife data
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www.biotnet.nsw.gov.au

NSW DPI Fisheries Fish Community Status and Threatened Species data
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dpi.nsw.gov.au/fishing/species-protection/threatened-species-distributions-in-nsw

Executive summary

The *Basin Plan 2012* (Basin Plan) requires Basin states to prepare water resource plans (WRPs). The risk assessment for the NSW Murray-Darling Basin Porous Rock Water Resource Plan Area (GW6) has been prepared to meet the requirements of the Basin Plan, assessing current and future risks to the condition and continued availability of the water resources. This document will be used to guide the development of the NSW Murray-Darling Basin Porous Rock WRP.

Part 9 of Chapter 10 of the Basin Plan sets out the key requirements for WRP risk assessments.

Chapter 10, Part 9 of the Basin Plan			
10.41	Risk identification and assessment methodology		
	(1)	Regard to current and future risks	
	(2)	(a)	Risks to meeting environmental watering requirements
		(b)	Risks arising from matters referred to in section 10.20(1) (productive base of groundwater)
		(c)	Risks arising from potential interception activities
		(d)	Risks arising from elevated levels of salinity or other types of water quality degradation
	(3)	(a)	Risks identified in section 4.02
	(4)	List the identified risks	
	(5)	Assess each risk	
	(6)	Categories of level of risk	
	(7)	Description of the data and methods	
	(8)	Description of uncertainty	
10.42	Description of risks		
10.43	Strategies for addressing risks		
	(1)	Water resource plan risk mitigation strategies	
	(2)	Strategies take account of Chapter 10 requirements	
	(3)	(a)	WRPs must regard to strategies listed in section 4.03(3)

The risk assessment framework adopts a cause/threat/impact model that describes the impact pathway for risks to affect a receptor. The risk level of an impact is a function of the likelihood of a cause or threat occurring, and the consequence of the impact on the receptor. The risk level is assessed with the current mechanisms and rules in place, as provided for under the NSW *Water Management Act 2000* (WMA 2000) and the relevant water sharing plan/s (WSP).

The Basin Plan requires a WRP to describe strategies to address medium or high risks in a manner commensurate with the level of risk. A strategy is commensurate with the level of risk if it results in the level of risk being tolerable. If the risk cannot be addressed to a tolerable level, an explanation should be provided. For example, there may be instances where an identified risk cannot be mitigated due to a range of constraints including, but not limited to infrastructure, third party economic or social impacts, or sustainable diversion limits.

Risk-based management assists water managers to prioritise, plan and direct resources to monitor, mitigate or respond to the factors that pose the highest overall risks. It ensures that strategies (both existing and proposed) are targeted to the appropriate part of the water system. In the context of the NSW risk assessment process, a medium or high risk does not automatically imply existing management or rules are inadequate or require change, or that new strategies are required. Rather, the risk assessment can be considered a 'red flag' process to provide guidance for where more detailed investigation may be required.

Medium and high risk outcomes identified in this risk assessment were reviewed to determine whether they are adequately addressed by existing strategies, or whether modifications or new strategies may be required. Risk treatment options were developed following a systematic approach outlined in Figure 8-1 and Table 8-1. Defining tolerable risk outcomes (i.e. those high or medium results NSW considers are acceptable or adequately managed by existing water resource management strategies) were also part of this approach. Explanations for risk outcomes that the WRP cannot address in a manner commensurate with the level of risk are provided in Table 8-3 and the following consolidated risk table.

Consolidated risk table

The consolidated risk table has been developed in conjunction with the Murray Darling Basin Authority (MDBA) and in response to stakeholder feedback on risk assessment drafts. The table presents a summary of risk outcomes for each risk assessed in this report contextual information to meet Basin Plan accreditation requirements. It provides a line of sight for each sustainable diversion limit (SDL) resource unit between the risk assessment and risk treatment pathway and includes the following elements which reflect the requirements of the Basin Plan Chapter 10 Part 9 Approaches to addressing risks to water resources:

risk assessment including risk identification and the risk calculation basis (existing critical mechanisms mitigating risk at the time the risk was assessed, consequence, likelihood, risk outcome and data confidence),
risk treatment pathway including risk treatment option, strategies to address all medium and high risk outcomes and additional critical mechanisms introduced as a result of water resource plan development or available to manage risk but not active when risk was assessed,
tolerability assessment provided for each medium and high risk outcome and associated explanations,
ongoing risk monitoring provided by indicating where monitoring and evaluation is expected for the water resource plan and associated water sharing, water quality management and long term watering plans.

The consolidated risk table should be used in conjunction with Table 8-7. This table is an overview of strategy and mechanism relationships. It provides details of the associated management plan and other legislative instrument part or section references (including the Basin Plan), and the relevant water sharing plan and water quality management plan objectives. The following table describes the content of the consolidated risk table; also refer to Appendix 1 for an overview of the risk assessment process and further explanation of risk assessment drivers and terms.

Consolidated risk table interpretation

General information

Each risk has a separate consolidated table section. Each section title contains the relevant report section, risk title and abbreviation used in tables within this report.

The consolidated table is divided into two sections (**risk assessment** and **risk treatment pathway**) to clearly show the transition from risk assessment to risk treatment, including which critical water management mechanisms were in place when the risk was assessed, prior to WRP commencement.

SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEM [R1]

Risk assessment							Risk treatment pathway					
Sustainable diversion limit (SDL) resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**

Location information

WRP water management unit information as specified in the Basin Plan.

Information on the calculation basis of the risk outcome

Existing critical mechanisms are included here as the risk outcomes were calculated with these WSP or WMA 2000 based water management controls in place. These key active mechanisms currently address the risk. Mechanisms have been included to provide further detail on the **strategies to address risk** and are not intended to be a comprehensive list of all relevant mechanisms. Refer to the water resource plan for the accreditation status of trade rules and listed sections of the WMA 2000.

Consequence and likelihood are used to determine the risk outcome via the matrices described in the relevant section of this report. The column entry abbreviations are:

H high
M medium
L low

And includes the following additional category in some circumstances.

Nil

Risk outcome (result) and confidence ranking

Risk outcome is a function of consequence and likelihood, the following coding is used. ' – QAL' indicates the risk was qualitatively assessed.

Further data confidence information is in Appendix B

H	High
M	Medium
L	Low
Nil	Nil

Information on the application of the risk treatment pathway

Risk treatment option refers to options A-G listed in the **risk treatment pathway** and summarised below; more than one may apply. See Table 8-1 for full descriptions.

A No new strategies required or possible.
B Fill knowledge gap and evaluate effectiveness of existing strategies.
C Knowledge improvement via monitoring, evaluation and reporting (MER) plan is proposed.
D Adjustment of WSPs or WMA 2000 based rules.
E Implementation dormant WSP or WMA 2000 rules.
F Develop and implement new Basin Plan or WSP strategies.
G Review interactions with complementary WMA 2000 processes/other legislation.

Strategies to address risk are required by the Basin Plan to be identified for all medium and high risk outcomes. These are the broad water management and knowledge improvement approaches NSW uses to identify and address risks to water resources. A summary of strategies and their related existing and additional critical mechanisms can be found in Table 8-7. Refer to WRP for the accreditation status of trade rules and listed sections of the WMA 2000

Additional critical mechanisms are WSP or WMA 2000 based water management controls that have been developed, modified, substantially changed in implementation status as a result of WRP development, or are inactive but available if required. Each mechanism has an associated risk treatment option on the **risk treatment pathway**. Mechanisms have been included to provide further detail on the **strategies to address risk** and are not intended to be a comprehensive list of all relevant mechanisms.

Outcomes of risk treatment

Tolerable / residual risk outcome refers to:

1 Any change to the **risk outcome** after the application of **additional critical mechanisms** and recalculation of (residual) risk. For groundwater risk assessments, these mechanisms have not changed the **risk outcomes**.

2 The tolerable status of the **risk outcome**. NSW has considered whether risk outcomes are acceptable on the basis the risk is adequately managed by the existing and additional critical mechanisms. This is in line with the *Basin Plan Water Resource Plan Requirements Position Statement 9B Strategies for addressing risks.* The tolerable status is indicated by paler shading of the risk outcome as below. Explanations are included in the second column of this section. Low risk outcomes have N/A (not applicable) as they do not require a tolerable status. Refer to Table 8-3 for a summary of explanations.

H	High – tolerable
H	High – not tolerable
M	Medium – tolerable
M	Medium – not tolerable

Link to monitoring and management plans

Information regarding the ongoing monitoring, evaluation and reporting for water management plan performance including the WRP, WSP, water quality management plan (WQM Plan) and long-term watering plan (LTWP) (where relevant). Refer to the environmental monitoring, evaluation and reporting plan EMER Plan for further information.

SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEMS [R1]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**

Consolidated risk table interpretation

General information

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Risk assessment							Risk treatment pathway					
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Location information

WRP water management unit information as specified in the Basin Plan.

Information on the calculation basis of the risk outcome

Existing critical mechanisms are included here as the risk outcomes were calculated with these WSP or WMA 2000 based water management controls in place. These key active mechanisms currently address the risk. Mechanisms have been included to provide further detail on the **strategies to address risk** and are not intended to be a comprehensive list of all relevant mechanisms. Refer to the water resource plan for the accreditation status of trade rules and listed sections of the WMA 2000.

Consequence and likelihood are used to determine the risk outcome via the matrices described in the relevant section of this report. The column entry abbreviations are:

H high
M medium
L low

And includes the following additional category in some circumstances.

Nil

Risk outcome (result) and confidence ranking

Risk outcome is a function of consequence and likelihood, the following coding is used. ' – QAL' indicates the risk was qualitatively assessed.

Further data confidence information is in Appendix B

H	High
M	Medium
L	Low
Nil	Nil

Information on the application of the risk treatment pathway

Risk treatment option refers to options A-G listed in the **risk treatment pathway** and summarised below; more than one may apply. See Table 8-1 for full descriptions.

A No new strategies required or possible.
B Fill knowledge gap and evaluate effectiveness of existing strategies.
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D Adjustment of WSPs or WMA 2000 based rules.
E Implementation dormant WSP or WMA 2000 rules.
F Develop and implement new Basin Plan or WSP strategies.
G Review interactions with complementary WMA 2000 processes/other legislation.

Strategies to address risk are required by the Basin Plan to be identified for all medium and high risk outcomes. These are the broad water management and knowledge improvement approaches NSW uses to identify and address risks to water resources. A summary of strategies and their related existing and additional critical mechanisms can be found in Table 8-7. Refer to WRP for the accreditation status of trade rules and listed sections of the WMA 2000

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Outcomes of risk treatment

Tolerable / residual risk outcome refers to:

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2 The tolerable status of the **risk outcome**. NSW has considered whether risk outcomes are acceptable on the basis the risk is adequately managed by the existing and additional critical mechanisms. This is in line with the *Basin Plan Water Resource Plan Requirements Position Statement 9B Strategies for addressing risks.* The tolerable status is indicated by paler shading of the risk outcome as below. Explanations are included in the second column of this section. Low risk outcomes have N/A (not applicable) as they do not require a tolerable status. Refer to Table 8-3 for a summary of explanations.

H	High – tolerable
H	High – not tolerable
M	Medium – tolerable
M	Medium – not tolerable

Link to monitoring and management plans

Information regarding the ongoing monitoring, evaluation and reporting for water management plan performance including the WRP, WSP, water quality management plan (WQM Plan) and long-term watering plan (LTWP) (where relevant). Refer to the environmental monitoring, evaluation and reporting plan EMER Plan for further information.

SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEMS [R1]

Risk assessment							Risk treatment pathway					
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale).	Nil	Nil	Nil	H/L	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public	N/A	None required	MER planned for WSP and WQM Plan objectives

Consolidated risk table interpretation

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SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEM [R1]

Risk assessment							Risk treatment pathway					
Sustainable diversion limit (SDL) resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**

Location information

WRP water management unit information as specified in the Basin Plan.

Information on the calculation basis of the risk outcome

Existing critical mechanisms are included here as the risk outcomes were calculated with these WSP or WMA 2000 based water management controls in place. These key active mechanisms currently address the risk. Mechanisms have been included to provide further detail on the **strategies to address risk** and are not intended to be a comprehensive list of all relevant mechanisms. Refer to the water resource plan for the accreditation status of trade rules and listed sections of the WMA 2000.

Consequence and likelihood are used to determine the risk outcome via the matrices described in the relevant section of this report. The column entry abbreviations are:

H high
M medium
L low

And includes the following additional category in some circumstances.

Nil

Risk outcome (result) and confidence ranking

Risk outcome is a function of consequence and likelihood, the following coding is used. ' – QAL' indicates the risk was qualitatively assessed.

Further data confidence information is in Appendix B

- H High
- M Medium
- L Low
- Nil Nil

Information on the application of the risk treatment pathway

Risk treatment option refers to options A-G listed in the **risk treatment pathway** and summarised below; more than one may apply. See Table 8-1 for full descriptions.

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B Fill knowledge gap and evaluate effectiveness of existing strategies.
C Knowledge improvement via monitoring, evaluation and reporting (MER) plan is proposed.
D Adjustment of WSPs or WMA 2000 based rules.
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Outcomes of risk treatment

Tolerable / residual risk outcome refers to:

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2 The tolerable status of the **risk outcome**. NSW has considered whether risk outcomes are acceptable on the basis the risk is adequately managed by the existing and additional critical mechanisms. This is in line with the *Basin Plan Water Resource Plan Requirements Position Statement 9B Strategies for addressing risks.* The tolerable status is indicated by paler shading of the risk outcome as below. Explanations are included in the second column of this section. Low risk outcomes have N/A (not applicable) as they do not require a tolerable status. Refer to Table 8-3 for a summary of explanations.

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- H High – not tolerable
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- M Medium – not tolerable

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SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEMS [R1]

Risk assessment							Risk treatment pathway					
GS50	Western Porous Rock	E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise.	M	L	L	H/L	N/A		interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent	N/A		

Consolidated risk table interpretation

General information	SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEM [R1]												
	Risk assessment							Risk treatment pathway					
	Sustainable diversion limit (SDL) resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
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SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEMS [R1]

Risk assessment							Risk treatment pathway					
GS41	Sydney Basin MDB	E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources.	M	Nil	Nil	H/L	N/A		ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source	N/A		

Consolidated risk table interpretation

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SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEM [R1]

Risk assessment							Risk treatment pathway					
Sustainable diversion limit (SDL) resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**

Location information

WRP water management unit information as specified in the Basin Plan.

Information on the calculation basis of the risk outcome

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- L Low
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Information regarding the ongoing monitoring, evaluation and reporting for water management plan performance including the WRP, WSP, water quality management plan (WQM Plan) and long-term watering plan (LTWP) (where relevant). Refer to the environmental monitoring, evaluation and reporting plan EMER Plan for further information.

SECTION 4.3 RISKS TO STRUCTURAL INTEGRITY OF THE GROUNDWATER SYSTEMS [R1]

Risk assessment							Risk treatment pathway					
GS17	Gunnedah-Oxley Basin MDB	E7 Trade limits or prohibitions between groundwater sources and management zones. K3 Existing groundwater level and take monitoring programs	H	Nil	Nil	H/L	N/A		*Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A		

SECTION 4.4 RISK OF GROUNDWATER EXTRACTION INDUCING CONNECTION WITH POOR QUALITY GROUNDWATER [R2]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E15 Setback distances from known contamination sites and plumes. E16 Bore construction standards. E17 Work approval conditions may place conditions on the bore such as screen depth conditions. E22 Allow licences to be issued and used to manage potential impacts of salinity and rising water tables.K5 Complementary water quality and environmental monitoring programs	Nil	L	Nil	H/M	N/A	1 Limit total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels. 2 Manage the location and rate of groundwater extraction at a local scale within water sources and SDL management units to prevent or manage localised drawdown related impacts. 6 Limit extraction near contamination sources. This strategy aims to protect overlying ground and surface water sources and public health and safety by limiting exposure to and mobilisation of contamination sources. 7 Limit induced inter aquifer connectivity. 7B Manage potential impacts of salinity and rising water tables 9 Implement the WQM Plan for the WRP area. 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.* K4 Proposed water quality and environmental monitoring programs	N/A	The risk outcomes for induced connection with poor water quality (salinity) in the NSW MDB Porous Rock are tolerable because strategies and mechanisms established in the relevant WSP are in place to manage local drawdown impacts that could lead to elevated salinity levels. With reference to other types of groundwater degradation NSW considers the NSW Environment Protection Authority's risk based licensing and approval system adequately manages the threat of water quality degradation from major contaminants entering the groundwater SDL source units from point sources and hence adequately mitigates risk. Mechanisms (i.e. measures) are also in place to reduce the mobilisation of nutrients within the SDL unit from known contamination sites and plumes induced from pumping. Refer to the WQM Plan (Tables 6 and 11) for further details.	MER planned for WQM Plan objectives
GS50	Western Porous Rock		M	M	M	H/M	F,A,A			M		
GS41	Sydney Basin MDB		M	M	M	H/M	F,A,A			M		
GS17	Gunnedah-Oxley Basin MDB		H	L	M	H/M	F,A,A			M		

SECTION 4.5 RISK OF LOCAL DRAWDOWN REDUCING GROUNDWATER ACCESS BY CONSUMPTIVE USERS [R3]

Risk assessment								Risk treatment pathway				
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E14 Setback distances for new bores from bores on neighbouring properties, bores used to supply local water or major utilities and NSW Department of Planning and Environment monitoring bores. K3 Existing groundwater level and take monitoring programs	Nil	Nil	Nil	H/H	N/A	1 Limit total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels. 2 Manage the location and rate of groundwater extraction at a local scale within water sources and SDL management units to prevent or manage localised drawdown related impacts. 5 Limit interference between bores. This strategy aims to limit new production bores impacting on established bores used for a set list of purposes. 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	These risk outcomes are tolerable because strategies and mechanisms are in place to manage local drawdown impacts. The WSP establishes minimum distances between groundwater extraction points (water supply works) to minimise interference and impacts. The Minister may also to apply restrictions on extraction from these works to minimise interference between users, to maintain or protect water levels in an aquifer, or to maintain pressure, or to ensure pressure recovery, in an aquifer. Risk calculations are based on extraction density mapping using a five kilometre radius. This is a conservative approach to identifying the cumulative impacts of bores.	MER planned for WSP and WQM Plan objectives
GS50	Western Porous Rock		M	M	M	H/H	F,A,A			M		
GS41	Sydney Basin MDB		M	L	L	H/H	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		H	H	H	H/H	F,A,A			H		

SECTION 4.6. RISK OF SEDIMENT COMPACTION IMPACTING SURFACE WATER USERS (QL1)

Risk assessment					Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Risk outcome**	**Data confidence**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
N/A	All overlying surface water SDL resource unit (see Table 3-1)	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. K3 Existing groundwater level and take monitoring programs	Nil – QAL	Low	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source. *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.* K1 Projects resulting from application of risk treatment option C Expert opinion with monitoring, evaluation and reporting confirmation strategies (Risk and potential impacts of sediment compaction on overlying surface water resources) *For description of K1 (knowledge strategy) see* Table 8-6	N/A	None required	MER planned for WSP and WQM Plan objectives, Knowledge strategy planned

SECTION 4.7. RISK OF GROUNDWATER EXTRACTION IMPACTING WATER USERS IN ADJACENT GROUNDWATER SYSTEMS (QL2)

Risk assessment					Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Risk outcome**	**Data confidence**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
N/A	All adjacent groundwater SDL resource units (see Table 3-1)	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. K3 Existing groundwater level and take monitoring programs	Nil – QAL	Low	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source. *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	None required	No WRP MER planned
N/A	All adjacent non Murray-Darling Basin resources (see Table 3-1)		Nil – QAL	Low	N/A			N/A		

SECTION 4.8. RISK OF POOR WATER QUALITY TO WATER USERS (QL3)

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application** **OR** **Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E15 Setback distances from known contamination sites and plumes. E16 Bore construction standards. E17 Work approval conditions may place conditions on the bore such as screen depth conditions. K3 Existing groundwater level and take monitoring programs K5 Complementary water quality and environmental monitoring programs Refer to WQM Plan (Tables 6 and 11) for a comprehensive list of mechanisms and explanatory text.	L	L	L – QAL	L/L	N/A	None required 9 Implement the WQM 13 Monitor groundwater resources and dependent ecosystems Plan for the WRP area	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	None required	MER planned for WQM Plan objectives
GS50	Western Porous Rock		L	L	L – QAL	L/L	N/A			N/A		
GS41	Sydney Basin MDB		L	L	L – QAL	L/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		L	L	L – QAL	L/L	N/A			N/A		

SECTION 5.3 RISK OF CLIMATE CHANGE REDUCING RECHARGE AND GROUNDWATER AVAILABILITY [R4]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. K3 Existing groundwater level and take monitoring programs	Nil	L	Nil	H/L	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit.	N/A	None required	MER planned for WSP and WQM Plan objectives
GS50	Western Porous Rock		L	L	L	H/L	N/A			N/A		
GS41	Sydney Basin MDB		L	L	L	H/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	L	L	H/L	N/A			N/A		

SECTION 5.4 RISK OF GROWTH IN BASIC LANDHOLDER RIGHTS REDUCING GROUNDWATER AVAILABILITY [R5]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). K3 Existing groundwater level and take monitoring programs	Nil	Nil	Nil	H/M	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E18 Minister may restrict BLR access. E19 Minister may limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer. E20 Minister may direct landholder accessing BLR to not waste or improperly use water.	N/A	None required	MER planned for WSP and WQM Plan objectives
GS50	Western Porous Rock		L	L	L	H/M	N/A			N/A		
GS41	Sydney Basin MDB		L	L	L	H/M	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		L	L	L	H/M	N/A			N/A		

SECTION 5.5 RISK OF GROWTH IN LOCAL WATER UTILITIES REDUCING GROUNDWATER AVAILABILITY [R6]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E7a Limits to trade of LWU licences. K3 Existing groundwater level and take monitoring programs	Nil	Nil	Nil	H/H	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E18 Minister may restrict BLR access. E19 Minister may limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer. E20 Minister may direct landholder accessing BLR to not waste or improperly use water.	N/A	None required	MER planned for WSP and WQM Plan objectives
GS50	Western Porous Rock		L	L	L	H/H	N/A			N/A		
GS41	Sydney Basin MDB		L	Nil	Nil	H/H	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		L	L	L	H/H	N/A			N/A		

SECTION 5.6 RISK OF INCREASES IN IRRIGATION EFFICIENCY AND IMPROVED WATER DELIVERY REDUCING RECHARGE [R7]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. K3 Existing groundwater level and take monitoring programs	Nil	Nil	Nil	H/L	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit.	N/A	None required	MER planned for WSP and WQM Plan objectives
GS50	Western Porous Rock		L	Nil	Nil	H/L	N/A			N/A		
GS41	Sydney Basin MDB		L	Nil	Nil	H/L	N/A			N/A		

SECTION 5.6 RISK OF INCREASES IN IRRIGATION EFFICIENCY AND IMPROVED WATER DELIVERY REDUCING RECHARGE [R7]

Risk assessment							Risk treatment pathway					
GS17	Gunnedah-Oxley Basin MDB		M	L	L	H/L	N/A			N/A		

SECTION 5.7 RISK OF GROWTH IN PLANTATION FORESTRY INTERCEPTING RECHARGE [R8]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	Plantation establishment and forestry operations on both Crown Land (including state forests) and freehold land are regulated by the *Plantations and Reafforestation Act 1999* (NSW), and the *Plantations and Reafforestation Regulation (Code) 2001*. The Department of Primary Industries' Forestry Division has responsibility for authorising plantations, and for auditing plantation establishment and forest operations for compliance. The risk of growth in plantation forestry intercepting recharge is considered in more detail in the surface water risk assessments; it has been included in the alluvial risk assessments for completeness. K3 Existing groundwater level and take monitoring programs	Nil	Nil	Nil	H/L	N/A	None required 13 Monitor groundwater resources and dependent ecosystems A NSW Commercial Plantations Policy is in development by the DPIE - Water and is expected to address potential forestry impacts on ground and surface waters.	N1 Sustainable Diversion Limits for each groundwater SDL resource unit.	N/A	None required	No WRP MER planned, NSW Department of Primary Industries Forestry monitoring in place
GS50	Western Porous Rock		L	Nil	Nil	H/L	N/A			N/A		
GS41	Sydney Basin MDB		L	Nil	Nil	H/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	Nil	Nil	H/L	N/A			N/A		

<table>
<tr><th colspan="11">SECTION 5.8 RISK OF GROWTH IN MINING REDUCING GROUNDWATER AVAILABILITY (QL4)</th></tr>
<tr><th colspan="5">Risk assessment</th><th colspan="6">Risk treatment pathway</th></tr>
<tr><th>SDL resource unit code</th><th>SDL resource unit</th><th>Existing critical mechanisms
(mechanisms active when risk was assessed)</th><th>Risk outcome</th><th>Data confidence</th><th>Risk treatment option</th><th>Strategies to address risk
(refer to Table 8-7 for further information)</th><th>Additional critical mechanisms
(mechanisms introduced as a result of WRP development or available but not active when risk was assessed)</th><th>Tolerable / residual risk outcome</th><th>Explanation of tolerable risk application
OR
Explanation of why risk cannot be addressed
(refer to Table 8-3)</th><th>Monitoring and evaluation</th></tr>
<tr><td>GS38</td><td>Oaklands Basin</td><td rowspan="4">E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale).
E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits.
E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise.
E4 Extraction limits for individual works to manage extraction at the extraction point.
E5 Compliance with individual extraction limits.
E6 Prohibit trade between surface water and groundwater sources.
E7 Trade limits or prohibitions between groundwater sources and management zones.
K3 Existing groundwater level and take monitoring programs</td><td>L</td><td>M</td><td>N/A</td><td rowspan="4">None required
13 Monitor groundwater resources and dependent ecosystems</td><td rowspan="4">N1 Sustainable Diversion Limits for each groundwater SDL resource unit.
The following mechanisms are available for use if required in the WRP area.
E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to:
(a) maintain water levels in an aquifer, or
(b) maintain, protect or improve the quality of water in an aquifer, or
(c) prevent land subsidence or compaction in an aquifer, or
(d) protect groundwater–dependent ecosystems or
(e) maintain pressure or to ensure pressure recovery in an aquifer.
E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source
Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.</td><td>N/A</td><td rowspan="4">None required</td><td rowspan="4">No WRP MER planned, NSW Aquifer Interference Policy directs MER.</td></tr>
<tr><td>GS50</td><td>Western Porous Rock</td><td>L</td><td>M</td><td>N/A</td><td>N/A</td></tr>
<tr><td>GS41</td><td>Sydney Basin MDB</td><td>L</td><td>M</td><td>N/A</td><td>N/A</td></tr>
<tr><td>GS17</td><td>Gunnedah-Oxley Basin MDB</td><td>L</td><td>M</td><td>N/A</td><td>N/A</td></tr>
</table>

SECTION 6.3 RISK OF GROUNDWATER EXTRACTION CAUSING LOCAL DRAWDOWN (GROUNDWATER–DEPENDENT ECOSYSTEMS) [R9]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application** **OR** **Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. K3 Existing groundwater level and take monitoring programs E22 Allow licences to be issued and used to manage potential impacts of salinity and rising water tables.	Nil	Nil	Nil	H/H	N/A	1 Limit total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels. 2 Manage the location and rate of groundwater extraction at a local scale within water sources and SDL management units to prevent or manage localised drawdown related impacts. 3 Limit the location and rate of extraction in the vicinity of high priority groundwater–dependent ecosystems. 7B Manage potential impacts of salinity and rising water tables 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *Improved implementation of the following existing critical mechanism* E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	Risk is tolerable as a substantial amount of new GDE mapping information has been used to identify high priority GDEs within the WRP area as discussed in section 6.2 significantly improving the implementation of this existing mechanism. The WSP establishes minimum distances between new or amended water supply works and GDEs. The Minister may also apply restrictions on extraction from water supply works to protect GDEs.	MER planned for WSP objectives
GS50	Western Porous Rock		M	M	M	H/H	D, E			M		
GS41	Sydney Basin MDB		L	L	L	H/H	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	H	H	H/H	D, E			H		

SECTION 6.3 RISK OF GROUNDWATER EXTRACTION CAUSING LOCAL DRAWDOWN (INSTREAM ECOLOGICAL VALUES) [R10]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application** **OR** **Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. K3 Existing groundwater level and take monitoring programs K5 Complementary water quality and environmental monitoring programs E22 Allow licences to be issued and used to manage potential impacts of salinity and rising water tables.	Nil	Nil	Nil	H/H	N/A	1 Limit total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels. 2 Manage the location and rate of groundwater extraction at a local scale within water sources and SDL management units to prevent or manage localised drawdown related impacts. 4 Limit impacts of groundwater extraction on surface water flows and surface / groundwater hydraulic relationships. 7B Manage potential impacts of salinity and rising water tables 13 Monitor groundwater resources and dependent ecosystems	Risk is tolerable as there are strategies in place to manage extraction based on degree of surface to groundwater connectivity. Risks are tolerable because the contribution of groundwater to support instream ecological values is less than surface water as these systems are less highly connected to surface waters. As also applies for R9, the WSP establishes minimum distances between new or amended water supply works and streams. The Minister may also apply restrictions on extraction from water supply works to protect GDEs – which include instream ecological values.	N/A	Risk is tolerable as there are strategies in place to manage extraction based on degree of surface to groundwater connectivity. Risks are tolerable because the contribution of groundwater to support instream ecological values is less than surface water as these systems are less highly connected to surface waters. As also applies for R9, the WSP establishes minimum distances between new or amended water supply works and streams. The Minister may also apply restrictions on extraction from water supply works to protect GDEs – this includes groundwater dependent instream ecological values.	MER planned for WSP objectives
GS50	Western Porous Rock		L	M	L	H/H	N/A			N/A		
GS41	Sydney Basin MDB		M	L	L	H/H	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		L	H	M	H/H	D,E			M		

<table>
<tr><th colspan="13">SECTION 6.4 RISK OF GROWTH IN PLANTATION FORESTRY INTERCEPTING RECHARGE (GROUNDWATER–DEPENDENT ECOSYSTEMS) [R11]</th></tr>
<tr><th colspan="7">Risk assessment</th><th colspan="6">Risk treatment pathway</th></tr>
<tr><th>SDL resource unit code</th><th>SDL resource unit</th><th>Existing critical mechanisms
(mechanisms active when risk was assessed)</th><th>Consequence</th><th>Likelihood</th><th>Risk outcome</th><th>Data confidence (Consequence / Likelihood)</th><th>Risk treatment option</th><th>Strategies to address risk
(refer to Table 8-7 for further information)</th><th>Additional critical mechanisms
(mechanisms introduced as a result of WRP development or available but not active when risk was assessed)</th><th>Tolerable / residual risk outcome</th><th>Explanation of tolerable risk application
OR
Explanation of why risk cannot be addressed
(refer to Table 8-3)</th><th>Monitoring and evaluation</th></tr>
<tr><td>GS38</td><td>Oaklands Basin</td><td rowspan="4">Plantation establishment and forestry operations on both Crown Land (including state forests) and freehold land are regulated by the Plantations and Reafforestation Act 1999 (NSW), and the Plantations and Reafforestation Regulation (Code) 2001. The Department of Primary Industries' Forestry Division has responsibility for authorising plantations, and for auditing plantation establishment and forest operations for compliance.

The risk of growth in plantation forestry intercepting recharge is considered in more detail in the surface water risk assessments; it has been included in the alluvial risk assessments for completeness.

K3 Existing groundwater level and take monitoring programs</td><td>Nil</td><td>Nil</td><td>Nil</td><td>H/L</td><td>N/A</td><td rowspan="4">None required
13 Monitor groundwater resources and dependent ecosystems
A NSW Commercial Plantations Policy is in development by the DPIE - Water and is expected to address potential forestry impacts on ground and surface waters.</td><td rowspan="4">N1 Sustainable Diversion Limits for each groundwater SDL resource unit.</td><td>N/A</td><td rowspan="4">None required</td><td rowspan="4">No WRP MER planned, NSW Department of Primary Industries Forestry monitoring in place</td></tr>
<tr><td>GS50</td><td>Western Porous Rock</td><td>M</td><td>Nil</td><td>Nil</td><td>H/L</td><td>N/A</td><td>N/A</td></tr>
<tr><td>GS41</td><td>Sydney Basin MDB</td><td>L</td><td>Nil</td><td>Nil</td><td>H/L</td><td>N/A</td><td>N/A</td></tr>
<tr><td>GS17</td><td>Gunnedah-Oxley Basin MDB</td><td>M</td><td>Nil</td><td>Nil</td><td>H/L</td><td>N/A</td><td>N/A</td></tr>
</table>

SECTION 6.4 RISK OF GROWTH IN PLANTATION FORESTRY INTERCEPTING RECHARGE (INSTREAM ECOLOGICAL VALUES) [R12]

Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	Plantation establishment and forestry operations on both Crown Land (including state forests) and freehold land are regulated by the *Plantations and Reafforestation Act 1999* (NSW), and the *Plantations and Reafforestation Regulation (Code) 2001*. The Department of Primary Industries' Forestry Division has responsibility for authorising plantations, and for auditing plantation establishment and forest operations for compliance. The risk of growth in plantation forestry intercepting recharge is considered in more detail in the surface water risk assessments; it has been included in the alluvial risk assessments for completeness. K3 Existing groundwater level and take monitoring programs	Nil	Nil	Nil	H/L	N/A	None required 13 Monitor groundwater resources and dependent ecosystems A NSW Commercial Plantations Policy is in development by the DPIE - Water and is expected to address potential forestry impacts on ground and surface waters.	N1 Sustainable Diversion Limits for each groundwater SDL resource unit.	N/A	None required	No WRP MER planned, NSW Department of Primary Industries Forestry monitoring in place
GS50	Western Porous Rock		L	Nil	Nil	H/L	N/A			N/A		
GS41	Sydney Basin MDB		L	Nil	Nil	H/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		L	Nil	Nil	H/L	N/A			N/A		

SECTION 6.5 RISK OF CLIMATE CHANGE REDUCING RECHARGE AND GROUNDWATER AVAILABILITY (GROUNDWATER–DEPENDENT ECOSYSTEMS) [R13]												
Risk assessment							**Risk treatment pathway**					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. K3 Existing groundwater level and take monitoring programs	Nil	L	Nil	H/L	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *Improved implementation of the following existing critical mechanism* E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	None required	MER planned for WSP and WQM Plan objectives, also refer to surface water WRP and LTWP
GS50	Western Porous Rock		M	L	L	H/L	N/A			N/A		
GS41	Sydney Basin MDB		L	L	L	H/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	L	L	H/L	N/A			N/A		

SECTION 6.5 RISK OF CLIMATE CHANGE REDUCING RECHARGE and GROUNDWATER AVAILABILITY (INSTREAM ECOLOGICAL VALUES) [R14]													
Risk assessment							Risk treatment pathway						
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. K3 Existing groundwater level and take monitoring programs	Nil	L	Nil	H/L	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	None required	MER planned for WSP and WQM Plan objectives, also refer to surface water WRPs and LTWPs
GS50	Western Porous Rock		L	L	L	H/L	N/A			N/A		
GS41	Sydney Basin MDB		L	L	L	H/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		L	L	L	H/L	N/A			N/A		

SECTION 6.6. RISK OF POOR WATER QUALITY TO THE ENVIRONMENT (GROUNDWATER–DEPENDENT ECOSYSTEMS) (QL5)												
Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
Land and waste management practices												
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. E16 Bore construction standards. E17 Work approval conditions may place conditions on the bore such as screen depth conditions. K3 Existing groundwater level and take monitoring programs K5 Complementary water quality and environmental monitoring programs Refer to WQM Plan (Tables 6 and 11) for a comprehensive list of mechanisms and explanatory text.	Nil	L	Nil – QAL	L/L	N/A	None required 9 Implement the WQM Plan for the WRP area 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *Improved implementation of the following existing critical mechanism* E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	None required	MER planned for WQM Plan objectives
GS50	Western Porous Rock		M	L	L – QAL	L/L	N/A			N/A		
GS41	Sydney Basin MDB		M	L	L – QAL	L/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	L	L – QAL	L/L	N/A			N/A		
Land management induced water quality (salinity) deterioration												
GS38	Oaklands Basin		Nil	L	Nil – QAL	L/L	N/A	9 Implement the WQM Plan for the WRP area 13 Monitor groundwater resources and dependent ecosystems		N/A	Risk is tolerable because there are no water management strategies or mechanisms available to address the risk. Dryland salinity is a land management issue that cannot be mitigated under a water resource plan. Refer to the Water quality management plan—GW11 NSW Murray Darling Basin Porous Rock Water Resource Plan area tables 6, 8 and 11 for further information regarding complementary land management strategies.	MER planned for WQM Plan objectives
GS50	Western Porous Rock		M	L	L – QAL	L/L	N/A			N/A		
GS41	Sydney Basin MDB		M	M	M – QAL	L/L	G			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	M	M – QAL	L/L	G			N/A		
Pumping induced water quality (salinity) deterioration												
GS38	Oaklands Basin		Nil	L	Nil – QAL	L/L	N/A	None required 9 Implement the WQM Plan for the WRP area 13 Monitor groundwater resources and dependent ecosystems		N/A	None required	MER planned for WQM Plan objectives
GS50	Western Porous Rock		M	L	L – QAL	L/L	N/A			N/A		
GS41	Sydney Basin MDB		M	L	L – QAL	L/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	L	L – QAL	L/L	N/A			N/A		

SECTION 6.6. RISK OF POOR WATER QUALITY TO THE ENVIRONMENT (INSTREAM ECOLOGICAL VALUES) (QL5 continued)												
Risk assessment							Risk treatment pathway					
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Consequence**	**Likelihood**	**Risk outcome**	**Data confidence (Consequence / Likelihood)**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
Land and waste management practices												
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. K3 Existing groundwater level and take monitoring programs K5 Complementary water quality and environmental monitoring programs Refer to WQM Plan (Tables 6 and 11) for a comprehensive list of mechanisms and explanatory text.	Nil	L	Nil – QAL	L/L	N/A	None required 9 Implement the WQM Plan for the WRP area 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	None required	MER planned for WQM Plan objectives
GS50	Western Porous Rock		M	L	L – QAL	L/L	N/A			N/A		
GS41	Sydney Basin MDB		M	L	L – QAL	L/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	L	L – QAL	L/L	N/A			N/A		
Land management induced water quality (salinity) deterioration												
GS38	Oaklands Basin		Nil	L	Nil – QAL	L/L	N/A	9 Implement the WQM Plan for the WRP area 13 Monitor groundwater resources and dependent ecosystems		N/A	Risk is tolerable because there are no water management strategies or mechanisms available to address the risk. Dryland salinity is a land management issue that cannot be mitigated under a water resource plan. Refer to the Water quality management plan—GW11 NSW Murray Darling Basin Porous Rock Water Resource Plan area tables 6, 8 and 11 for further information regarding complementary land management strategies.	MER planned for WQM Plan objectives
GS50	Western Porous Rock		M	L	L – QAL	L/L	N/A			N/A		
GS41	Sydney Basin MDB		M	M	M – QAL	L/L	G			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	M	M – QAL	L/L	G			N/A		
Pumping induced water quality (salinity) deterioration												
GS38	Oaklands Basin		Nil	L	Nil – QAL	L/L	N/A	None required 9 Implement the WQM Plan for the WRP area 13 Monitor groundwater resources and dependent ecosystems		N/A	None required	MER planned for WQM Plan objectives
GS50	Western Porous Rock		M	L	L – QAL	L/L	N/A			N/A		
GS41	Sydney Basin MDB		M	L	L – QAL	L/L	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		M	L	L – QAL	L/L	N/A			N/A		

<table>
<tr><th colspan="11">SECTION 6.7. RISK OF GROWTH IN BASIC LANDHOLDER RIGHTS AND LOCAL WATER UTILITIES TO THE ENVIRONMENT (QL6)</th></tr>
<tr><th colspan="5">Risk assessment</th><th colspan="6">Risk treatment pathway</th></tr>
<tr><th>SDL resource unit code</th><th>SDL resource unit</th><th>Existing critical mechanisms
(mechanisms active when risk was assessed)</th><th>Risk outcome</th><th>Data confidence</th><th>Risk treatment option</th><th>Strategies to address risk
(refer to Table 8-7 for further information)</th><th>Additional critical mechanisms
(mechanisms introduced as a result of WRP development or available but not active when risk was assessed)</th><th>Tolerable / residual risk outcome</th><th>Explanation of tolerable risk application
OR
Explanation of why risk cannot be addressed
(refer to Table 8-3)</th><th>Monitoring and evaluation</th></tr>
<tr><td>GS38</td><td>Oaklands Basin</td><td rowspan="4">E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale).
E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits.
E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise.
E4 Extraction limits for individual works to manage extraction at the extraction point.
E5 Compliance with individual extraction limits.
E6 Prohibit trade between surface water and groundwater sources.
E7 Trade limits or prohibitions between groundwater sources and management zones.
E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale.
K3 Existing groundwater level and take monitoring programs</td><td>Nil – QAL</td><td>L</td><td>N/A</td><td rowspan="4">None required
13 Monitor groundwater resources and dependent ecosystems</td><td rowspan="4">N1 Sustainable Diversion Limits for each groundwater SDL resource unit.
The following mechanisms are available for use if required in the WRP area.
E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to:
(a) maintain water levels in an aquifer, or
(b) maintain, protect or improve the quality of water in an aquifer, or
(c) prevent land subsidence or compaction in an aquifer, or
(d) protect groundwater–dependent ecosystems or
(e) maintain pressure or to ensure pressure recovery in an aquifer.
E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source.
Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.
E18 Minister may restrict BLR access.
E19 Minister may limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer
E20 Minister may direct landholder accessing BLR to not waste or improperly use water</td><td>N/A</td><td rowspan="4">None required</td><td rowspan="4">No WRP MER planned</td></tr>
<tr><td>GS50</td><td>Western Porous Rock</td><td>Nil – QAL</td><td>L</td><td>N/A</td><td>N/A</td></tr>
<tr><td>GS41</td><td>Sydney Basin MDB</td><td>Nil – QAL</td><td>L</td><td>N/A</td><td>N/A</td></tr>
<tr><td>GS17</td><td>Gunnedah-Oxley Basin MDB</td><td>Nil – QAL</td><td>L</td><td>N/A</td><td>N/A</td></tr>
</table>

SECTION 6.8. RISK OF GROWTH IN MINING REDUCING GROUNDWATER AVAILABILITY (GROUNDWATER–DEPENDENT ECOSYSTEMS AND INSTREAM ECOLOGICAL VALUES) (QL7)												
Risk assessment						Risk treatment pathway						
SDL resource unit code	**SDL resource unit**	**Existing critical mechanisms** (mechanisms active when risk was assessed)	**Risk outcome GDE**	**Risk outcome Instream Ecological Value**	**Data confidence**	**Risk treatment option**	**Strategies to address risk** (refer to Table 8-7 for further information)	**Additional critical mechanisms** (mechanisms introduced as a result of WRP development or available but not active when risk was assessed)	**Tolerable / residual risk outcome**	**Explanation of tolerable risk application OR Explanation of why risk cannot be addressed** (refer to Table 8-3)	**Monitoring and evaluation**
GS38	Oaklands Basin	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale). E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits. E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise. E4 Extraction limits for individual works to manage extraction at the extraction point. E5 Compliance with individual extraction limits. E6 Prohibit trade between surface water and groundwater sources. E7 Trade limits or prohibitions between groundwater sources and management zones. E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. K3 Existing groundwater level and take monitoring programs	L	Nil	M/M	N/A	None required 13 Monitor groundwater resources and dependent ecosystems	N1 Sustainable Diversion Limits for each groundwater SDL resource unit. *Improved implementation of the following existing critical mechanism* E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale. *The following mechanisms are available for use if required in the WRP area.* E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. E9 Minister may apply trade limits or prohibitions between local management areas within a groundwater source *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	N/A	None required	No WRP MER planned, NSW Aquifer Interference Policy directs MER.
GS50	Western Porous Rock		L	L	M/M	N/A			N/A		
GS41	Sydney Basin MDB		L	L	M/M	N/A			N/A		
GS17	Gunnedah-Oxley Basin MDB		L	L	M/M	N/A			N/A		

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Abbreviations

Abbreviation	Description
AAL	Aquifer access licence
AWD	Available water determination
BLR	Basic landholder rights
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIWA	Directory of Important Wetlands in Australia
DPI Water	Department of Primary Industries Water (now part of NSW Department of Planning and Environment)
DWMS	Drinking water management system
EEC	Endangered ecological community
EWR	Environmental watering requirements
GDE	Groundwater–dependent ecosystem
HEVAE	High ecological value aquatic ecosystems
IRG	Incident response guide
LTAAEL	Long term average annual extraction limit
LTWP	Long-term watering plan
LWU	Local water utility
MDB	Murray-Darling Basin
the Authority	Murray-Darling Basin Authority
MER	Monitoring, evaluation and reporting
NOW	NSW Office of Water (now part of NSW Department of Planning and Environment)
NWI	National Water Initiative
OEH	NSW Office of Environment and Heritage
PEA	Priority environmental asset
PRA	*Plantations and Reafforestation Act 1999* (NSW)
QAL	This suffix on a risk outcome indicates a qualitative assessment
SDL	Sustainable diversion limit
SDL resource unit	Sustainable diversion limit resource unit
the Minister	NSW Minister responsible for Water
WAL	Water access licence
WMA 2000	*Water Management Act 2000* (NSW)
WQM Plan	Water quality management plan
WRP	Water resource plan
WSP	Water sharing plan

1. Introduction

1.1. Background

The Basin Plan is an adaptive management framework that has been developed by the Murray-Darling Basin Authority (MDBA) to provide a coordinated approach to managing water resources across the four member states and territory in the Murray-Darling Basin (MDB).

A risk assessment is a key step in the development of a water resource plan (WRP) for each valley and groundwater source in the MDB. Chapter 4, Part 2 of the Basin Plan (Risks and strategies to address risks) sets out matters that must be considered in terms of risk and management strategies in WRPs. Chapter 10, Part 9 (Approaches to addressing risk to water resources) outlines how Basin States must undertake risk assessments as well as the Murray-Darling Basin Authority’s associated accreditation requirements.

The Basin Plan requires that a WRP must be prepared having regard to current or future risks to the condition and continued availability of water resources of a water resource plan area. This risk assessment will form Schedule D of the WRP.

Figure 1-1 illustrates the relationship of the risk assessment document with the other elements of the WRP.

1.2. Document map

This risk assessment identifies and addresses risks to water resources to meet the requirements of Chapter 10, Part 9. Table 1-1 summarises where the Basin Plan requirements are addressed in this risk assessment.

The document is organised according to receptors, such that the risks to other water-dependent values and users (sections 4, 5 and 7), risks to the environment (section 6) and risks to other uses (section 7) are assessed together.

These sections address risk to the condition or continued availability of Basin water resources and the consequences of the materialisation of these risks as identified in Chapter 4.02 of the Basin Plan; namely, that water quality or quantity is insufficient to meet consumptive, economic, environmental, and public benefit (social, cultural, Indigenous) uses and values.

Risks are analysed in sections 4 to 7 of this report. Five basic steps are described for each risk (10.41(5)); these are:

- the impact pathway, with a summary of how the cause and threat may arise (10.41(2), (3); 10.42(b))
- identification of likelihood and consequence metrics, and description of how low, medium and high categories were defined for each metric (10.41(5); 10.42(a))
- summary of the data and method used to fulfil each likelihood and consequence metric (10.41(7))
- identification and discussion of strategies that are in place to address risks (10.43)
- combination of likelihood and consequence rankings to derive an overall risk outcome (10.41(5), (6)).

Note that where a risk outcome is highlighted as medium or high, it does not necessarily imply existing management actions and mechanisms require change or are inadequate. In many circumstances these risks will already have a level of management in place that is commensurate with the risk outcome.

Strategies for addressing risks as having a medium or higher level of risk (10.43(1) are discussed in section 8.

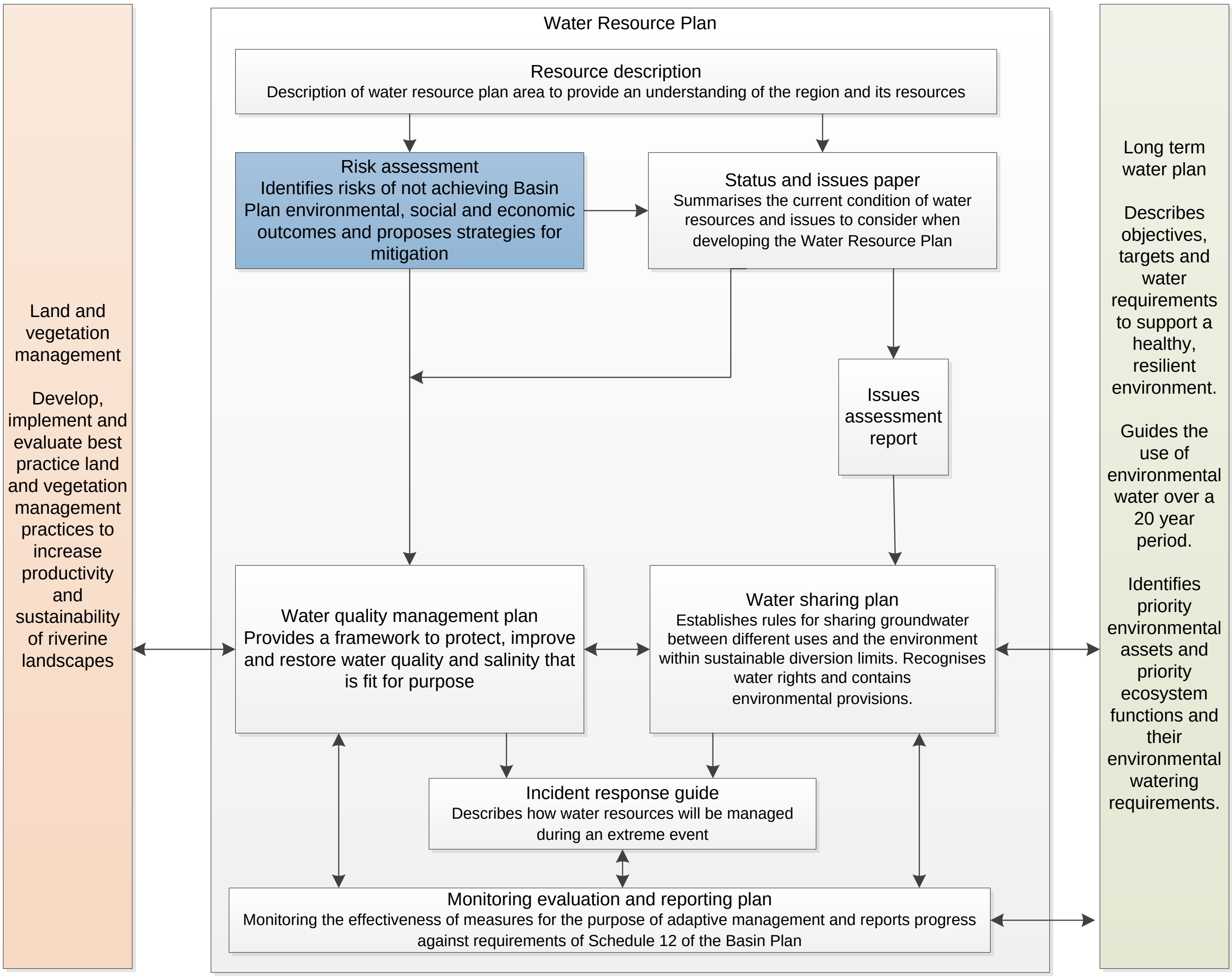


Figure 1-1 Components of the water resource plan

Table 1-1 Basin Plan requirements and where each is addressed in this risk assessment

Basin Plan requirement		Location in this document		Location in WRP
Chapter 4—Identification and management of risks to Basin water resources **Part 2—Risks and strategies to address risks**				
4.02	Risks to condition, or continued availability, of Basin water resources, and consequential risks	Whole report		3 3.1 3.2 3.3 1.3.1 1.7 4.4
4.02(1)(a)	Insufficient water available for the environment	6	Risk to water available for the environment	
4.02(1)(b)	Water being of a quality unsuitable for use	4	Risk to consumptive users	
		6	Risk to water available for the environment	
4.02(1)(c)	Poor health of water-dependent ecosystems.	6	Risk to water available for the environment	
4.02(2)(a)	Insufficient water is available, or water is not suitable for consumptive and other economic uses of Basin water resources	4	Risk to consumptive users	
		5	Risk to aquifer access licence holders	
4.02(2)(b)	Insufficient water is available, or water is not suitable to maintain social, cultural, Indigenous and other public benefit values	7	Risk to other groundwater–dependent values	
4.03	Strategies to manage, or address, identified risks	8.5	Summary of strategies to address risk (Table 8-7 column 6)	
4.04	Guidelines published by the Authority	N/A	No guidelines published	
Chapter 8—Environmental watering plan **Part 5—Methods for identifying environmental assets and ecosystem functions and their environmental watering requirements**				
8.49	Identification of environmental assets and their environmental watering requirements	6.1.1	Environmental watering requirements in a groundwater context	4.1 4.2 4.4
8.50	Identification of ecosystem functions and their environmental watering requirements	6.2.1	6.2.1. HEVAE for groundwater–dependent ecosystems	
8.51	Determination of environmental watering requirements for environmental assets and functions	6.2.2	6.2.2. HEVAE for instream ecological values	
		Table 6-2	LTWP EWRs that may benefit PEAs and PEFs dependent on both groundwater and surface water	
Schedule 8	Criteria for identifying an environmental asset	Appendix C	HEVAE alignment with Schedules 8 and 9 of the Basin Plan (groundwater dependent ecosystems)	
Schedule 9	Criteria for identifying an ecosystem function	Appendix D	HEVAE alignment with Schedules 8 and 9 of the Basin Plan (groundwater dependent instream ecological values)	
Chapter 10—Water resource plan requirements **Part 2—Identification of water resource plan area and other matters**				
10.02	Identification of water resource plan area and water resources	3.1	Identification of the water resource plan area	2 2.1 2.2
10.03	Identification of SDL resource units and water resources			
10.05	Regard to other water resources	3.3	Connectivity (also tables 3-1 and 3-2)	
		4.6	Risk of sediment compaction impacting surface water users (QL1)	
		4.7	Risk of groundwater extraction impacting water users in adjacent groundwater systems (QL2)	

Basin Plan requirement		Location in this document		Location in WRP
		6.3, 6.4, 6.5, 6.6, 6.7, 6.8	Risk to groundwater dependent instream ecological values (R10, R12, R14, QL5-7)	
Part 3—Incorporation and application of long-term annual diversion limit **Division 2—Take for consumptive use**				
10.12(1)(e)	Accounting for water - significant hydrological connections	3.3	Connectivity	2.2
Part 4—The sustainable use and management of water resources **Division 3—Groundwater**				
10.17	Priority environmental assets and priority ecosystem functions	6.1.1, Table 6-2	Environmental watering requirements in a groundwater context	4.2
10.18	Priority environmental assets dependent on groundwater	Page ii	Consolidated risk table	2.2 4.1.1 4.2 3
		6	Risk to water available for the environment	
		6.1.1	Environmental watering requirements in a groundwater context	
		6.2	Assigning a consequence ranking	
		6.2.1	HEVAE for groundwater dependent ecosystems	
		6.3, 6.4, 6.5, 6.6, 6.7, 6.8	Risk to groundwater dependent ecosystems (R9, R11, R13, QL5-7)	
		8	Risk treatment overview	
		8.1	Existing water resource management strategies, actions and mechanisms	
		8.3	Tolerable risk outcomes	
10.19	Groundwater and surface water connections	Page ii	Consolidated risk table	2.2 4.1.1 4.2 3
		3.3	Connectivity	
		6	Risk to water available for the environment	
		6.2	Assigning a consequence ranking	
		6.2.2	HEVAE for groundwater dependent instream ecological values	
		6.3, 6.4, 6.5, 6.6, 6.7, 6.8	Risk to groundwater dependent instream ecological values (R10, R12, R14, QL5-7)	
		8	Risk treatment overview	
		8.1	Existing water resource management strategies, actions and mechanisms	
		8.2	Tolerable risk outcomes	
10.20	Productive base of groundwater	Page ii	Consolidated risk table	2.2 4.1.1 4.3 3
10.20(1)(a)	Overall structural integrity of the aquifer	4.3	Risk to structural integrity of the aquifer system	
		4.5	Risk of local drawdown in bores reducing groundwater access by consumptive users	
		4.7	Risk of groundwater extraction impacting water users in adjacent groundwater systems (QL2)	
10.20(1)(b)	Overall hydraulic relationships and properties between groundwater and surface water systems, between groundwater systems, and within groundwater systems	3.3	Connectivity	
		4.4	Risk of groundwater extraction inducing connection with poor quality groundwater	
		4.6	Risk of sediment compaction impacting surface water users (QL1)	
		4.7	Risk of groundwater extraction impacting water users in adjacent groundwater systems (QL2)	

Basin Plan requirement		Location in this document		Location in WRP
		8	Risk treatment overview	
		8.1	Existing water resource management strategies, actions and mechanisms	
		8.2	Tolerable risk outcomes	
10.21	Additional requirements for Western Porous Rock, Gunnedah-Oxley Basin MDB, Sydney Basin MDB SDL resource units	8.1	Existing water resource management strategies, actions and mechanisms	1.6, 1.8
		8.5	Summary of strategies to address risk	
10.22	Description of how requirements have been met	Page ii	Consolidated risk table	4.1 4.2 4.3
10.22(b)	Rule explanations	8	Risk treatment overview	
		8.1	Existing water resource management strategies, actions and mechanisms	
		8.2	Tolerable risk outcomes	
		4.3.3, 4.4.3, 4.5.3, 4.6.2, 4.7.2, 4.8.4, 5.3.3, 5.4.3, 5.5.3, 5.6.3, 5.7.3, 5.8.2, 6.3.3, 6.4.3, 6.5.3, 6.6.2, 6.7.2, 6.8.2	Existing water management actions and mechanisms (all risks)	
Part 5—Interception activities				
10.23	Listing types of interception activity			5.6
10.23(1)	Potential interception activities	3.3	Connectivity	
		5.7, 6.4	Risk of growth in plantation forestry intercepting recharge	
		5.8, 6.8	Risk of growth in mining reducing groundwater availability	
Part 6—Planning for environmental watering				
10.26(2)(a)	Planning for environmental watering	6.1.1	Environmental watering requirements in a groundwater context	4.2
		6.2.1	HEVAE for groundwater dependent ecosystems	
		6.2.2	HEVAE for instream ecological values	
		8	Risk treatment overview	
		8.5	Summary of strategies to address risk	
		Appendix C	HEVAE alignment with Schedules 8 and 9 of the Basin Plan (groundwater dependent ecosystems)	
		Appendix D	HEVAE alignment with Schedules 8 and 9 of the Basin Plan (Instream ecological values)	
Part 7—Water quality objectives **Division 3—Groundwater**				
10.35B	Identification of water quality target values	4.4	Risk of groundwater extraction inducing connection with poor quality groundwater	6
		4.8	Risk of poor water quality to water users	
		6.6	Risk of poor water quality to the environment	
10.35C	Consideration to be given to rules or measures	8.5	Summary of strategies to address risk	
10.35D	Additional requirements for Western Porous Rock, Gunnedah-Oxley Basin MDB, Sydney Basin MDB SDL resource units	4.4, 4.8, 6.6	Water quality related risks (R2, QL3, QL5)	
Part 9—Approaches to addressing risks to water resources				

Basin Plan requirement		Location in this document		Location in WRP
10.41	Risk identification and assessment methodology			3
10.41(1)	Regard to current and future risks to the condition and continued availability of the water resources of the WRP area	whole document		3.1
		2	NSW Basin Plan risk assessment framework	
		2.2	The risk assessment framework	
		3.3	Connectivity	
		4.1, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8	Risks to consumptive users (R1-3, QL1-3)	
		5.1, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8,	Risks to aquifer access licence holders (R4-8, QL4)	
		6.1, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8	Risks to the environment (R9-14, QL5-7)	
		8	Risk treatment overview	
10.41(2)(a)	Risks to the capacity to meet environmental watering requirements	2.2	The risk assessment framework	
		6	Risk to water available for the environment	
		6.1	Background	
		6.1.1	Environmental watering requirements in a groundwater context	
		6.2	Assigning a consequence ranking	
		6.3, 6.4, 6.5, 6.6, 6.7, 6.8	Risks to the environment (R9-14, QL5-7)	
		Appendix D	Appendix D HEVAE alignment with Schedules 8 and 9 for groundwater dependent instream ecological values	
10.41(2)(b)	Risks arising from the matters referred to in section 10.20(1)	Refer to 10.20(1) above		
10.41(2)(c)	Risks arising from potential interception activities	3.3	Connectivity	
		5.7, 6.4	Risk of growth in plantation forestry intercepting recharge	
		5.8, 6.8	Risk of growth in mining reducing groundwater availability	
10.41(2)(d)	Risks arising from elevated levels of salinity or other types of water quality degradation	4.4	Risk of groundwater extraction inducing connection with poor quality groundwater	
		4.5	Risk of local drawdown in bores reducing groundwater access by consumptive users	
		4.8	Risk of poor water quality to water users (QL3)	
		6.6	Risk of poor water quality to the environment (QL5)	
10.41(3)(a)	Regard to risks identified in section 4.02	1.2	Document map (also see 4.02 above)	
10.41(3)(b)	Guidelines published by the Authority	N/A	No guidelines published	
10.41(4)	List of risks	Page ii	Consolidated risk table	3.2
		2.3	Risk assessment scope	
10.41(5)	Assessment of each risk	Page ii	Consolidated risk table	3.2
		Figures 4-1, 4-2, 4-3, 4-4, 4-6, 4-7, 4-8	Impact pathways (Risk to consumptive users R1-3, QL1-3)	
		Figures 5-1, 5-2, 5-3, 5-4, 5-5, 5-6, 5-7	Impact pathways (Risk to aquifer access licence holders R4-8, QL4)	
		Figures 6-1, 6-7, 6-8, 6-9, 6-10, 6-11, 6-12	Impact pathways (Risk to the environment R9-14, QL5-7)	
		4.3.4, 4.4.4, 4.5.4, 4.6.3, 4.7.3, 4.8.5	Risk outcomes (consumptive users R1-3, QL1-3)	
		5.3.4, 5.4.4, 5.5.4, 5.6.4, 5.7.4, 5.8.3	Risk outcomes (Risk to aquifer access licence holders R4-8, QL4)	

Basin Plan requirement		Location in this document		Location in WRP
		6.3.4, 6.4.4, 6.5.4, 6.6.3, 6.7.3, 6.8.3	Risk outcomes (Risk to the environment R9-14, QL5-7)	
10.41(6)	Definition of the level of risk for each risk	Page ii	Consolidated risk table	3.2
		2.2	Risk assessment framework	
		2.4	Limitations and uncertainties	
		4.3.4, 4.4.4, 4.5.4, 4.6.3, 4.7.3, 4.8.5, 5.3.4, 5.4.4, 5.5.4, 5.6.4, 5.7.4, 5.8.3, 6.3.4, 6.4.4, 6.5.4, 6.6.3, 6.7.3, 6.8.3	Risk outcomes (all risks)	
		Also see consequence and likelihood section listings under 10.41(7)		
10.41(7)	Description of the data and methods used to identify and assess the risks	2.2	Risk assessment framework	3.2
		2.3	Risk assessment scope	
		2.4	Limitations and uncertainties	
		Appendix B	Data summary table	
		4.2, 4.2.1, 4.6, 4.6.3, 4.7, 4.7.3, 4.8, 4.8.2	Consequence (Risks to consumptive users R1-3, QL1-3)	
		5.2, 5.8, 5.8.3	Consequence (Risks to aquifer access licence holders R4-8, QL4)	
		6.2 (including all sections), 6.6, 6.6.3, 6.7, 6.7.3, 6.8, 6.8.3	Consequence (Risks to the environment (R9-14, QL5-7)	
		4.3.1, 4.4.1, 4.5.1, 4.6, 4.6.1, 4.7, 4.7.3, 4.8, 4.8.1	Likelihood (Risks to consumptive users R1-3, QL1-3)	
		5.3.1, 5.4.1, 5.5.1, 5.6.1, 5.7.1, 5.8, 5.8.3	Likelihood (Risks to aquifer access licence holders R4-8, QL4)	
		6.3.1, 6.4.1, 6.5.1, 6.6, 6.6.1, 6.7, 6.7.3, 6.8, 6.8.3	Likelihood (Risks to the environment R9-14, QL5-7)	
		4.2.1, 4.3.2, 4.4.2, 4.5.2, 4.6.1, 4.7.1, 4.8.3	Risks to consumptive users (R1-3, QL1-3) Confidence in data	
		5.2.1, 5.3.2, 5.4.2, 5.5.2, 5.6.2, 5.7.2, 5.8.1	Risks to aquifer access licence holders (R4-8, QL4) Confidence in data	
		6.2.3, 6.3.2, 6.4.2, 6.5.2, 6.6.1, 6.7.1, 6.8.1.	Risks to the environment (R9-14, QL5-7) Confidence in data	
10.41(8)	Description of quantified uncertainties in the level of risk attributed to each risk	N/A	Risk uncertainties have not been quantified	3.2
10.42	Description of risks	4.1, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 5.1, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8 6.1, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8	Risks to consumptive users (R1-3, QL1-3) Risks to aquifer access licence holders (R4-8, QL4) Risks to the environment (R9-14, QL5-7)	3.2
10.42(a)	Description of each risk			
10.42(b)	Description of factors that contribute to each risk			
10.43	Strategies for addressing risks			
10.43(1)(a)	Strategies to address medium and high risks	Page ii	Consolidated risk table	
		4.3.3, 4.4.3, 4.5.3, 4.6.2, 4.7.2, 4.8.4, 5.3.3, 5.4.3, 5.5.3, 5.6.3, 5.7.3, 5.8.2, 6.3.3, 6.4.3, 6.5.3, 6.6.2, 6.7.2, 6.8.2	Existing water management actions and mechanisms (all risks)	
		8	Risk treatment overview	
		8.1	Existing water resource management strategies, actions and mechanisms	
		8.5	Summary of strategies to address risk	
10.43(1)(b)	Explanations for medium and high risks that cannot be addressed	Page ii	Consolidated risk table	
		8.2	Tolerable risk outcomes	

Basin Plan requirement		Location in this document		Location in WRP
10.43(2)	Strategy takes account of another Part of Ch. 10	8.5	Summary of strategies to address risk (Table 8-7 column 6)	
10.43(3)(a)	Strategies listed in 4.03(3)	8.5	Summary of strategies to address risk (Table 8-7 column 6)	
10.43(3)(b)	Guidelines published by the Authority	N/A	No guidelines published	

2. NSW Basin Plan risk assessment framework

2.1. Introduction

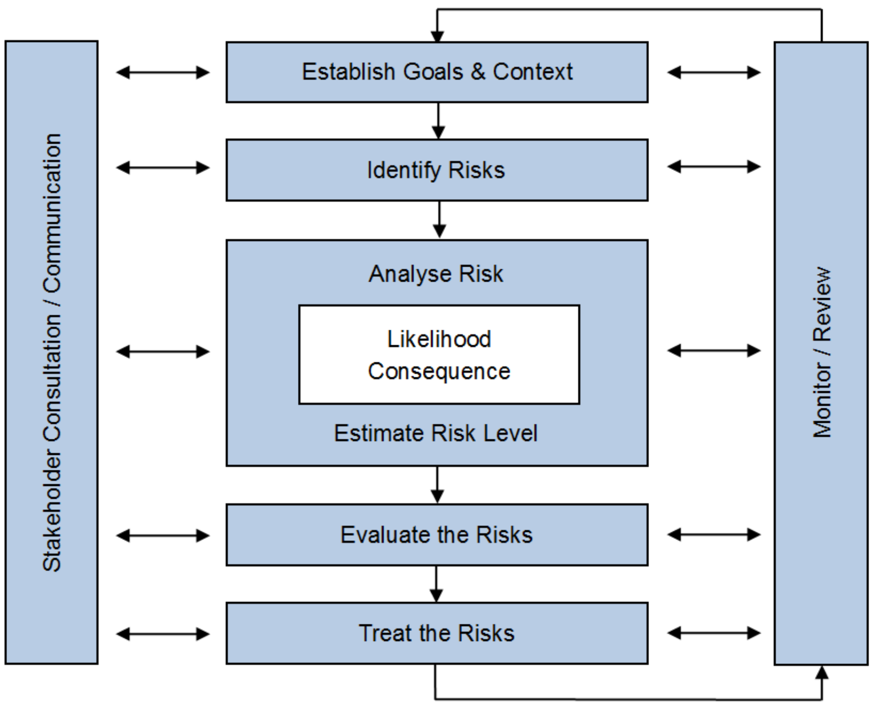
Risk-based management is not a new concept in water resource planning in NSW. Considerable work has been undertaken by State governments and under Commonwealth-level intergovernmental initiatives to design and implement risk-based water planning. The *National Water Initiative (NWI) Policy Guidelines for Water Planning and Management,* endorsed by the Council of Australian Governments (COAG), adopts a risk-management approach.

Risk-based management assists water managers to prioritise and direct time and effort to monitor, mitigate or respond to factors that pose the highest overall risks. It ensures that management is targeted to the appropriate part of the water system.

NSW has been implementing risk-based water planning processes since implementing water reform in the late 1990s. These approaches have included the initial Stressed Rivers and Aquifer Risk Assessments in 1998 (DLWC 1998a and b). The macro-water planning process adopted in 2004 to complete water sharing plans across the State also used a risk-based approach (DPI Water 2015; Raine *et al*. 2012).

2.2. Framework

Risk assessments for each NSW WRP follow the process illustrated in Figure 2-1. This process is consistent with the *NWI Policy Guidelines for Water Planning and Management* and NSW's Basin Plan obligations.



Source: AS/NZS ISO 31000:2009 (Standards Australia 2009)

Figure 2-1 The NSW Basin Plan risk assessment framework

The risk assessment framework adopts a cause/threat/impact model that describes the pathway for impacts to a receptor. Impacts occur where there is a cause (e.g. groundwater pumping) that creates a threat (e.g. declining groundwater levels) which may then impact on a receptor or value (e.g. a connected stream). Adopting the cause/threat/impact pathway approach provides a systematic way to identify the full range of factors that may lead to an impact, while also being consistent with the internationally recognised risk standard which considers both likelihood and consequence.

The causes, threats and impacts considered in this assessment are summarised in Table 2-1. Causes have the potential to induce an outcome (the threat) to various extents, depending upon the aquifer and the level of aquifer development. Receptors are considered in an intergenerational context, that is, current and future uses and users, as required under Basin Plan section 10.41(1).

Table 2-1 Summary of causes, threats and impacts considered in this risk assessment

Cause	Threat	Impact
Reduction in pressure caused by groundwater extraction Groundwater extraction Land and waste management practices Change in recharge from climate change Growth in basic landholder rights (BLR) Growth in local water utility (LWU) use Reduced recharge from increase in irrigation efficiency Growth in plantation forestry intercepting recharge Growth in mining reducing groundwater availability Land management induced water quality (salinity) deterioration Pumping induced water quality (salinity) deterioration	Sediment compaction affecting the resource units of the WRP and adjacent resource units Induced connection with poor quality groundwater Less access for groundwater users Contamination of groundwater Less groundwater available for licensed users from current (i.e. AWDs are reduced from current) Lower groundwater levels reducing groundwater access by groundwater-dependent ecosystems (GDEs)[1] Lower groundwater levels reducing discharge to connected streams[2]	Water resources unsuitable or unavailable for consumptive users (domestic and stock, town water supply, irrigation, other commercial) Reduction in groundwater allocation for aquifer access licence Poor health of groundwater-dependent ecosystems (GDEs) Poor health of groundwater-dependent instream ecological values

[1]Reduced groundwater access encompasses a reduced capacity to meet groundwater environmental water requirements.
[2]Reduced discharge to connected streams encompasses a reduced capacity to meet groundwater derived surface water environmental water requirements

The risk level of an impact is a function of the *likelihood* of a cause and threat occurring, and the *consequence* of the impact on the receptor. For this risk assessment, the following definitions have been adopted:

- likelihood: the probability that a cause will result in a threat. It is not an indication of the size of the threat, but rather conveys the probability that the threat will be significant.
- consequence: the loss of value for an impacted receptor.

An example of how the cause/threat/impact model and likelihood/consequent standard have been combined is illustrated in Figure 2-2, for risks arising from river regulation and surface water extraction.

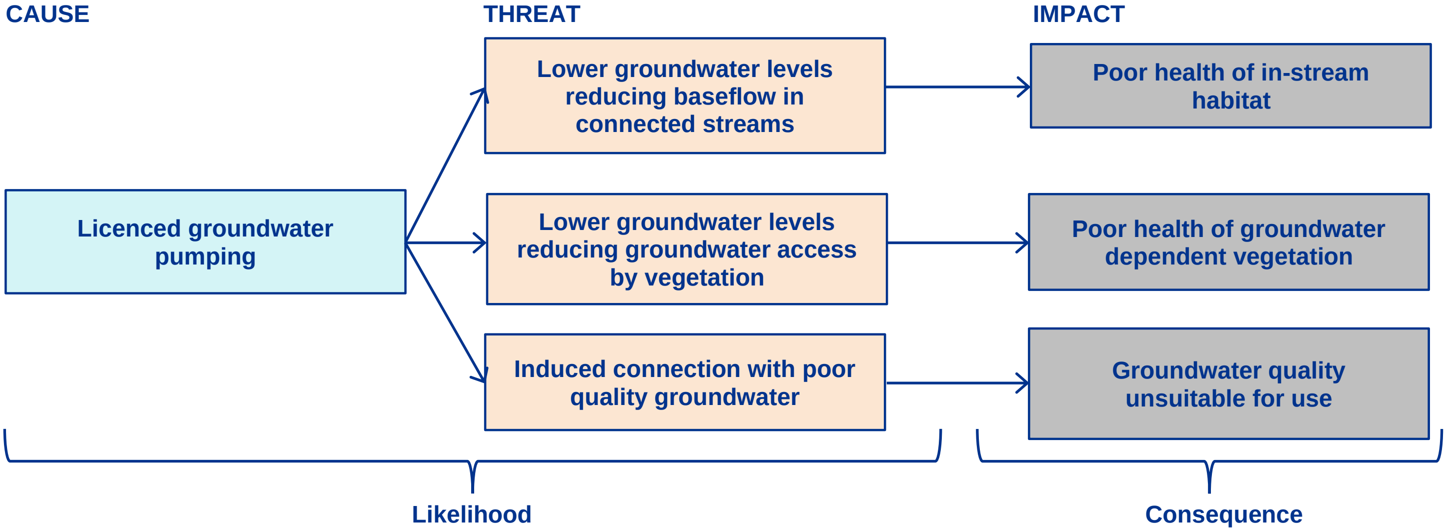


Figure 2-2 Example of an impact pathway for identifying risks associated with licensed groundwater extraction

Risk levels are calculated based on the standard risk assessment matrix used under the macro-planning approach (DPI Water 2015) with the addition of nil categories where required for an individual risk (Table 2-2).

Table 2-2 Risk assessment matrix

Risk Level		Likelihood			
		0	1	2	3
Consequence	0	Nil	Nil	Nil	Nil
	1	Nil	Low	Low	Medium
	2	Nil	Low	Medium	High
	3	Nil	Medium	High	High

A consolidated risk table has been developed for each water resource plan area (WRP area) to capture the risk assessment process (see Executive Summary). Key elements include identification of the risk causes, consequence and likelihood metrics, existing water management actions and mechanisms, and risk outcomes. The consolidated table also identifies any new strategies and management mechanisms and any relevant monitoring and evaluation activities.

An outline of the process and definitions used in this risk assessment is provided in Appendix A.

2.3. Scope

The Basin Plan sets out the risks to be included in a risk assessment. Based on these requirements, the criteria adopted for including cause/threat/impact combinations in this assessment are that:

- the risk directly relates to a change in the water resource, which may be a change the quantity, quality or structure of the resource
- risks where the cause or threat would be mitigated though the use of NSW groundwater management tools, such as rules within a water sharing plan.

The risks included in this assessment are inherent risks to the groundwater resource, or arise from the use of the resource.

Risks that do not have an apparent cause/threat/impact pathway in a groundwater resource context have not been qualitatively assessed. Table 2-3 lists the risks assessed in this document.

Risks not specifically responsible for changing the quantity, quality or structure of the groundwater resource may still impact groundwater–dependent values or use groundwater as a pathway. For example irrigation causing a saline water table to rise which then impacts vegetation or connected streams. This risk would be addressed by irrigation measures such as increasing efficiency or reducing application rates rather than groundwater resource management measures, and is therefore not considered in this risk assessment. These impacts will be considered as part of the valley-specific salinity technical reports.

Table 2-3 List of risks assessed in this document

Risk receptor	Risk code	Risk name
Risks to consumptive users	R1	Risks to structural integrity of the groundwater systems
	R2	Risk of groundwater extraction inducing connection with poor quality groundwater
	R3	Risk of local drawdown in bores reducing groundwater access by consumptive users
	QL1	Risk of sediment compaction impacting surface water users
	QL2	Risk of groundwater extraction impacting water users in adjacent groundwater systems
	QL3	Risk of poor water quality to water users
Risks to Aquifer access licence holders	R4	Risk of climate change reducing recharge and groundwater availability
	R5	Risk of growth in basic landholder rights reducing groundwater availability
	R6	Risk of growth in local water utilities reducing groundwater availability
	R7	Risk of increases in irrigation efficiency and improved water delivery reducing recharge
	R8	Risk of growth in plantation forestry intercepting recharge
	QL4	Risk of growth in mining reducing groundwater availability
Risks to water available for the environment	R9	Risk of groundwater extraction causing local drawdown (GDEs)
	R10	Risk of groundwater extraction causing local drawdown (Instream ecological value)
	R11	Risk of growth in plantation forestry intercepting recharge (GDEs)
	R12	Risk of growth in plantation forestry intercepting recharge (Instream ecological value)
	R13	Risk of climate change reducing recharge and groundwater availability (GDEs)
	R14	Risk of climate change reducing recharge and groundwater availability (Instream ecological value)
	QL5	Risk of poor water quality to the environment (GDEs and instream ecological values)
	QL6	Risk of growth in basic landholder rights and local water utilities to the environment (GDEs and instream ecological values)
	QL7	Risk of growth in mining reducing groundwater availability (GDEs and instream ecological values)

2.3.1. Timeframe

Establishing the timeframe for the risk assessment determines the point from which the potential for impact will be assessed. Timeframe is an essential consideration in groundwater-related risk assessments due to the potential for very long time lags between cause and impact. Given this potential occurs within many systems, the approach adopted within this assessment is to capture all causes that either have already occurred, or may occur during the term of a water sharing plan (WSP) (10 years). These causes may result in threats that could impact receptors beyond the lifetime of the WSP. This approach enables potential impacts to be incorporated even though they may occur in future planning timeframes.

As required by the Basin Plan, this risk assessment identifies and assesses current and future risks. The following definitions have been adopted:

- current risk: the risks that may affect the condition or continued availability of water resources existing prior to the commencement of the WRP and prior to the application of any new or altered water management actions, mechanisms or strategies. Current risk has been assessed with the existing water sharing plan (WSP) rules based on the Water Management Act 2000 (WMA 2000) set in place.
- future risk: these risks may affect the condition or continued availability of water resources during or subsequent to the 10 year term of relevant WSPs. Future risk is also assessed with the existing WSP or WMA 2000-based strategy set in place. Future risks that have been assessed include risk to the environment and to licensed water users from growth in water extraction by basic landholder rights (both domestic and stock and farm dam interception), interception activities (including growth in plantation forestry) and climate change.

As noted above, many water management actions and mechanisms are already in place and may adequately address risk. Therefore the purpose of this risk assessment is to review the risks and associated management measures for current and future effectiveness, and to verify whether the level of risk is matched by the level of water resource management. This purpose is underpinned in the WRPs through the inclusion of monitoring, review and adaptive management processes to confirm that the risk levels derived are appropriate, and the management of the risks is effective and commensurate with the level of risk.

2.3.2. Scale

In NSW, groundwater WRP areas are made up of a number of sustainable diversion limit resource units (SDL resource units) which correlate to groundwater sources or a number of groundwater sources. Generally, this risk framework has been applied at the finest scale supported by available data.

In NSW, groundwater systems are predominantly managed via WSPs which are divided into groundwater sources or smaller management units enabling resource management at a risk appropriate scale. Consequently groundwater source scale datasets have been relied on for many assessments in this document. At these scales, individual aquifers within each water source are not individually considered.

Risk outcomes are provided at the SDL resource unit scale unless a finer scale of data is available. Where a number of groundwater sources make up an SDL resource unit and data is available at the groundwater source (or finer) scale, the section text will indicate which scale has been applied.

Where a finer scale than SDL resource unit is used, several risk outcomes may be applicable to one SDL resource unit. In these instances risk outcome tables will generally refer to both the SDL resource unit and the appropriate scale for the risk outcome while likelihood and consequence tables and associated text will predominantly refer to the finer scale. SDL resource unit and component groundwater sources and finer scales applying in this document are listed in Table 2-4.

Table 2-4 General guide to data and management scale used in this document

NSW Murray-Darling Basin Porous Rock SDL resource units	Groundwater source or finer scale*
Western Porous Rock (GS50)	Western Murray Porous Rock Groundwater Source
Gunnedah-Oxley Basin MDB (GS17)	Gunnedah–Oxley Basin MDB Groundwater Source Gunnedah–Oxley Basin MDB (Spring Ridge) Management Zone, (which does not include water contained in rocks of Permian and Triassic age) Gunnedah–Oxley Basin MDB (Other) Management Zone
Sydney Basin MDB (GS41)	Sydney Basin MDB Groundwater Source Sydney Basin MDB (Macquarie Oxley) Management Zone (which does not include water contained in rocks of Permian and Triassic age) Sydney Basin MDB (Other) Management Zone.
Oaklands Basin (GS38)	Oaklands Basin Groundwater Source

* These management units are established by the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*

Scale is important to the interpretation of risk outcomes. Even within an SDL resource unit risks for specific receptors will vary depending upon factors such as the level of extraction, connections with other units, or nature of confinement. In particular, the behaviour of confined and unconfined aquifers is very distinct and significantly influences the extent to which threats will materialise. The qualitative risk values should therefore be considered in this context. Strategies identified to manage or address risks (section 8) take into consideration any local-scale characteristics which may have some bearing on the assessed risks.

2.4. Limitations and uncertainties

A 'best available information' approach was used to undertake this risk assessment. As much as practically possible, the most current data available were used to assess risks. Where relevant data has been made available after the completion of the analyses and time constraints preclude its inclusion in this risk assessment, it will be considered in any future risk assessments. Similarly, any new or additional data will be integrated into future risk assessments after the WRP commences, where appropriate.

A description of the data sources used to quantify likelihood and consequence metrics is provided in Appendix B to meet Basin Plan section 10.41(7). Appendix B also discusses the uncertainties in risk and the confidence level of the metrics used, to meet section 10.41(8).

Confidence in the data used is rated according to the criteria in Table 2-5.

It is highlighted that where a likelihood and/or consequence level cannot be determined due to lack of data, a 'moderate' rating has been assigned to the metric. This is a conservative middle-ground that allows a pragmatic assessment of the risk. In some circumstances quantitative assessment of a risk is constrained by inadequate data for both likelihood and consequence metrics. Where this occurs a qualitative approach has been used to determine a risk outcome. Where these assessments are made, the reasoning is provided in the appropriate section and additional risk level categories are defined and indicated by the addition of the text '-QAL' to the risk outcome.

Identified data/knowledge gaps are considered during the development of strategies for medium and high outcomes in section 8 as required under Basin Plan 10.43(1).

Table 2-5 Criteria used for rating confidence in data

Low	Moderate	High
Insufficient data/information available for assessment Data not applicable to the scale of the assessment Data/information based on estimates using methods/analytical models with a high degree of uncertainty Estimated data not based on any reliable measurements Anecdotal evidence only	Limited available data/information but applicable to the scale of the assessment Limited data based on reliable measurements Data/information based on estimates using methods/numerical models with moderate levels of certainty Limited documented evidence	Sufficient data/ information available for assessment Reliable data available for the scale of assessment Data based on reliable measurements Data/information based on estimates using methods/numerical models with a high degree of certainty Documented evidence available

Constraints around data availability and the scale of the risk assessment mean that uncertainty can be introduced within each step of the risk assessment. The reliability of the risk outcomes is influenced by:

- risk metrics that do not accurately capture the impact pathway
- the way metrics categories are defined (i.e. nil, low, medium, high, nil – QAL, low – QAL, medium – QAL, high – QAL)
- lack of applicable data to analyse metrics
- use of data that is 'best available' but is not strictly suitable.

The reliability of the risk outcomes therefore needs to recognise limitations in the framework, as well as data unavailability or mismatches.

The discussion in each section of this report identifies the key controls on each risk and the basis for metrics that describe the impact pathways. The discussion also captures where significant constraints in the available data have been identified.

Consideration is given to confidence in data when developing strategies for medium or high level risks; for example, strategies might be based on fill knowledge gaps or evaluating the effectiveness of water management actions and mechanisms filling there is insufficient or limited data available and the confidence in the data used is low.

Key limitations identified in the preparation of this risk assessment:

- unless otherwise stated, an SDL resource unit spatial scale was adopted. Separate aquifers within a single groundwater source were considered as one, which would have implications if confined and unconfined aquifers are treated in the same way.
- consequence rankings consider the loss of value when an impact on a receptor occurs. A qualitative indication of value was used instead of actual data indicating either social or economic value.
- quantitative risk outcomes are based on best available data. They indicate the potential for impact so that management actions and strategies can be prioritised where necessary.
- qualitative risk outcomes will have low data confidence in all circumstances. These risk outcomes are identified by the suffix ' – QAL'.

3. Overview of the water resource plan area

3.1. Identification

For the purpose of section 10.02 of the Basin Plan, this risk assessment is applicable to the WRP area and the water resources identified in section 3.06(d) of the Basin Plan as the NSW Murray-Darling Basin Porous Rock WRP area.

For the purpose of section 10.03 of the Basin Plan, the following are identified the:

- SDL resource units in this risk assessment are those described as within the NSW MDB Porous Rock WRP area (GW6) in section 6.03 and Schedule 4 of the Basin Plan:
  - Western Porous Rock (GS50)
  - Gunnedah-Oxley Basin MDB (GS17)
  - Oaklands Basin (GS38)
  - Sydney Basin MDB (GS41)
- water resources within each SDL resource unit are those described in section 6.03 and Schedule 4 to the Basin Plan within the NSW MDB Porous Rock WRP area.

3.2. Characterisation

The NSW Murray-Darling Basin Porous Rock Water Resource Plan area, hereafter referred to as the NSW MDB Porous Rock, covers groundwater located within the sedimentary basins in the NSW portion of the Murray-Darling Basin (Figure 3-1). This plan area also includes alluvial sediments that overly the basin that have not been separately mapped and incorporated into other WRPs as individual SDL resource units.

The Western Porous Rock is located in the far west of the state; it extends from south of Broken Hill and west of the Lachlan Alluvium and Murrumbidgee Alluvium WRP areas to the state borders with Victoria and South Australia. The Gunnedah-Oxley Basin MDB is located on the eastern side of the MDB located between Narrabri, Gunnedah and Dubbo. The Oaklands Basin is in the south-central area of the state and is completely buried by the Murrumbidgee and Murray Alluviums. The Sydney Basin MDB is in the eastern extent of the MDB extending southward along the MDB catchment border reaching near to Bathurst.

The four resource units of the NSW MDB Porous Rock align with the four groundwater sources established by the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*. A full description of these groundwater resources and their characterisation is provided in the NSW Murray-Darling Basin Porous Rock Resource Description Report (NSW Department of Industry 2018a).

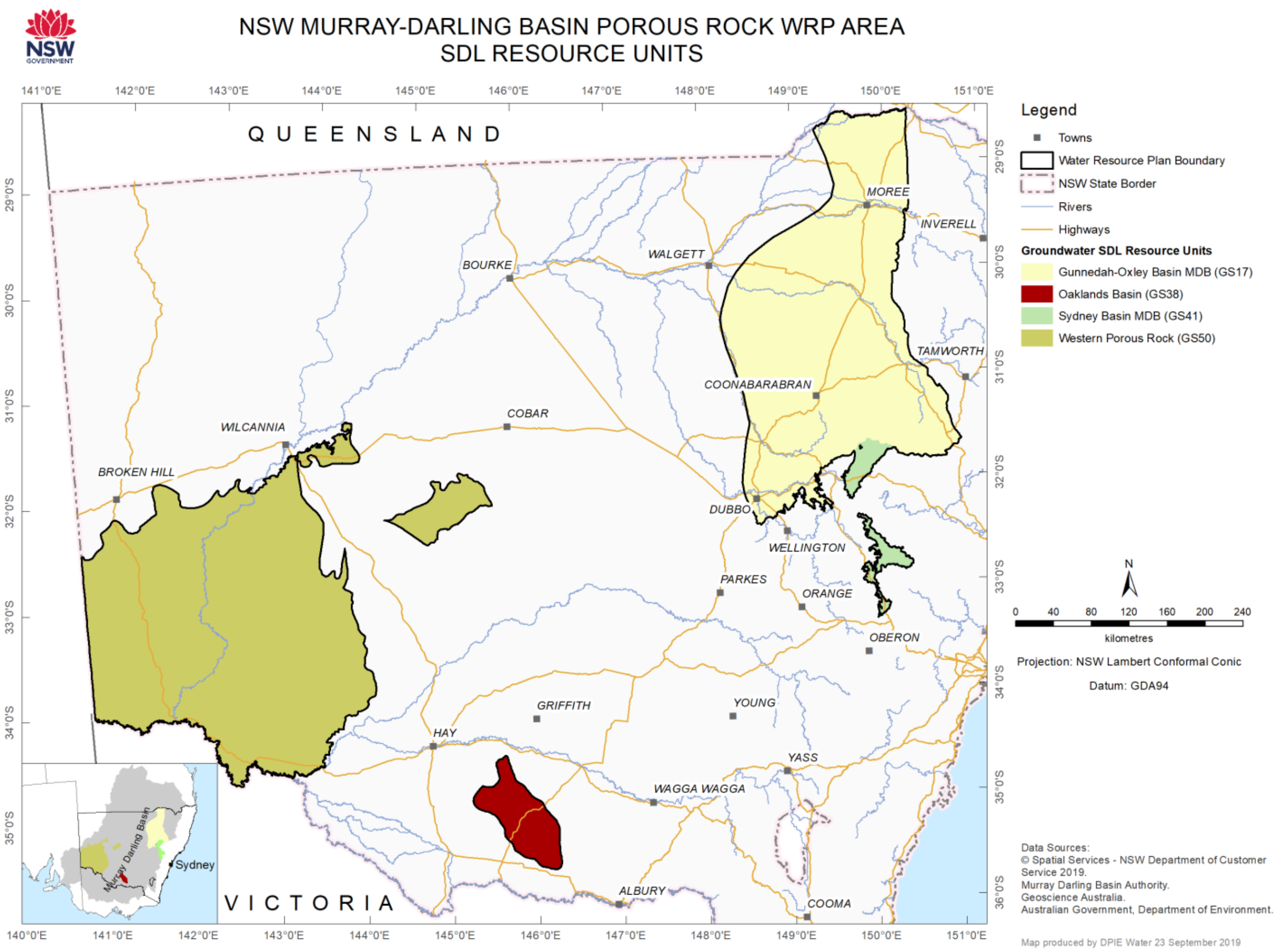


Figure 3-1 NSW Murray-Darling Basin Porous Rock Water Resource Plan area

3.3. Connectivity

Following the definition of connectivity set out in the MDBA's Position Statement 2B (Murray-Darling Basin Authority 2016), water resources are only considered to have a significant hydrologic connection in this report if both of the following criteria apply:

- water of one resource is physically able to move to the other resource (whether naturally or because of connections created by infrastructure and not limited to being an adjacent resource)
- activities in one resource may have a material impact on the state or condition of the other (including changes in surface or groundwater levels and pressures, quantity, timing of water availability or quality).

3.3.1. Groundwater-groundwater connectivity

Each porous rock resource unit is part of a sedimentary basin system. Most of these systems are larger than the porous rock resource unit boundaries within this water resource plan area and are consequently expected to have hydraulic connections across the state borders with SDL resource units in Queensland, South Australia and Victoria and other groundwater resources outside the Murray-Darling Basin in NSW where sufficient permeability and appropriate hydraulic head conditions prevail.

For these SDL resource units, the flow of groundwater is largely governed by both primary porosity with water movement around the rock grains, as well as secondary porosity with water movement through fractures made up of a combination of joints, bedding plane separation, faults and cavities within the rock mass. The ability to transmit usable quantities of water depends on the continuous interconnection of these higher permeability features. Groundwater flow is highest where fractures are both continuous, and interconnected. Groundwater flow is also often strongly influenced by the degree of weathering of the rock mass.

Recharge to these systems is primarily through infiltration from rainfall, runoff and surface water within the outcropping areas. Inflow can also occur from downward percolation of groundwater from overlying permeable strata that coincides with layers of the sedimentary sequences that have sufficient permeability for groundwater exchange to occur.

The Permo – Triassic sediments of the Gunnedah and Sydney Basin are part of a larger depositional system that extends outside of the Murray-Darling Basin to the south east and into Queensland north of the NSW border. Consequently, groundwater flow across these boundaries would occur where sufficient permeability and appropriate hydraulic head conditions prevailed. The low economic potential of this groundwater, due to the low permeability of the strata and high salinity of the groundwater, has resulted in little being known of regional groundwater flow systems between these sedimentary basins however groundwater flows at the intermediate to local scale within them have been studied associated with coal and gas resource exploitation.

The Jurassic sediments identified as the Oxley Basin that overlie the Permo – Triassic sediments of the Gunnedah and Sydney Basin were deposited contemporaneously with the Surat Basin located further west. However removal of the Pilliga Sandstone by erosion, which is the main groundwater target of these sequences, has hydraulically isolated the Oxley Basin from the Surat Basin. Groundwater through flow in the Pilliga Sandstone outside of the outcropping catchments is expected to occur in response to the prevailing hydraulic heads. Given the magnitude and spatial location of current extraction from the sandstone, induced changes to the natural groundwater flow conditions between the surface water catchments is not anticipated.

The Murray Geological Basin within NSW includes the Lower Lachlan, Lower Murrumbidgee and Lower Murray Alluviums, and the Western Porous Rock SDL resource units. The Lower Lachlan and Lower Murrumbidgee grade into the Western Porous Rock SDL resource unit on their western boundaries and groundwater through flow is uninterrupted across contiguous boundaries. The Lower Darling Alluvium and the southern extent of the Upper Darling Alluvium overlie and adjoin the sediments of the Murray Geologic Basin. The younger sediments of the Darling Alluvium are hydraulically connected to the Western Porous Rock SDL resource unit to varying degrees dependent on the juxtaposition of sediments of sufficient permeability.

The level of impact on the hydraulic relationships and properties between these groundwater systems was considered in setting the SDLs for these resource units and in setting LTAAELs for non-Basin resources. The management of extraction to these limits will ensure these hydraulic relationships are maintained to the acceptable level of impacts determined during that assessment. The volume of groundwater exchange between the resource units of the NSW MDB Porous Rock and non-Basin groundwater resources including the Great Artesian Basin is insignificant with regard to impacts on water availability and access rights in these resources. There is no connectivity between the Gwydir Alluvium and the NSW Murray-Darling Basin Porous Rock as these water resources do not share a contiguous boundary and there is significant separation between them.

Adjacent groundwater resource units and connectivity relationships and management are outlined in Table 3-1. Adjacent interstate Murray-Darling Basin resources are managed by the relevant state under the applicable water resource plan. NSW non-Basin resources are managed under the applicable water sharing plan. For further information refer to the NSW Murray-Darling Basin Porous Rock Water Resource Plan Groundwater Resource Description Report (NSW Department of Industry 2018a).

3.3.2. Groundwater-surface water connectivity

Within the Western Porous Rock SDL resource unit area there is significant hydrologic connection to the Lower Darling and Intersecting Streams surface water resource units. Water tables are generally below surface water systems and these circumstances represent a “losing system” for streams or rivers. That is, water is lost from the surface water flow to the groundwater system. An exception to this generalisation is the lower Murray River (within the Lower Darling resource unit) prior to reaching the South Australian border which alternates from losing to gaining conditions.

The interaction between the Murray River and the aquifers is complex and dynamic. During periods of high flows fresh river water recharges the shallow alluvial aquifer whereas saline groundwater flows into the river during low flow conditions. Groundwater and surface water level data indicate that the river reach between Euston and the South Australian border alternates from losing to gaining conditions. This depends on river levels, groundwater heads in the alluvial aquifers and the underlying Parilla Sand. Groundwater recharge or discharge to the river is controlled by the presence or absence of aquitards separating the local and regional aquifers, as well as the locations of locks and weirs and the influence of underlying basement structures. Although the Murray River is considered to be hydraulically connected to the recent alluvium confined to the floodplain groundwater pumping impacts from the regional aquifer (Parilla Sand) at the river are subdued or delayed. This lag time of groundwater pumping impacts is acknowledged in setting the extraction limit of the resource and the Western Porous Rock is managed independently from the river.

Three salt interception schemes operate within the Western Porous Rock SDL resource unit area and aim to reduce and manage the amount of salt reaching the Murray River. Groundwater is pumped to salt management basins for evaporation and operate in conjunction with other salt interception schemes to reduce the reduced the salinity in the River Murray. Details of the Mallee Cliffs Salt Interception Scheme, Buronga / Mourquong Salt Interception Scheme and Lake Victoria / Rufus River Salt Interception Schemes are shown in Table 3-2.

Being totally buried beneath the Lower Murrumbidgee and Lower Murray Deep Alluviums, groundwater in the Oaklands Basin is not connected to surface water.

The higher elevated areas associated with the Sydney Basin MDB, along with the higher rainfall, and more incised nature of the sediments would facilitate groundwater to discharge as baseflow into creeks along the upper catchments. As such, stream flows may be reliant on groundwater discharge during drought times. Within much of the Gunnedah-Oxley Basin MDB, with the exception of some of the more elevated fringe areas, it is not considered that groundwater has a direct connection to surface water systems. Within elevated fringe areas there is potential for discharge as baseflow into creeks of upland surface water catchments on the eastern margins of the resource unit.

Porous Rock resource units that contain outcrop areas of high elevation (i.e. the Sydney Basin MDB and Gunnedah-Oxley Basin MDB) may contribute baseflow to overlying streams, however the low permeability of porous rock resources limits the potential for material impact to occur on the adjacent surface water SDL resource units from activities such as groundwater extraction from the MDB Porous Rock. These hydrologic connections are considered to have low levels of significance at a localised scale hence the surface and groundwater systems are managed separately. These relationships have not been quantified or characterised thus risk for instream ecological values has been assessed at the resource unit scale. For unregulated gaining streams groundwater is not considered to be a major contributor to surface water flows in comparison to other inputs such as rainfall.

Risk of groundwater extraction induced sediment compaction impacting surface water users in overlying resource units has been assessed in this document, refer to QL1 in section 4.6 for further information. Risk outcomes for all overlying surface water SDL resource units is Nil – QAL. Risk of lower groundwater levels reducing discharge to overlying streams and impacting the health of groundwater-dependent instream ecological values has also been assessed in this document. The following threats have been examined and medium and high risk outcomes determined:

- extraction causing local drawdown (R10, section 6.3)
  medium risk outcomes for the Gunnedah-Oxley Basin MDB, low and nil risk outcomes for other resource units
- growth in plantation forestry intercepting recharge (R12, section 6.4)
  nil risk outcomes for all resource units
- climate change reducing recharge and groundwater availability (R14, section 6.5)
  low risk outcomes for all resource units
- land and waste management practices, land management, extraction causing water quality deterioration (QL5, section 6.6)
  medium risk outcomes for the Sydney Basin MDB and Gunnedah-Oxley Basin MDB resource units, nil or low risk outcomes for the remaining resource units (land management induced water quality (salinity) deterioration only)
- growth in basic landholder rights and local water utility entitlement reducing groundwater availability (QL6, section 6.7)
  nil risk outcomes for all resource units
- growth in mining reducing groundwater availability (QL7, section 6.8)
  nil or low risk outcomes for all resource units.

Refer to the appropriate sections of the report for all analysis details and all risk outcomes. Note the degree of connectivity between ground and surface waters was considered for each resource unit in determining the consequence ranking (section 6.2.2.2), however the likelihood metrics used do not take the level of connectivity into account and consequently the risks may be overstated. For risks such as R14, the risk of climate change reducing recharge and groundwater availability, both recharge and discharge connectivity relationships would be relevant to incorporate in a more detailed assessment than has been undertaken in this document. The limitations in the likelihood metrics, including geographic scale, spatial spread and data confidence, are discussed in the confidence in data sections for the medium risk outcomes listed (6.3.2, 6.5.2, 6.6.1). Strategies to address these risks are described in the consolidated table, Table 8-7, and in the existing water management actions and mechanisms sections for each risk (6.3.3, 6.5.3, 6.6.2).

The level of impact on hydraulic relationships and properties between groundwater systems and connected surface water systems was considered in setting the SDLs and LTAAELs for these resource units. The management of extraction to these limits will ensure hydraulic relationships are maintained to the acceptable level of impact determined during that assessment. The long term management rules allow the utilisation of some of the large storage volume component of groundwater systems during low recharge periods. This strategy addresses seasonal variation in recharge. Longer term changes in recharge due to climate change would be addressed by a review of the LTAAEL/SDL at the time of the water sharing plan remake (water sharing plans have ten year terms). Part 4 of Chapter 7 of the Basin Plan allows SDLs for groundwater SDL resource units to be adjusted by up to 5% to reflect new or improved information about the groundwater resources, including improved information on climate change impacts.

Protection of groundwater derived baseflows from localised groundwater extraction impacts are provided for in the WSP. Minimum distances are established between new or amended water supply works and streams. The

Minister may also apply restrictions on extraction from water supply works to protect GDEs – which include instream ecological values. This may be applied during periods of reduced water availability. For information regarding the process of applying these actions and mechanisms refer to Schedule I of the NSW Murray–Darling Basin Porous Rock WRP.

Protection for groundwater-derived instream baseflows from surface water extraction related impacts are provided by the planned environmental water provisions in surface water WRP areas and WSPs. See the Namoi, Macquarie-Castlereagh, Intersecting Streams, and NSW Murray and Lower Darling surface water WRPs and LTWPs for further details.

As described in Table 8-6 there are several knowledge strategies that are relevant to these risks:

- K3 Existing groundwater level and take monitoring programs
- K4 Proposed water quality and environmental monitoring
- K5 Complementary water quality and environmental monitoring programs

For further information refer to the EMER Plan, Schedule H of the NSW Murray–Darling Basin Porous Rock WRP. In addition the surface water EMER Plans are responsive to risk outcomes and describe monitoring programs for base flow related risks in unregulated rives. For further information on the groundwater resources refer to the NSW Murray–Darling Basin Porous Rock Water Resource Plan Groundwater Resource Description Report (NSW Department of Industry 2018a).

Adjacent surface water resource units, connectivity relationships and management are outlined in Table 3-1. For further information regarding the groundwater resource units refer to the NSW Murray-Darling Basin Porous Rock Water Resource Plan Groundwater Resource Description Report (NSW Department of Industry 2018a).

Table 3-1 NSW MDB Porous Rock resource units and adjacent management areas

SDL resource unit	Adjacent SDL resource unit[2]	Adjacent water resource plan / non-Basin water sharing plan	Hydrologic connection	Rationale	Management approach (also see Table 3-2)
GS17 Gunnedah-Oxley Basin MDB	*underlies* SS20 Macquarie-Castlereagh[1]	SW11 Macquarie-Castlereagh Water Resource Plan	Significant (low)	Potential for discharge as baseflow into creeks of upland surface water catchments on the eastern margins of the resource unit. The low permeability of the porous rocks limits potential for material impact on the adjacent SDL resource units	Surface and groundwater extraction managed to SDL / LTAAEL. Planned environmental water rules in surface waters protect baseflow.
	SS21 Namoi[1]	SW14 Namoi Water Resource Plan	Significant (low)	Potential for discharge as baseflow into creeks of upland surface water catchments on the eastern margins of the resource unit. The low permeability of the porous rocks limits potential for material impact on the adjacent SDL resource units	Surface and groundwater extraction managed to SDL / LTAAEL. Planned environmental water rules in surface waters protect baseflow.
	overlies and adjacent to GS20 Lachlan Fold Belt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL
	GS37 New England Fold Belt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL
	underlies and adjacent to GS22 Liverpool Ranges Basalt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL

SDL resource unit	Adjacent SDL resource unit[2]	Adjacent water resource plan / non-Basin water sharing plan	Hydrologic connection	Rationale	Management approach (also see Table 3-2)
	GS47 Upper Namoi Alluvium	GW14 Namoi Alluvium Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and alluvial resources	Groundwater extraction managed to SDL / LTAAEL
	Surat Groundwater Source, Great Artesian Basin (*non-Basin resource*)	*Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2020*	Not significant	The low permeability shales and volcanics of the non-Basin GAB that directly overlie the Gunnedah Oxley Basin results in insignificant exchange of groundwater	Groundwater extraction managed to SDL / LTAAEL
	adjacent to				
	GS41 Sydney Basin MDB	GW6 NSW Murray-Darling Basin Porous Rock Water Resource Plan	Not significant	The low permeability of the porous rocks limits potential for material impact on the adjacent SDL resource units	Groundwater extraction managed to SDL / LTAAEL
	Sydney Basin (*non-Basin resource in coastal NSW*)	*Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*	Not significant	The low permeability of the porous rocks limits potential for material impact on the adjacent non-Basin resources	Groundwater extraction managed to SDL / LTAAEL
	Oxley Basin (*non-Basin resource in coastal NSW*)	*Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*	Not significant	The low permeability of the porous rocks limits potential for material impact on the adjacent non-Basin resources	Groundwater extraction managed to SDL / LTAAEL
GS41 Sydney Basin MDB	*underlies*				
	SS20 Macquarie-Castlereagh[1]	SW11 Macquarie-Castlereagh Water Resource Plan	Significant (low)	Potential for discharge as baseflow into creeks of upland surface water catchments. The low permeability of the porous rocks limits potential for material impact on the adjacent SDL resource units	Surface and groundwater extraction managed to SDL / LTAAEL. Planned environmental water rules in surface waters protect baseflow.

SDL resource unit	Adjacent SDL resource unit[2]	Adjacent water resource plan / non-Basin water sharing plan	Hydrologic connection	Rationale	Management approach (also see Table 3-2)
	overlies and adjacent to				
	GS20 Lachlan Fold Belt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL
	underlies and adjacent to				
	GS22 Liverpool Ranges Basalt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL
	GS15 Coolaburragundy – Talbragar Alluvium	GW12 Macquarie-Castlereagh Alluvium Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and alluvial resources	Groundwater extraction managed to SDL / LTAAEL
	GS45 Upper Macquarie Alluvium	GW12 Macquarie-Castlereagh Alluvium Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and alluvial resources	Groundwater extraction managed to SDL / LTAAEL
	adjacent to				
	GS17 Gunnedah-Oxley Basin MDB	GW6 NSW Murray-Darling Basin Porous Rock Water Resource Plan	Not significant	The low permeability of the porous rocks limits potential for material impact on the adjacent SDL resource units	Groundwater extraction managed to SDL / LTAAEL
	Sydney Basin (*non-Basin resource in coastal NSW*)	*Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*	Not significant	The low permeability of the porous rocks limits potential for material impact on the adjacent non-Basin resources	Groundwater extraction managed to SDL / LTAAEL
	Oxley Basin (*non-Basin resource in coastal NSW*)	*Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*	Not significant	The low permeability of the porous rocks limits potential for material impact on the adjacent non-Basin resources	Groundwater extraction managed to SDL / LTAAEL

SDL resource unit	Adjacent SDL resource unit[2]	Adjacent water resource plan / non-Basin water sharing plan	Hydrologic connection	Rationale	Management approach (also see Table 3-2)
GS50 Western Porous Rock	*underlies*				
	SS17 Intersecting Streams[1]	SW13 Intersecting Streams Water Resource Plan	Significant (low)	Overlying portion of the Intersecting Streams resource unit contains a limited number of surface water features.	Groundwater extraction managed to SDL / LTAAEL
	SS18 Lower Darling[1]	SW8 NSW Murray and Lower Darling Water Resource Plan	Significant (low)	Complex and dynamic connectivity relationship with losing / gaining river sections. Groundwater extraction impacts on the river are subdued and / or delayed.	Groundwater extraction managed to SDL / LTAAEL and salinity management in place (see Table 3-2)
	adjacent to				
	GS25 Lower Lachlan	GW10 Lachlan Alluvium Water Resource Plan	Significant (low)	Sediments have similar geological characteristics and permeabilities and are within the Murray Geologic Basin	Groundwater extraction managed to SDL / LTAAEL
	GS28a, b Lower Murrumbidgee Shallow and Deep Alluviums	GW9 Murrumbidgee Alluvium Water Resource Plan	Significant (low)	Sediments have similar geological characteristics and permeabilities and are within the Murray Geologic Basin	Groundwater extraction managed to SDL / LTAAEL
	GS6 SA Murray (*interstate*)	GW4 South Australian Murray Region Water Resource Plan	Significant (low)	Sediments have similar geological characteristics and permeabilities and are within the Murray Geologic Basin	NSW Groundwater extraction managed to SDL / LTAAEL. Interstate SDL and WRP applies
	GS7 SA Murray Salt Interception Schemes (*interstate*)	GW4 South Australian Murray Region Water Resource Plan	Significant (low)	Sediments have similar geological characteristics and permeabilities and are within the Murray Geologic Basin	NSW Groundwater extraction managed to SDL / LTAAEL. Interstate SDL and WRP applies
	GS9b Wimmera-Mallee: Sedimentary Plain (*interstate*)	GW3 Wimmera-Mallee (groundwater) Water Resource Plan	Significant (low)	Sediments have similar geological characteristics and permeabilities and are within the Murray Geologic Basin	NSW Groundwater extraction managed to SDL / LTAAEL. Interstate SDL and WRP applies

SDL resource unit	Adjacent SDL resource unit[2]	Adjacent water resource plan / non-Basin water sharing plan	Hydrologic connection	Rationale	Management approach (also see Table 3-2)
	GS9c Wimmera-Mallee: deep (*interstate*)	GW3 Wimmera-Mallee (groundwater) Water Resource Plan	Significant (low)	Sediments have similar geological characteristics and permeabilities and are within the Murray Geologic Basin	NSW Groundwater extraction managed to SDL / LTAAEL. Interstate SDL and WRP applies
	overlies and adjacent to				
	GS10 Adelaide Fold Belt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL
	GS19 Kanmantoo Fold Belt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL
	GS20 Lachlan Fold Belt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL
	underlies and adjacent to				
	GS42 Upper Darling Alluvium	GW7 Darling Alluvium Water Resource Plan	Significant (low)	The younger sediments of the Darling Alluvium are hydraulically connected to varying degrees dependent on the juxtaposition of sediments of sufficient permeability	Groundwater extraction managed to SDL / LTAAEL
	GS23 Lower Darling Alluvium	GW7 Darling Alluvium Water Resource Plan	Significant (low)	The younger sediments of the Darling Alluvium are hydraulically connected to varying degrees dependent on the juxtaposition of sediments of sufficient permeability	Groundwater extraction managed to SDL / LTAAEL
	overlies				

SDL resource unit	Adjacent SDL resource unit[2]	Adjacent water resource plan / non-Basin water sharing plan	Hydrologic connection	Rationale	Management approach (also see Table 3-2)
Oaklands Basin	GS20 Lachlan Fold Belt	GW11 NSW Murray-Darling Basin Fractured Rock Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and Fractured Rock resources	Groundwater extraction managed to SDL / LTAAEL
	underlies				
	GS28b Lower Murrumbidgee Deep Alluvium	GW9 Murrumbidgee Alluvium Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and alluvial resources	Groundwater extraction managed to SDL / LTAAEL
	GS27b Lower Murray Deep Alluvium	GW8 Murray Alluvium Water Resource Plan	Not significant	Permeability differences result in insignificant groundwater exchange between Porous Rock and alluvial resources	Groundwater extraction managed to SDL / LTAAEL

[1] Areas of surface water resource units that are directly underlain by alluvial, NSW GAB Shallow or NSW MDB Fractured Rock resource units, or by non-Basin GAB resources do not share a contiguous boundary with this NSW MDB Porous Rock resource unit.

[2] Adjacent interstate Murray-Darling Basin resources are managed by the relevant state under the applicable water resource plan

Table 3-2 Connectivity management in the NSW MDB Porous Rock

SDL resource unit	Adjacent SDL resource unit	Connectivity management type	Groundwater source / management zone	Associated water source / management zone
Western Porous Rock GS50	Lower Darling SS18	Mallee Cliffs Salt Interception Scheme	Western Murray Porous Rock Groundwater Source *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*	NSW Murray Regulated River Water Source *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2016*
Western Porous Rock GS50	Lower Darling SS18	Buronga / Mourquong Salt Interception Scheme	Western Murray Porous Rock Groundwater Source *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*	NSW Murray Regulated River Water Source *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2016*
Western Porous Rock GS50	Lower Darling SS18	Lake Victoria / Rufus River Salt Interception Scheme	Western Murray Porous Rock Groundwater Source *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*	NSW Murray Regulated River Water Source *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2016*

4. Risks to consumptive users

4.1. Background

Impacts as a result of groundwater extraction that can occur across a large expanse of a groundwater system have the potential to affect multiple users within the system and in connected systems. For the NSW MDB, these impacts can include:

- aquifer compaction that may reduce bore yields and damage bore infrastructure or impact connected water resources
- poor or non-compliant land and waste management practices that may result in contamination of groundwater
- induced connection with poor quality groundwater resulting in degradation of groundwater quality
- EROSION of groundwater access in local areas by high extraction intensity and local drawdown impacts.

These impacts could affect the physical ability of any user within an aquifer system or a connected aquifer or surface water system to extract their groundwater entitlements. The impact pathways for considering potential impacts on all consumptive users are summarised in Figure 4-1, and the risks are analysed in the following sections.

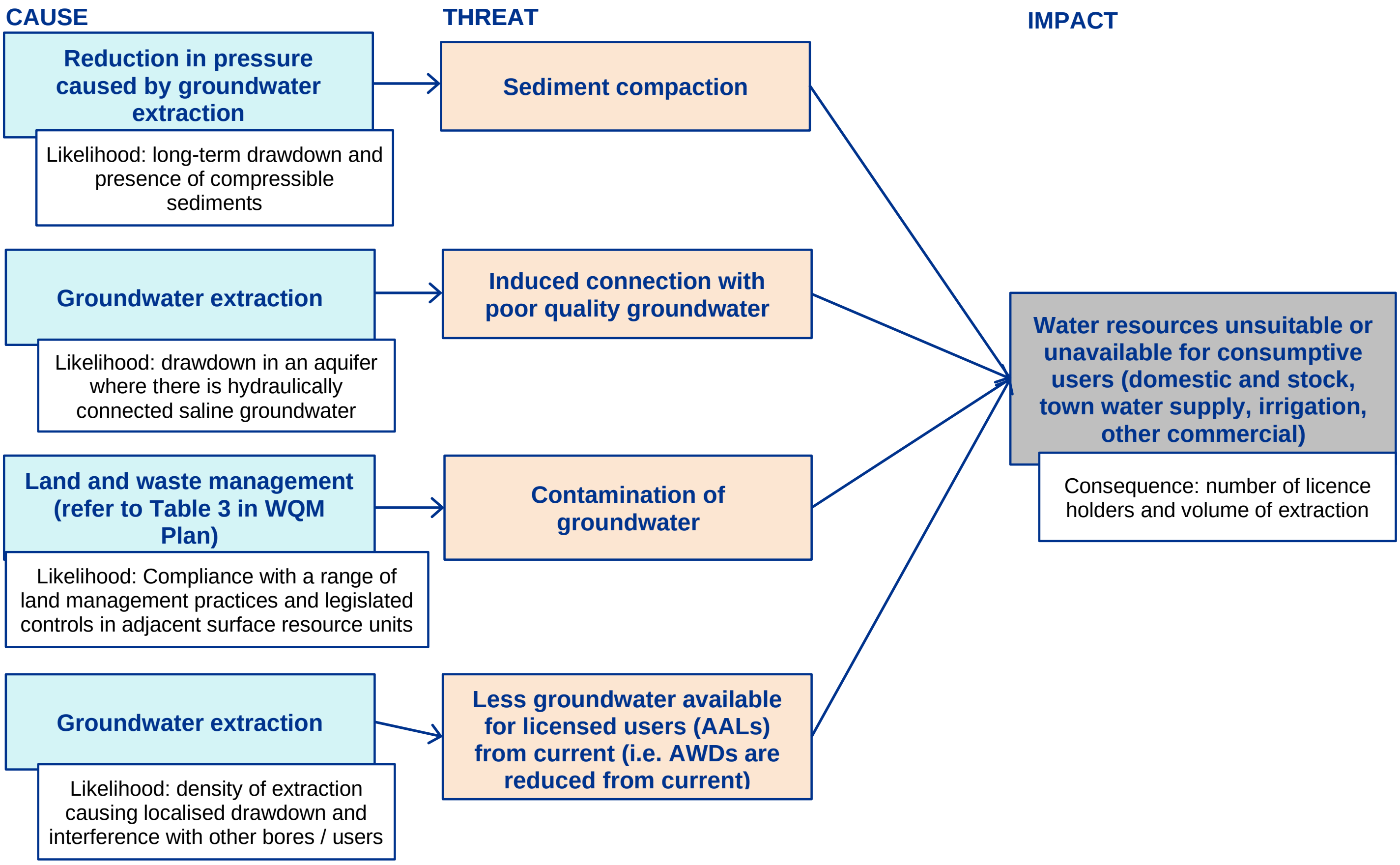


Figure 4-1 Impact pathways for risks to consumptive users

4.2. Assigning a consequence ranking

The consequence of impacts on consumptive users focuses on the potential magnitude of impact on all consumptive users of the aquifer system, using the metrics:

- number of users of the groundwater source
- total volume of extraction in the groundwater source.

These consequence metrics aim to describe the resource value for consumptive users and the sensitivity of the receptors (i.e. consumptive users) to impacts. Sensitivity is considered to be higher where a greater number of users may be impacted. Therefore, more users within a groundwater source equates to a higher consequence.

The volume of extraction within a groundwater source has also been used to describe the consequence of risks. A groundwater resource that has a greater level of (average) annual extraction is assumed to be more highly depended upon, and provide greater value to users. Any reduction in the extraction volume available to users as a result of the risk impact would alter the value of the resource to those users.

Using this approach, a higher consequence occurs in groundwater sources where there are a high number of groundwater extractors, and where a high volume of annual average extraction also occurs.

The categories used to describe consequence are defined in Table 4-1. The low, medium and high categories were defined by the 30th and 70th percentiles of the datasets. These percentiles were selected to provide three relatively equal categories around the median (i.e. the 50th percentile). The median was used as the mid-point of the data, as variables like water extraction can often be skewed towards the lower values. The use of the median in natural resource management is commonly used to assess the spread of data. For example, the approach adopted by the Bureau of Meteorology to categorise groundwater level trends and status in their Groundwater Insight tool (BOM 2017) used the 30th and 70th percentiles.

Defining categories in this way provides a relative consequence score across all NSW groundwater sources in the MDB. This approach assumes that within the dataset, there will always be groundwater sources that fall within each of the low, medium and high consequence categories. Using relative consequence identifies those groundwater sources within the NSW MDB which could be most impacted by risks; this approach assists to prioritise management of the resource.

The total volume of extraction includes the annual extraction volume for all licenced production bores averaged over 10 years of metered data. Extraction in the Sydney Basin MDB SDL resource unit is not metered. Where metering has not been implemented, licensed groundwater extraction is assumed to be equivalent to full entitlement. Note this is different to the Oaklands Basin where there are no aquifer access licences and no requirements for BLR.

Table 4-1 Consequence metrics and results for the NSW MDB Porous Rock (consumptive users)

Metric	Metric category	Metric category definition [3]	SDL resource unit
Number of extractors[1]	Nil	No water access licences	Oaklands Basin - 0
	Low	< 16 access licences (i.e. 30th percentile of number of access licences for all NSW MDB groundwater sources)	
	Medium	16 – 76 access licences (i.e. 30th – 70th percentile of number of access licences for all NSW MDB groundwater sources)	Western Porous Rock = 20 Sydney Basin MDB = 29
	High	> 76 access licences (i.e. 70th percentile of number of access licences for all NSW MDB groundwater sources)	Gunnedah-Oxley Basin MDB = 147
Average annual extraction	Low	Average annual extraction< 710 ML/yr (i.e. 30th percentile of extraction volume for all NSW MDB groundwater sources)	Oaklands Basin = 0 (assumed no extraction)[4]

Metric	Metric category	Metric category definition [3]	SDL resource unit
volume authorised by access licences (averaged over 10 years)[2]	Medium	Average annual extraction 710 – 7,337 ML/yr (i.e. 30th – 70th percentile of extraction volume for all NSW MDB groundwater sources)	Western Porous Rock = 5,192 Sydney Basin MDB = 2,657[5] Gunnedah-Oxley Basin MDB = 5,257
	High	Average annual extraction > 7,337 ML/yr (i.e. 70th percentile of extraction volume for all NSW MDB alluvial groundwater sources)	

Data source: [1] NSW Water Licensing System (2017), [2] NSW Water Accounting System (2017)
[3] No porous rock data was included in the calculations of the 30th and 70th percentiles
[4] As there are no aquifer access licences in this groundwater source, and no water requirements for basic landholder rights, extraction is assumed to be 0 ML
[5] Extraction is not metered so entitlement has been assumed to be fully used.

Consequence rankings for NSW MDB Porous Rock WRP area are provided in Table 4-2 and are as follows:

- nil in the Oaklands Basin
- medium in the Western Porous Rock and Sydney Basin MDB
- high in the Gunnedah-Oxley Basin MDB.

There is no licenced or basic landholder rights extraction from the Oaklands Basin SDL resource unit. As there is no extraction there is no risk receptor and therefore no potential for consequences to occur.

Table 4-2 Consequence matrix and rankings for the NSW MDB Porous Rock (consumptive users)

		Number of groundwater extractors			
		0	**< 16**	**16 - 76**	**> 76**
Average annual extraction volume (ML/yr)	**< 710 ML/yr**	Nil Oaklands Basin	Low	Low	Medium
	710 – 7,337 ML/yr	Nil	Low	Medium Western Porous Rock, Sydney Basin MDB	High Gunnedah-Oxley Basin MDB
	> 7,337 ML/yr	Nil	Medium	High	High

SDL resource unit	Consequence ranking
Oaklands Basin	Nil
Western Porous Rock	Medium
Sydney Basin MDB	Medium
Gunnedah-Oxley Basin MDB	High

4.2.1. Confidence in data

The confidence in the data used for the consequence matrix is high according to the criteria in Table 2-5, as the data is measured (with the exception of the Sydney Basin MDB, where extraction was estimated from licenced volumes and data confidence is moderate) and applicable to the specific groundwater sources and the scale of assessment. The greatest uncertainty is whether the metrics of ‘number of access licences’ and ‘extraction volume’ accurately reflect the level of dependence, sensitivity and value of the groundwater sources to describe the consequence.

It is acknowledged that this approach does not distinguish between uses of different priority or value. Options for assessing the consequence may include considering reliance on groundwater as distinct from surface water, as surface water may be accessible and currently used by groundwater extractors. If data on the relative reliance between surface and groundwater becomes available in the future, it may be useful to incorporate into the consequence matrix.

The following sections describe the analysis of the likelihood of causes and threats occurring. The likelihood rankings then feed into the overall risk determination.

4.3. Risks to structural integrity of the groundwater system (R1)

The main concern associated with structural integrity and groundwater withdrawal from groundwater systems is compaction of strata, leading to reduced groundwater storage and lower long-term bore yields. This assessment considers the potential for compaction of the whole aquifer system, which includes both the aquifers and aquitards. Sediment compaction may also result in subsidence of the ground surface; however, subsidence risks are outside the scope of this risk.

Compaction can occur when groundwater is removed by pumping or drainage from highly compressible sediments (Galloway and Sneed 2013). The reduction of fluid pressure in the pores of unconsolidated sediments is inevitably accompanied by some deformation of the aquifer system. Both the aquifers and aquitards that constitute the groundwater system undergo deformation, but to different degrees.

Typical aquifer sediments such as sand and gravel have low compressibility as their lower porosity and crystalline grains create a more structurally competent aquifer matrix that is less prone to deformation. Changes in aquifer pressure therefore have to be large before collapse of the aquifer matrix occurs. Conversely, typical aquitard sediments such as clay and silt have a higher porosity. Because of the higher porosity, water pressure within the pore spaces contributes more to the structural integrity of the aquitard. A reduction in pressure over long periods dewaters the pores and allows the sediment grains to collapse into the pore spaces. Therefore, the same reduction in pressure creates more compression in aquitard sediments than in aquifer sediments.

Compaction of sediments within an aquifer system can be either reversible or irreversible. Reversible compaction occurs in all aquifer systems to various extents in response to groundwater level changes. Seasonal discharge and recharge processes result in some compaction when groundwater levels are low, which is then fully recovered when groundwater levels increase again (Galloway et al.1999).

Irreversible compaction occurs in response to long term declines in groundwater pressure. Over the longer term, the slow process of drainage from aquitards and finer grained sediments occurs. As described above, once drainage from first the thin and then the thicker aquitard sediments occurs, structural deformation of the sediments is more likely, such that the resulting compaction cannot be reversed (Galloway et al.1999). The outcome is some permanent loss of storage capacity of the aquifer system (Alley et al.1999).

This impact pathway is shown in Figure 4-2 and demonstrates the threat, ‘Significant drawdown and sediment compaction’, may result from drawdown in the compressible sediments of the groundwater system, the primary cause of which would be groundwater pumping (the cause). The likelihood of sediment compaction occurring can therefore be described by the degree of drawdown combined with the presence of compressible sediments.

The consequence of sediment compaction is assessed by considering the users of the groundwater system that would be affected by compaction. In this case, all users may be affected by lower yields or damaged bores as a result of sediment compaction. The likelihood and consequence risk metrics are discussed in more detail below.

Apart from the Western Porous Rock SDL resource unit which is comprised of unconsolidated sediments, compaction and subsidence would not be expected for these porous rock resources as the aquifers and aquitards are comprised of consolidated material.

Consideration of the impact of sediment compaction on the overlying surface water resources and adjacent groundwater resources are considered in section 4.6 and section 4.7.

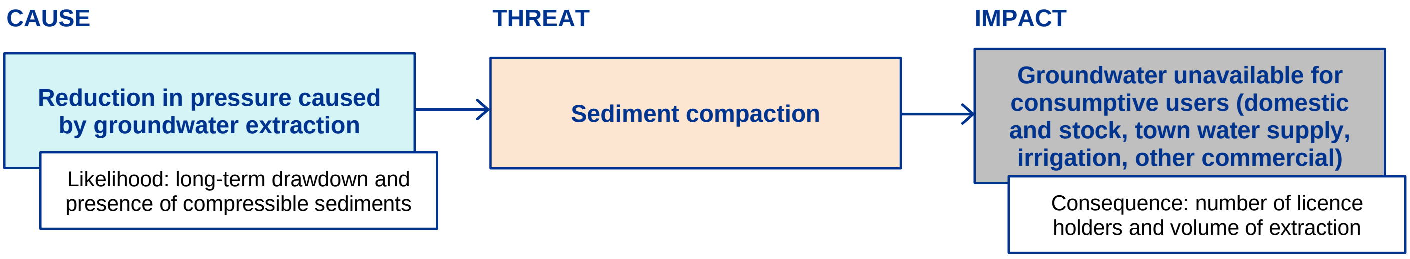


Figure 4-2 Impact pathway for risks to structural integrity of the groundwater systems impacting consumptive water users

4.3.1. Determining the likelihood ranking

The likelihood of sediment compaction within the groundwater system and reduced yields from production bores is described by the:

- proportion of compressible sediments in the aquifer system
- change in pressure within the aquifer system due to long-term drawdown in relation to saturated thickness of aquifer system.

Compaction of sediments is relevant to the structural integrity of the aquifer system and groundwater supply for two reasons: firstly, aquitards, due to their finer grains, are more porous and hence more compressible but also less permeable than the coarser materials that make up the highly transmissive layers of the aquifer. The aquitard itself can comprise a large portion of the groundwater storage capacity of a confined aquifer system and when water is pumped out the aquifer over a period of time the permeability difference between the aquifer and the aquitard can lead to compaction of the aquitard which has been observed to reduce vertical leakage and to lower aquifer yields (Galloway et al. 1999).

Secondly, the deformation of an aquitard can also damage bore infrastructure. For these reasons, the analysis considers compaction and deformation of the alluvial sequence as a whole within the resource units, as opposed to confining the analysis to the aquifer units only.

Thick sequences of fine-grained sediment (clay, sandy clay, silt, and sandy silt) are required for irreversible compression to become significant; the metric categories reflect these requirements (

Table 4-3).

It is considered that aquifer systems with less than 20% compressible materials will not be susceptible to compaction. Including a 'nil' likelihood to account for small percentages of compressible sediments means that non-compressible aquifer systems will be considered 'no risk', as without significant compressible sediments there is no potential for impact, for example, in fractured rock systems.

A medium susceptibility to compression requires more than 50% compressible sediments in the aquifer system. There is some empirical evidence to support this delineation between categories. The San Joaquin Valley in California is comprised of more than 50% compressible sediments, and with significant groundwater extraction from the deep aquifer, the fine-grained sediments were compacted which caused up to 15 m subsidence at the surface (Galloway et al. 1999). The potential for compression increases as the percentage of compressible sediments in the alluvial aquifer profile increases.

The other component of the likelihood metrics is drawdown. Compaction primarily occurs when fluid pressure in the sediments declines during the pumping cycle. The likelihood of any future compaction is linked to the likelihood of future drawdowns levels exceeding the previous maximum drawdown (Ali et al. 2004). Therefore a key control on the likelihood of compaction occurring is the water level at the commencement of the pumping season (i.e. the recovered water level).

Changes in recovered groundwater levels over the available monitoring period were calculated using hydrographs and expressed as a percentage of saturated aquifer system thickness. For comparison, where subsidence has occurred in the Lower Namoi valley (Ross and Jeffery, 1991), long-term drawdown between August 1974 and February 1990 ranged from 19% to 50% of initial (August 1974) saturated thickness, which would translate to a medium or high likelihood of impacts to the structural integrity of the aquifer.

This assessment addresses the potential for future compaction as a result of historic long-term change in seasonally recovered groundwater levels. The data used considers long-term data since pre-development for all monitoring bores in the WRP area. Use of the historical recovered water level data assumes that the responses observed since pre-development will continue into the future. Where the starting groundwater level is declining, seasonal drawdowns could exceed previous maximum levels, increasing the risk of compaction. In reality this is a conservative approach.

Saturated thickness here is considered as the saturated thickness of the whole alluvial system. All water sources consist largely of unconfined shallow and semi-confined/confined deep aquifers, with varying degrees of connection between the two. The necessary reliance on regional scale datasets means these aquifers have not been considered individually, and so risk outcomes must be viewed as a combined outcome.

Table 4-3 and Table 4-4 show the data for each of the likelihood metrics, and the resulting likelihood rankings which are as follows:

- nil in the Oaklands Basin, Sydney Basin MDB and Gunnedah-Oxley Basin MDB
- low in the Western Porous Rock

For the majority of SDL resource units in the NSW MDB Porous Rock WRP area the consolidated nature of the units means that the likelihood of aquifer compaction is low. The Western Porous Rock resource unit is unconsolidated but the small recovered drawdown level as a proportion of saturated thickness means that the likelihood of aquifer compaction is low.

Note there is no data available for the Oaklands Basin to determine long-term decline in seasonally recovered groundwater levels. In these circumstances a medium result should apply however as there are no aquifer access licences or demand for basic landholder rights in this resource unit a result of low is more appropriate. The use of either medium or low in this calculation would not affect the likelihood ranking as there is a nil result for the percentage of compressible sediments.

Table 4-3 Likelihood metrics and results for the NSW MDB Porous Rock (drawdown in compressible sediments)

Likelihood metric	Metric category	Category definition	SDL resource unit results[1]
Percentage of compressible sediments	Nil	< 20 % compressible sediments in the alluvial aquifer system profile	Oaklands Basin Gunnedah-Oxley Basin MDB Sydney Basin MDB
	Low	20 - 50% compressible sediments in the alluvial aquifer system profile	
	Medium	50 - 80% compressible sediments in the alluvial aquifer system profile	Western Porous Rock[2]
	High	> 80% compressible sediments in the alluvial aquifer system profile	
Long-term decline in seasonally recovered groundwater levels[1]	Low	Recovered water levels was <20% of saturated thickness in >90% of bores	Gunnedah-Oxley Basin MDB Western Porous Rock Oaklands Basin[3]
	Medium	Recovered water levels was between 20 and 40% of saturated thickness in >10% of bores	Sydney Basin MDB[2]
	High	Recovered water levels was >40% of saturated thickness in >10% of bores	

Data source: [1] NSW Department of Planning and Environment Groundwater Data System, 2017
[2] As there is no data, a medium ranking has been used
[3] While there is no data on drawdown in the Oaklands Basin SDL resource unit a low ranking has been applied given that there are no aquifer access licences in this SDL resource unit, and no water requirements for basic landholder rights.

Table 4-4 Likelihood matrix and rankings for the NSW MDB Porous Rock (drawdown in compressible sediments)

		Thickness of compressible sediments (as percentage of aquifer thickness)			
		Minor (<20%)	**Low (20-50%)**	**Medium (50-80%)**	**High (>80%)**
Long-term decline in seasonally recovered groundwater levels	**Low (<20% decline in saturated thickness in >90% of bores)**	Nil Gunnedah-Oxley Basin MDB, Oaklands Basin	Low	Low Western Porous Rock	Medium
	Medium (20-40% decline in sat thickness in >10% of bores)	Nil Sydney Basin MDB	Low	Medium	High
	High (>40% decline in sat thickness in >10% of bores)	Nil	Medium	High	High

SDL resource unit	Likelihood ranking
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Nil

[1] A 'medium' ranking is assigned for metrics where data is not available

4.3.2. Confidence in data

This assessment has been undertaken with consideration to the well understood processes of:

- groundwater pumping and drawdown
- propagation of drawdown laterally and vertically, and the retarding effects of intervening aquitards
- compaction of both aquitards and the whole groundwater system.

There is no direct measurement and monitoring of subsidence or compaction in the NSW MDB Porous Rock resource units. The assessment does not attempt to accurately predict potential compaction under aquifer system and groundwater pumping scenarios. Rather, the assessment draws upon the known factors and processes associated with compaction, and uses reliable data on both groundwater drawdown and compressible sediment thickness from the NSW government databases to provide a practical categorisation of relative compaction risk. Some limitations of the groundwater level data are:

- frequency of monitoring (i.e. monthly monitoring) may result in peak maximum drawdown not being recorded, although some bores are telemetered with continuous monitoring that would pick up maximum drawdown
- observation bore locations do not necessarily target areas of high risk of subsidence, or areas of highest areas of depressurisation, as the network was not designed for subsidence monitoring, however monitoring bores are located within areas of high extraction
- monitoring bores are located at a distance from pumping bores, so greater actual drawdown will occur at pumping bore sites (i.e. greater than measured in observation bores).

There is an additional uncertainty due to the way the data was used in the analysis. Drawdown and saturated thickness have been measured at each monitoring bore taking into consideration the nature of the aquifer at each site, which varies spatially across a groundwater source; results were then aggregated for the groundwater source as a whole. This aggregation of data across aquifers may affect the accuracy of drawdown (seasonally recovered levels) used in the likelihood analysis. The confidence in the groundwater drawdown data is moderate according to the criteria in Table 2-5, and as sediment composition data is unavailable, the confidence in this metric is low. In the absence sediment composition data for the four SDL resource units, a conservative approach has been adopted.

4.3.3. Existing water management actions and mechanisms

All groundwater in storage and all rainfall recharge calculated for high conservation value areas within a groundwater source was reserved as planned environmental water, with some exceptions explained below. In addition to protecting groundwater–dependent ecosystems in these areas, this water is also reserved to ensure long-term integrity of the groundwater system. In most groundwater sources, 100 percent of groundwater storage is reserved as planned environmental water. Limiting the total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels ensures a share of the water remains for the environment to protect aquifer structural integrity and pressure.

Temporary water restrictions orders can be made under section 324 of the WMA 2000 to prohibit or restrict groundwater extraction if the Minister is satisfied it is necessary to do so to prevent land subsidence or compaction in an aquifer, or to maintain pressure, or to ensure pressure recovery, in an aquifer. For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

4.3.4. Risk outcomes

Combining the likelihood (Table 4-4) and consequence (Table 4-2) rankings provides the overall risk outcomes (Table 4-5) for aquifer compaction impacting aquifer users as:

- nil in the Oaklands Basin, Sydney Basin MDB and Gunnedah-Oxley MDB
- low in the Western Porous Rock.

Table 4-5 Overall risk outcomes for impacts on consumptive users associated with structural integrity in the NSW MDB Porous Rock

		Likelihood			
		Nil	**Low**	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil	Nil
Consequence	**Low**	Nil	Low	Low	Medium
Consequence	**Medium**	Nil Sydney Basin MDB	Low Western Porous Rock	Medium	High
Consequence	**High**	Nil Gunnedah-Oxley Basin MDB	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Nil

4.4. Risk of groundwater extraction inducing connection with poor quality groundwater (R2)

Productive aquifers can be in close proximity to, and have some degree of hydraulic connection with, aquifers that contain groundwater of lesser quality (e.g. that is more saline). Under natural hydraulic gradients, flow may occur from the productive aquifer to the poorer quality groundwater, or from the poorer quality groundwater to the productive aquifer.

Pumping creates a low pressure zone around the production bore that continues to spread laterally and vertically whilst pumping occurs. The cumulative effect of many bores pumping in a region over multiple seasons can reverse hydraulic gradients which were preventing saline groundwater from flowing into the productive aquifer, or increase gradients and accelerate flow into a productive aquifer that has historically occurred at very low rates, or sporadically.

The pathway for impact is that licensed groundwater pumping may induce flow from areas of poor quality groundwater, which then impacts the quality of groundwater being extracted, possibly rendering it unsuitable for some consumptive uses (Figure 4-3).

This risk has been assessed in relation to salinity. Also see sections 4.8 and 6.6 for further consideration of groundwater quality.

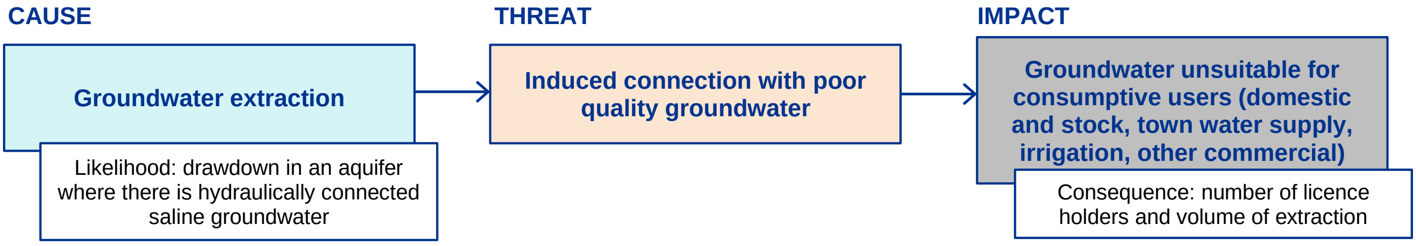


Figure 4-3 Impact pathway for risk of groundwater extraction inducing connection with poor quality groundwater impacting consumptive water users

4.4.1. Determining the likelihood of the impact occurring

Likelihood can be conceptualised with consideration to the drawdown extent in a productive aquifer, the presence of poorer quality groundwater in adjoining units or zones of the main aquifer, and how poor the groundwater quality is in relation to that of the productive zones of the aquifer.

The likelihood of groundwater extraction causing flow of poorer quality groundwater into a fresh resource is described in this analysis by the:

- decline in seasonally recovered groundwater levels
- salinity difference between developed aquifer and adjacent aquifers, or areas of poorer quality groundwater within the same aquifer

The long-term changes in seasonal recovery levels were adopted as the likelihood metric instead of total or maximum drawdown, as flow from areas of poorer quality groundwater (such as aquitards) is a typically slow process, and water quality changes would generally only become evident after a long period of declining groundwater levels. Declines in seasonal recovery levels were measured in monitoring bores in each groundwater source. Saturated thickness was defined from the water table to the base of the aquifer, disregarding the separate aquifers in the in the NSW MDB Porous Rock WRP area.

Salinity difference within and between groundwater systems was also considered to assign a likelihood ranking. The NSW government monitoring bores were sampled for salinity at the time of their construction; however, groundwater quality data collection from the WRP area has subsequently been sporadic. A summary of available salinity data in the NSW MDB Porous Rock WRP is provided below (Table 4-6).

Table 4-6 Available salinity data for the NSW MBD Porous Rock

SDL resource unit	Water quality – salinity
Oaklands Basin	No information on water quality in the Oaklands Basin SDL resource unit
Western Porous Rock	Most of the water is highly saline and extracted for salt interception of for dewatering to enable mineral sands mining. Changes to groundwater salinity are therefore not generally a threat to consumptive users.
Sydney Basin MDB	Groundwater quality is typical of sedimentary basins within NSW of Permian age, with salinity levels making water supplies unsuitable for potable or irrigation supplies, but may be suitable for stock supply (DPI Water 2017c)
Gunnedah-Oxley Basin MDB	Groundwater quality is typical of sedimentary basins within NSW of Permian age, with salinity levels making water supplies unsuitable for potable or irrigation supplies, but may be suitable for stock supply. The exception is the low salinity groundwater within the Jurassic sandstone in the Spring Ridge area of the Gunnedah-Oxley Basin MDB that supports irrigated agriculture (DPI Water 2017c).

Likelihood categories are as defined in Table 4-7. Salinity metric categories were selected to reflect the potential transition between Beneficial Use categories from drinking water (<1,000 mg/L) to irrigation (<3,500 mg/L). The combined drawdown and salinity gradient categories and resulting likelihood rankings are shown in Table 4-8 and are as follows:

- low in the Oaklands Basin and Gunnedah-Oxley Basin MDB
- medium in the Western Porous Rock and Sydney Basin MDB.

Table 4-7 Likelihood metrics and results for the NSW MDB Porous Rock (induced connectivity with saline groundwater)

Likelihood metric	Metric category	Category definition	SDL resource unit results[1]
Decline in seasonally recovered groundwater levels[1]	Low	Recovered drawdown was < 20% of saturated thickness in >90% of bores	Gunnedah-Oxley Basin MDB Western Porous Rock Oaklands Basin[3]
	Medium	Recovered drawdown was between 20 and 40% of saturated thickness in >10% of bores	Sydney Basin MDB (no data)[2]
	High	Recovered drawdown was > 40% of saturated thickness in > 10% of bores	
Salinity difference within and between groundwater systems	Low	Salinity difference < 1,000 mg/L	
	Medium	Salinity difference between 1,000 and 3,500 mg/L	Gunnedah-Oxley Basin MDB Sydney Basin MDB (no data)[2] Oaklands Basin (no data)[2]
	High	Salinity difference > 3,500 mg/L	Western Porous Rock

Data source: [1] NSW Department of Planning and Environment Groundwater Data System (2017)

[2] Where there is no data, a medium ranking has been assigned

[3] While there is no data on drawdown in the Oaklands Basin SDL resource unit, a low rating has been applied given that there are no aquifer access licences in this SDL resource unit, and no water requirements for basic landholder rights.

Table 4-8 Likelihood matrix and rankings for the NSW MDB Porous Rock (induced connectivity with saline groundwater)

		Salinity difference between developed and adjacent groundwater systems (mg/L)		
		<1,000	**1,000 - 3,500**	**>3,500**
Decline in recovered groundwater levels	**Rare (<20% decline in saturated thickness in >90% of bores)**	Low	Low Gunnedah-Oxley Basin MDB, Oaklands Basin	Medium Western Porous Rock
	Possible (20-40% decline in sat thickness in >10% of bores)	Medium	Medium Sydney Basin MDB	High
	Likely (>10% decline in sat thickness in >10% of bores)	High	High	High

SDL resource unit	Likelihood ranking
Oaklands Basin	Low
Western Porous Rock	Medium
Sydney Basin MDB	Medium
Gunnedah-Oxley Basin MDB	Low

4.4.2. Confidence in data

This assessment has been undertaken with consideration to the well understood processes of:

- groundwater pumping and drawdown
- induced flow under altered hydraulic gradients.

The assessment uses reliable data from the NSW government databases, on seasonally recovered groundwater levels (as an indicator of long-term drawdown), and groundwater quality within the main and linked aquifer systems, to provide a practical categorisation of groundwater drawdown and quality variation.

Some limitations of the data are that:

- monitoring bores are located at a distance from pumping bores, so greater actual drawdown will occur in pumping bores (i.e. greater than measured in observation bores)
- monitoring bores are not normally located in areas of high salinity as the networks were designed largely for understanding conditions in the productive aquifers
- the spatial density of groundwater quality data in non-productive groundwater systems is generally low.

The confidence in the groundwater drawdown data is moderate according to the criteria in Table 2-4, as it is measured, specific to the NSW MDB Porous Rock WRP area, and is of appropriate scale for the assessment. Groundwater quality data is very limited and therefore of low confidence.

4.4.3. Existing water management actions and mechanisms

The *Water Management Act 2000* requires that the water quality of all water sources should be protected.

Limiting the total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels ensures a share of the water remains for the environment to protect groundwater quality and hydraulic relationships.

There are additional rules that restrict the granting or amending of water supply work approvals near a contamination source to protect the quality of the groundwater source. Bore construction requirements and mandatory conditions for decommissioning works also apply to ensure that there is no path for contaminants or poor quality groundwater to enter a water source or allow cross aquifer contamination. . For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

Table 11 in the WQM Plan (WRP Schedule F) describes NSW Environment Protection Authority and local council risk based approaches to management of point source contaminants.

4.4.4. Risk outcomes

Combining the likelihood (Table 4-8) and consequence (Table 4-2) rankings provides the overall risk outcomes for poor quality groundwater migration impacting aquifer users. Risk outcomes are shown in Table 4-9 and are as follows:

- nil in the Oaklands Basin
- medium in the Western Porous Rock, Sydney Basin MDB and Gunnedah-Oxley Basin MDB.

Table 4-9 Overall risk outcomes for impacts on consumptive users associated with migration of poor quality groundwater in the NSW MDB Porous Rock

		Likelihood		
		Low	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil
	Low	Low	Low	Medium
	Medium	Low	Medium Western Porous Rock, Sydney Basin MDB	High
	High	Medium Gunnedah-Oxley Basin MDB	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Medium
Sydney Basin MDB	Medium
Gunnedah-Oxley Basin MDB	Medium

4.5. Risk of local drawdown in bores reducing groundwater access by consumptive users (R3)

Local drawdown in groundwater levels occurs whenever groundwater is pumped from a bore; this can become a problem as the intensity of groundwater extraction increases and the changes to groundwater pressure extend vertically and laterally. As area of drawdown expands, reduced access by individual consumptive users may result initially from reduced bore yields, and increased pumping costs.

Over time, access may become limited by lower groundwater levels extending below the water entry inlets of the more shallow bores, and by deterioration of groundwater quality.

The pathway for impacts associated with drawdown reducing groundwater availability for consumptive groundwater extractors is either from:

- physical limitations in accessing groundwater, or
- restrictions applied from administrative arrangements to manage areas of local drawdown.

This impact pathway is shown in Figure 4-4.

The likelihood of local drawdown reducing groundwater access by consumptive users can therefore be described as the density of extraction. The likelihood metrics are discussed in more detail below.

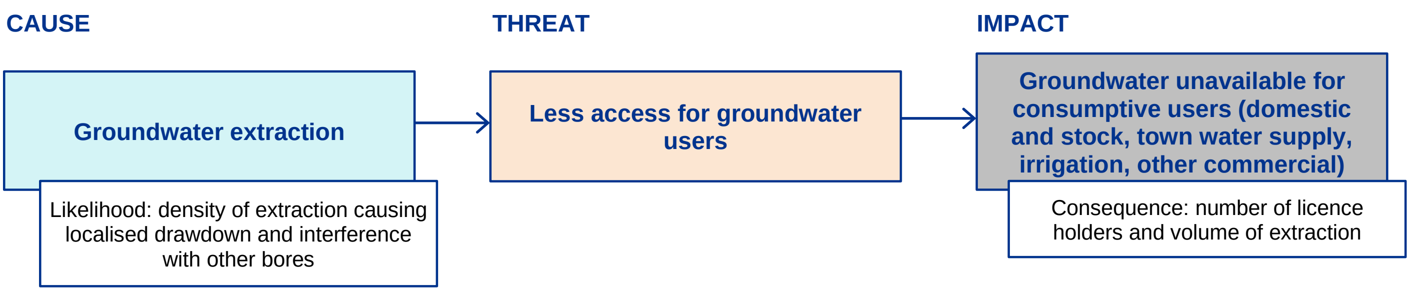


Figure 4-4 Impact pathway for risk of local drawdown in bores impacting groundwater access by consumptive users

4.5.1. Determining the likelihood of the impact occurring

The likelihood of groundwater extraction causing local drawdown in the NSW MDB Porous Rock, which may then impact access for other consumptive users, is described by the density of groundwater extraction.

Density of groundwater extraction can vary in time and space, and is influenced by:

- historical development
- individual landholder behaviour, in terms of bore location (and depth), and groundwater extraction regime (timing and rate; trading options)
- administrative controls, within water sharing plans that aim to minimise local drawdown impacts (including controls on bore location, groundwater extraction and trading).

Groundwater density was determined by calculating the volume of extraction within a five kilometre radius of each licensed groundwater bore. Where the five kilometre radius intersected other bores' radii, the extraction volumes were added to indicate an area of potentially higher extraction density. The point density analysis was based on 100 m^2 pixels across each groundwater source. The analysis calculated the total volume of extraction within a five kilometre radius of the centre of each 100 m^2 pixel across the NSW MDB groundwater sources.

A five kilometre radius was selected to represent a maximum (and conservative) area over which drawdown might occur in an unconfined aquifer, and allow any potential interactions between bores to be identified. Outside this radius, it is unlikely that drawdown from a single bore would be detectable.

A pixel size of 100 m^2 was selected as an appropriate scale to represent the cumulative impacts of groundwater extraction without resulting in huge (and unmanageable) volumes of data. Extraction density is reported in ML/year/km^2 (i.e. each 100 m^2 pixel was assigned a density in ML/year/km^2). Groundwater extraction densities were split into the categories shown in Table 4-10. The area of each category was calculated in hectares (Figure 4-5). Where bores had an extraction volume of either '0' or no value, an arbitrary value of 1 ML/yr was assigned.

Table 4-10 Groundwater extraction density categories based on point density analysis

Groundwater extraction density category[1]	Groundwater extraction density (ML/yr/km^2)	SDL resource unit Area (ha)
Negligible	<0.5 ML/yr/km^2	Gunnedah-Oxley Basin MDB = 5,966,368 Sydney Basin MDB = 267,980 Western Porous Rock = 7,542,924 Oaklands Basin = 507,226
Low	0.5 - 5 ML/yr/km^2	Gunnedah-Oxley Basin MDB = 35,218 Sydney Basin MDB = 7,026 Western Porous Rock = 8,073 Oaklands Basin = 0
Medium	5 - 50 ML/yr/km^2	Gunnedah-Oxley Basin MDB = 29,652 Sydney Basin MDB = 0 Western Porous Rock = 20,121 Oaklands Basin = 0
High	>50 ML/yr/km^2	Gunnedah-Oxley Basin MDB = 0 Sydney Basin MDB = 0 Western Porous Rock = 145 Oaklands Basin = 0

Data source: [1] Groundwater extraction density mapping based on data from NSW Water Accounting System (2017)

Equation 1 was used to obtain an overall groundwater extraction density score. This score allowed the highest density areas to more strongly influence the score as higher density implies greater potential for local drawdown and therefore higher likelihood of impacts on neighbouring bores. Areas of medium density have a lesser likelihood of impact, and low density has a lower likelihood again.

Equation 1 Groundwater extraction density score

Groundwater extraction density score = (Low density area (Ha) × 1) + (Medium density area (Ha) × 2) + (High density area (Ha) × 3)

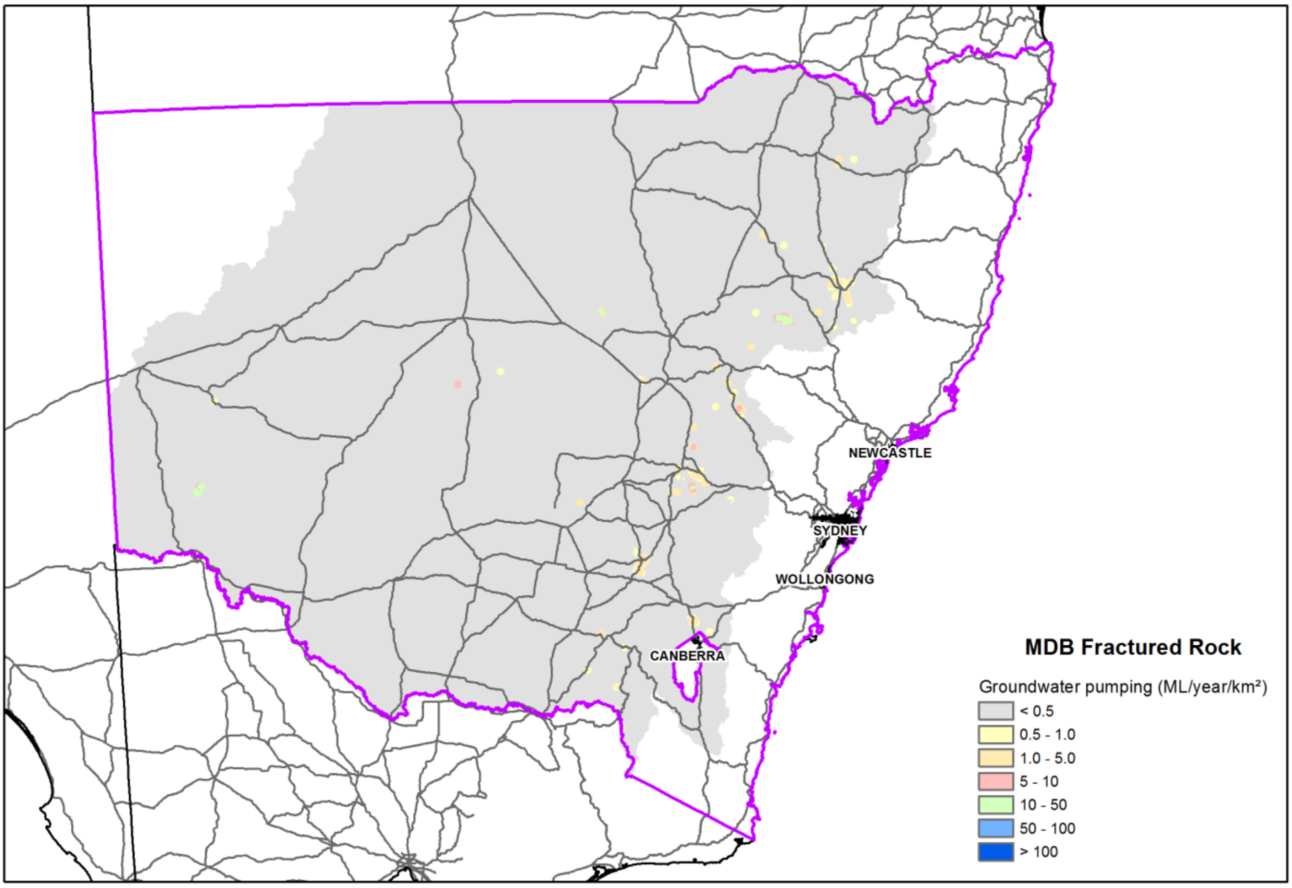


Figure 4-5 Groundwater extraction density mapping in the NSW MDB Porous Rock

Metric categories were defined according to percentiles of density results. Low density was considered to be the bottom 30% of density scores for all groundwater WRP areas in the NSW MDB, and high density was the top 30% of results, as shown in Table 4-11.

Likelihood rankings for the NSW Murray-Darling Basin Porous Rock are summarised in Table 4-12 and are as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB
- medium in the Western Porous Rock
- high in the Gunnedah-Oxley Basin MDB.

Table 4-11 Likelihood metrics and results for the NSW MDB Porous Rock (groundwater extraction density)

Likelihood metric	Metric category	Category definition	SDL resource unit results [1]
Groundwater extraction density score	Nil	No aquifer access licences	Oaklands Basin
	Low	Groundwater extraction density score < 14,168 (i.e. <30th percentile of extraction density for all NSW MDB metered bores)	Sydney Basin MDB = 7,026
	Medium	Groundwater extraction density score 14,168 – 72,072 (i.e. 30th – 70th percentile of extraction density for all NSW MDB metered bores)	Western Porous Rock = 48,750
	High	Groundwater extraction density score > 72,072 (i.e. >70th percentile of extraction density for all NSW MDB metered bores)	Gunnedah-Oxley Basin MDB = 94,552

Data source: [1] Groundwater extraction density mapping based on data from NSW Water Accounting System (2017)

Table 4-12 Likelihood matrix and rankings for the NSW MDB Porous Rock (groundwater extraction density)

Groundwater extraction density score		
	No aquifer access licences	Nil Oaklands Basin
	Low density (<14,168)	Low Sydney Basin MDB
	Moderate density (14,168 – 72,072)	Medium Western Porous Rock
	High density (>72,072)	High Gunnedah-Oxley Basin MDB

SDL resource unit	Likelihood ranking
Oaklands Basin	Nil
Western Porous Rock	Medium
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	High

4.5.2. Confidence in data

This assessment has been undertaken based on metered groundwater extraction data collected by WaterNSW. Production bore locations are identified throughout NSW, and licensed groundwater extraction is metered in to an accuracy that is more than sufficient for this assessment. The confidence in the data used for the likelihood metrics is therefore high according to the criteria in Table 2-5 for the Western Porous Rock and Gunnedah–Oxley Basin where extraction data is available.

As there are no aquifer access licence holders in the Oaklands Basin there are no production bores and therefore no extraction data. Confidence in the nil rating is high as access licences are managed through rigorous departmental processes.

Licensed groundwater extraction is not metered in the Sydney Basin MDB and groundwater extraction has been estimated for the Sydney Basin MDB. The confidence in the data used for the likelihood metrics is therefore medium for this resource unit.

4.5.3. Existing water management actions and mechanisms

Distance rules are used to minimise interference between bores and other impacts as a result of the placement of water supply works. Extraction limitations are also applied to some works to limit third party impacts. All SDL resource units within the WRP area have distance conditions between bores and property boundaries in place. The following distance conditions apply) in the NSW MDB Porous Rock WRP area:

- no trade is allowed between resource units within the WRP area and only between groundwater sources in some circumstances

- trade is restricted between management zones in the Gunnedah–Oxley Basin MDB Groundwater Source
- trade between states is permitted in the Gunnedah–Oxley Basin MDB and Western Murray Porous Rock Groundwater Sources where administrative arrangements have been agreed to and implemented by the states
- trade is not permitted between NSW WRP areas or with non-Basin groundwater sources.

The WMA 2000 requires the sharing of water must protect the water source and its dependent ecosystems. Additional restrictions may be applied under the Act in some circumstances to manage a range of issues including maintaining water levels in an aquifer. For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW Murray-Darling Basin WRP.

Adjacent interstate Murray-Darling Basin resources are managed by the relevant state under the applicable water resource plan. NSW non-Basin resources are managed under the applicable water sharing plan.

4.5.4. Risk outcomes

Combining the likelihood (Table 4-12) and consequence (Table 4-2) rankings provides the overall risk outcomes for local drawdown impacting groundwater access by consumptive users. Risk outcomes are shown in Table 4-13 and are as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB
- medium in the Western Porous Rock
- high in the Gunnedah-Oxley Basin MDB.

Table 4-13 Overall risk outcomes for impacts on consumptive users associated with local drawdown in the NSW MDB Porous Rock

		Likelihood			
		Nil	Low	Medium	High
Consequence	Low	Nil Oaklands Basin	Low	Low	Medium
	Medium	Nil	Low Sydney Basin MDB	Medium Western Porous Rock	High
	High	Nil	Medium	High	High Gunnedah-Oxley Basin MDB

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Medium
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	High

4.6. Risk of sediment compaction impacting surface water users (QL1)

This section considers the potential impacts of groundwater extraction derived sediment compaction on overlying surface water resources, including potential impacts on continued water availability arising from hydraulic relationships and properties not being maintained. The level of connectivity with adjacent water resources is described in section 3.3. Sediment compaction resulting from groundwater pressure loss would be limited to the confined or semi confined portion of the sediment profile and any induced changes to hydraulic properties will occur within this zone. The hydraulic properties of the water table aquifer that interact with surface water systems will not change as a consequence of sediment compaction in the underlying confined systems.

The risk to overlying surface water resources relating to surface elevation changes requires each of the following factors to be present and of sufficient magnitude to result in consequential impacts to the surface water resources:

- the degree of compaction to be of a sufficient magnitude to propagate through the sediment profile as a change to the land surface
- the resulting change in surface elevation to be significant with respect to the hydrologic and river channel processes
- any induced land surface elevation changes being spatially coincident with the surface water resources.

This impact pathway is shown in Figure 4-6 and demonstrates that the threat, 'Significant drawdown and sediment compaction affecting adjacent SDL resource units', may result from drawdown in the compressible sediments of the groundwater system, the primary cause being groundwater pumping (the cause). The likelihood of sediment compaction occurring can therefore be described by the degree of drawdown combined with the presence of compressible sediments in areas where impacts on adjacent SDL resource units are possible. The consequence of sediment compaction would be assessed by considering the users of the surface water systems in areas that would be affected by compaction. In this case, users may be affected by lower water availability.

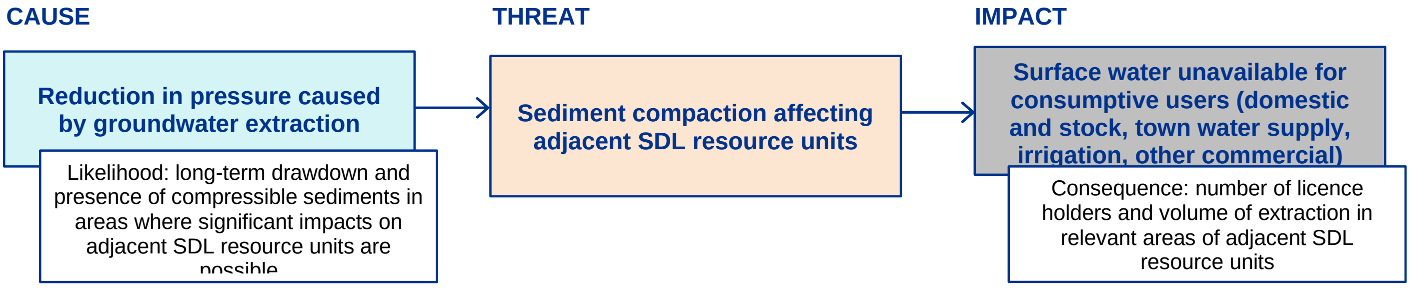


Figure 4-6 Impact pathway for risk of sediment compaction impacting consumptive surface water users

4.6.1. Confidence in data

This is a qualitative assessment based on NSW Department of Planning and Environment groundwater specialist expert opinion. As such the risk outcomes have low data confidence according to the criteria in Table 2-5.

4.6.2. Existing water management actions and mechanisms

The risk to surface water users from groundwater extraction within the WRP area was assessed during the development of the *Water Sharing Plan for the Murray Darling Basin Porous Rock Groundwater Sources 2020* following the assessment criteria outlined in DPI Water 2015. As rules were introduced to manage potential impacts in highly connected areas, the risks are considered to be adequately managed within acceptable impacts on surface water sources (DPI Water 2015) (i.e. tolerable). It is noted the level of connectivity between surface and groundwater was considered low to moderate for the porous rock groundwater sources.

The level of impact on the hydraulic relationships and properties between the groundwater systems and connected surface water systems (and between these groundwater systems and others, and within these groundwater systems) was considered in setting the SDLs for these SDL resource units. The management of extraction to these limits will ensure these hydraulic relationships are maintained to the acceptable level of impacts determined during that assessment.

For further information on existing water management actions and mechanisms that are relevant to surface water users refer to section 6.3.3 and for connectivity to section 3.3.2.

4.6.3. Risk outcomes

Quantitative assessment of this risk has not been possible due to lack of likelihood data which impacts the ability to determine the consequence results. This knowledge gap has an identified knowledge strategy (see Table 8-6).

For the NSW MDB Porous Rock, sediment compaction as the result of groundwater pumping is not considered to be a major risk for the overlying surface water SDL resource units based on current understanding of these resources. As groundwater extraction is managed to minimise potential compaction which is a precursor of surface water impact, qualitative risk outcomes of low have been applied to all adjacent SDL resource units (Table 4-14).

Table 4-14 Overall risk outcomes for impacts on consumptive users in adjacent surface water systems associated with groundwater extraction in the NSW MDB Porous Rock

SDL resource unit	Risk Outcome
All overlying surface water SDL resource units	Nil – QAL

4.7. Risk of groundwater extraction impacting water users in adjacent groundwater systems (QL2)

This section considers the potential impacts of groundwater extraction derived sediment compaction on adjacent groundwater resources including potential impacts on continued water availability arising from hydraulic relationships and properties not being maintained. The level of connectivity with adjacent water resources is described in section 3.3

Sediment compaction as the result of groundwater pumping is a localised impact constrained in extent to the area of significant hydraulic changes associated with pumping. Whilst the cumulative impacts of multiple pumping sites increases the impacted area, the total area of potential compaction will correspond to a much smaller area to that of observed pumping drawdowns.

The risk of structural damage to adjacent groundwater SDL resource units is dependent on significant pumping impacts propagating across the resource boundaries. This induced change in fluid pressure must also be significant with respect to the adjacent system's structural integrity.

This impact pathway is shown in Figure 4-7 and demonstrates that the threat, 'Significant drawdown and sediment compaction affecting adjacent SDL resource units', may result from drawdown in the compressible sediments of the groundwater system, the primary cause being groundwater pumping (the cause). The likelihood of sediment compaction occurring can therefore be described by the degree of drawdown combined with the presence of compressible sediments in areas where impacts on adjacent SDL resource units are possible. The consequence of sediment compaction would be assessed by considering the users of the adjacent groundwater systems in areas that would be affected by compaction. In this case, users may be affected by lower water availability.

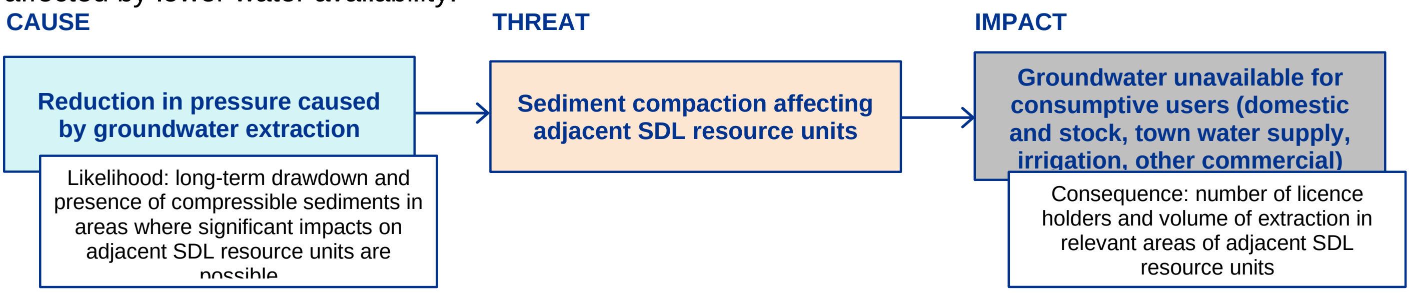


Figure 4-7 Impact pathway for risk of groundwater extraction impacting consumptive water users in adjacent groundwater systems

4.7.1. Confidence in data

This is a qualitative assessment based on NSW Department of Planning and Environment groundwater specialist expert opinion. As such the risk outcomes have low data confidence according to the criteria in Table 2-5

4.7.2. Existing water management actions and mechanisms

Existing water management actions and mechanisms are described in section 4.5.3.

4.7.3. Risk outcomes

Quantitative assessment of this risk has not been possible due to lack of likelihood data. This impacts the ability to determine the consequence results. This knowledge gap does not have an identified knowledge strategy and is considered low priority due to the nature of the risk and the management controls in place.

For the NSW MDB Porous Rock resource units, sediment compaction as the result of groundwater pumping is a negligible risk. The Gunnedah – Oxley Basin, Sydney Basin and Oaklands Basin are comprised of consolidated strata and potential for compaction is negligible. The volume of groundwater exchange between the Western Porous Rock and adjacent resources is insignificant with regard to impacts on water availability and access rights in this resource. There would be nil risk to the structural integrity of these resource units and to water users in adjacent Basin resource units and non-Basin resources as the result of groundwater pumping within the NSW MDB Porous Rock WRP area.

The level of impact from extraction on the hydraulic relationships and properties between groundwater systems was considered in setting the SDLs for groundwater resource units. The management of extraction to these limits will ensure these hydraulic relationships are maintained to the acceptable level of impacts determined during that assessment. See Table 3-1 for a list of adjacent surface and groundwater resources. Adjacent interstate Murray-Darling Basin resources are managed by the relevant state under the applicable water resource plan. NSW non-Basin resources are managed under the applicable water sharing plan.

Risk outcomes are provided in Table 4-15 and are nil – QAL for all Basin and non-Basin adjacent groundwater resources.

Table 4-15 Overall risk outcomes for impacts on consumptive users in adjacent groundwater systems associated with sediment compaction in the NSW MDB Porous Rock

SDL resource unit	Risk Outcome
All adjacent groundwater SDL resource units	Nil – QAL

Non Basin resources	Risk Outcome
All adjacent non-Basin resources	Nil – QAL

4.8. Risk of poor water quality to water users (QL3)

Likely causes of water quality degradation in the groundwater source through both point and diffuse sources, includes poor management practices that result in pesticides or other contaminants leaching into groundwater; inappropriate disposal and management of industrial waste; elevated nutrients and pathogens from animal waste and sewage discharges (onsite and sewage treatment plants).

Under the *Water Act 2007* sections 22(9)-(12) the Basin Plan does not regulate land use, management of natural resources that are not water, or the control of pollution. As such, strategies to mitigate the likelihood of this risk fall outside the scope of the water resource plan, the water quality management plan and this risk assessment.

NSW does accept there is potential for this risk to occur and has legislated controls in place to manage both the likelihood and consequences of the risk. The approach to assessing this risk is the broad consideration of whether there are effective legislated processes and controls that manage both the likelihood and consequence of risk occurrence.

Effective management systems are proactive, responsive, risk based and reliant on good knowledge of

- processes through which contamination can occur
- levels of toxicity and persistence of contaminants
- processes by which contaminants spread throughout groundwater system
- effectiveness of measures to mitigate risk likelihood such as licencing and compliance activities
- effectiveness of measures to mitigate risk consequence such as extraction controls and water treatment activities.

The pathway for impact shown in Figure 4-8 is that groundwater contaminants from such sources as onsite septics, sewage treatment plants, agriculture and industry may enter groundwater systems through natural infiltration, where best practice land management is not in place, or where there is ineffective or non-compliance with pollution controls. The contaminated groundwater could then be extracted and utilised for a range of consumptive purposes. Controls around entry of contaminants (likelihood) and the use of contaminated water (consequence) are assessed to provide the risk outcome.

There is also potential for groundwater extraction to induce connection with contaminated groundwater as discussed in section 4.4.

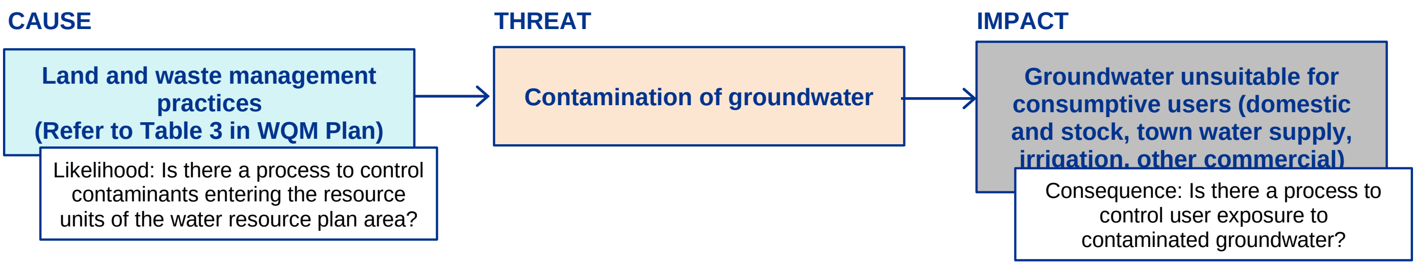


Figure 4-8 Impact pathway for risk of poor water quality to consumptive water users

4.8.1. Determining the likelihood of the impact occurring

Likelihood can be conceptualised with consideration to the process of minimising contamination from a range of sources entering and mobilising through groundwater systems.

The NSW Environment Protection Authority and local councils implement a risk based approach to the management of potential point source groundwater contaminants under the *Protection of the Environment Operations Act 1997,* the *Local Government Act 1993* and the *Local Government (General) Regulation 2005*. The NSW Environment Protection Authority is responsible for event monitoring as a result of licence compliance issues. Under the *Protection of the Environment Operations Act 1997* (POEO Act), the NSW Environment Protection Authority uses a risk-based licensing system that aims to ensure that all environment protection licensees receive an appropriate level of regulation based on the environmental risk of the activity taking into account site specific risks. Licenced industries include sewage treatment plants and various agricultural processing activities. Licensing conditions also include a monitoring and reporting component for compliance.

The risk of nutrients entering the SDL resource unit via onsite sewage systems is managed under the local government management framework provided in the application for installation. A risk classification is determined by the local government during the approval phase. Under the *Local Government Act 1993*, local councils are responsible for regulating the installation, operation and maintenance of septic systems, conducting audits and inspections and keeping a register of systems in use in the council area.

There are limited levers within scope of water planning to manage contaminants from diffuse agricultural sources such as nutrients and pathogens from animal waste. Strategies to address this potential risk include those established by Natural Resource Management agencies to provide advisory services that support and enable landholders to implement improved natural resource and agricultural management practices. These management measures contribute to reducing contaminants from poor quality groundwater entering the SDL resource unit that may lead to water quality degradation

NSW considers the NSW Environment Protection Authority's risk based licensing and approval system and local councils' regulation of onsite sewage management adequately manages the major causes of water quality degradation from major contaminants entering the groundwater SDL source units and so a likelihood ranking of low has been applied in Table 4-16.

Table 4-16 Likelihood metrics and results for the NSW MDB Porous Rock (contamination of groundwater)

Likelihood metric	Metric category	Category definition	SDL resource unit ranking
Is there a process to control contaminants entering the resource units of the water resource plan area?	Low	Legislated risk based management is in place	Gunnedah-Oxley Basin MDB, Western Porous Rock, Sydney Basin MDB, Oaklands Basin
	Medium	Legislated or other risk based management is in place	
	High	Legislated or other risk based management not in place	

4.8.2. Determining the consequence of the impact occurring

Consequence can be conceptualised with consideration to the process of minimising contaminated groundwater extraction, use and consumption.

Water utilities in NSW implement a risk-based approach to drinking water management to ensure a secure and safe drinking water supply. The *Public Health Act 2010* and the *Public Health Regulation 2012* require drinking water suppliers to develop and adhere to a Drinking Water Management System (DWMS) that takes a "multiple barrier approach" from catchment to tap. The DWMS addresses the elements of the Framework for Management of Drinking Water Quality (Australian Drinking Water Guidelines) and is a requirement of a water suppliers operating licence (NSW Ministry of Health 2013).

Potential risks to raw water and their management strategies are identified in the Drinking Water Management Systems for each local Council. Also refer to Tables 6 and 11 of the Water Quality Management Plan (Schedule F of the NSW MDB Porous Rock WRP and Table 3-23 of the Incident Response Guide (IRG) for Groundwater Resource Plan Areas (Schedule E of the NSW MDB Porous Rock WRP) for further information regarding management during water shortages or contamination events.

Groundwater used for drinking water (not supplied from a drinking water utility) should undergo comprehensive testing for a range of chemical and physical characteristics prior to use. The water should be retested if there are any changes in water quality, such as the appearance of odours, taste or colour. Local public health units provide advice on testing. The NSW Private Water Supply Guidelines provide information on groundwater, hazards and testing.

NSW considers the water utilities risk based approach to drinking water management adequately manages the raw water being of a quality unsuitable for treatment for human consumption for all groundwater SDL resource units and so a consequence ranking of low has been applied in Table 4-17.

Table 4-17 Consequence metrics and results for the NSW MDB Porous Rock (contamination of groundwater)

Consequence metric	Metric category	Category definition	SDL resource unit ranking
Is there a process to control user exposure to contaminated groundwater?	Low	Legislated risk based management is in place	Gunnedah-Oxley Basin MDB, Western Porous Rock, Sydney Basin MDB, Oaklands Basin
	Medium	Legislated or other risk based management is in place	
	High	Legislated or other risk based management not in place	

4.8.3. Confidence in data

This is a qualitative assessment of existing processes based on NSW Department of Planning and Environment groundwater quality specialist expert opinion and available information from other NSW government agencies. As no data has been reviewed a low data confidence applies according to the criteria Table 2-5.

4.8.4. Existing water management actions and mechanisms

Refer to Tables 6 and 11 of the Water Quality Management Plan (Schedule F of the NSW MDB Porous Rock WRP) for a comprehensive list of mechanisms and explanatory text.

4.8.5. Risk outcomes

Combining the likelihood (Table 4-16) and consequence (Table 4-17) rankings provides the overall risk outcomes for groundwater contamination from land and waste management practices. Risk outcomes are shown in Table 4-18 and are low in all resource units.

Table 4-18 Overall risk outcomes for impacts on consumptive users associated with poor water quality in the NSW MDB Porous Rock

		Likelihood		
		Low	**Medium**	**High**
Consequence	**Low**	Low Oaklands Basin, Gunnedah-Oxley Basin MDB, MDB Western Porous Rock, Sydney Basin MDB	Low	Medium
	Medium	Low	Medium	High
	High	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Low – QAL
Western Porous Rock	Low – QAL
Sydney Basin MDB	Low – QAL
Gunnedah-Oxley Basin MDB	Low – QAL

5. Risks to aquifer access licence holders

5.1. Background

There are a number of risks that may reduce the overall availability of groundwater such that available water determinations (AWDs) are announced to restrict groundwater extraction in an area. Because of the way licences and allocations are structured in NSW, AWDs only affect Aquifer Access Licences (AALs), while the taking of water by persons exercising basic landholder rights (BLR) and other licence types such as local water utility (LWU) licences maintain the ability to extract their full requirements or entitlement volumes. Therefore the impact of reduced groundwater availability would be largely borne by AAL holders. In particular, these risks will be greater in groundwater systems that are fully allocated or where allocation is in excess of the extraction limit (i.e. over-allocated).

The risks in this section focus on any potential future changes that may reduce groundwater availability for AAL holders. A reduction in recharge may result in a revised extraction limit under future water sharing plans. This may result in a reduced volume available for allocation, and specifically impact AALs through lower AWDs. Reduced recharge could be caused by:

- growth in plantation forestry which intercepts recharge and accesses the water table
- climate change causing lower recharge
- decrease in irrigation losses to the water table due to efficiency improvements

Growth in extraction could also reduce groundwater availability for AALs. In particular, as BLRs and LWU licences have priority access to groundwater, any growth in these rights or licenced entitlements would potentially erode groundwater availability for AAL holders.

The impact pathways for considering potential impacts to AALs are summarised in Figure 5-1.

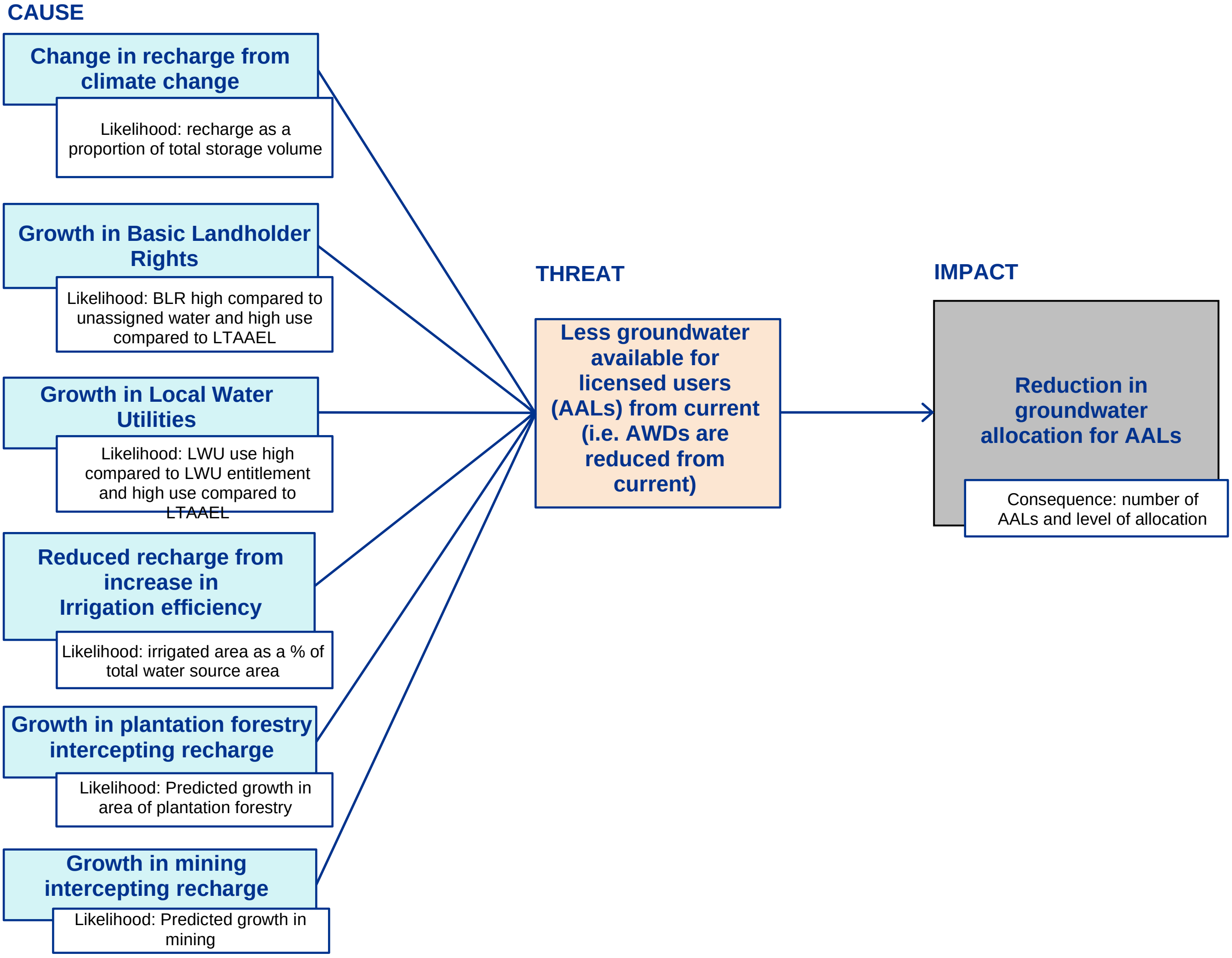


Figure 5-1 Impact pathways for risks to aquifer access licence holders

5.2. Assigning a consequence ranking

All the risks analysed in this section have a common receptor: AALs. The same consequence metrics can therefore be used for each risk. This section describes the consequences of impacting AALs through a variety of causes and threats.

The consequence of impacts on AALs is described by the metrics:

- number of AALs in a groundwater source, relative to all AALs in the NSW MDB
- whether the groundwater source is fully allocated or over-allocated.

The logic behind these metrics is that the more AALs within a single groundwater source, then the greater the number of users that may be detrimentally affected by reduced AWDs.

Consideration is also given to the level of allocation of the groundwater resource. A groundwater source that is over-allocated will have more severe AWDs than a source that is fully allocated. That is, the groundwater available under each AAL will be more significantly reduced in an over-allocated system, and impacts on the value of the AALs will be greater.

Consequence metrics and results for the NSW MDB Porous Rock are shown in Table 5-2. Again, a relative approach was used to assign a consequence to AALs was used (refer to section 4.2) to identify and prioritise the management of groundwater sources within the NSW MDB which could be most impacted.

The level of allocation (under / fully or over-allocated) was determined from the level of unassigned groundwater in each source. If the volume of unassigned water is less than 0 ML, the system is over-allocated. A zero value indicates a fully allocated system and a positive value indicated there is unassigned water (see Table 5-7). Where there is unassigned water, entitlement (including BLR) and therefore extraction will always be less than the LTAAEL and hence there is no cause for reduced AWDs, and no potential to impact AALs. There is no licenced extraction from the Oaklands Basin SDL resource unit. As there is no extraction there is no risk receptor and therefore no potential for consequences to occur. Consequence rankings are shown in Table 5-2 and are as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB and Western Porous Rock
- medium in the Gunnedah-Oxley Basin MDB.

Gunnedah-Oxley Basin MDB.

Table 5-1 Consequence metrics and results for the NSW MDB Porous Rock (impacts on aquifer access licences)

Metric	Metric category	Metric category definition	SDL resource unit results [1]
Number of AALs	Nil	No aquifer access licences	Oaklands Basin = 0
	Low	< 16 AALs (i.e. 30th percentile of number of AALs for all NSW MDB groundwater sources)	Western Porous Rock = 14
	Medium	16 – 78 users (i.e. 30th – 70th percentile of number of AALs for all NSW MDB groundwater sources[2])	Sydney Basin MDB = 29
	High	> 78 users (i.e. 70th percentile of number of AALs for all NSW MDB groundwater sources)	Gunnedah-Oxley Basin MDB = 142
Level of allocation	Low	Under or fully allocated (unassigned water = 0 or > 0)	Oaklands Basin = 2,500 ML Western Porous Rock = 163,349 ML Sydney Basin MDB = 15,407 ML Gunnedah-Oxley Basin MDB 98,095 ML
	High	Over-allocated (unassigned water < 0)	

Data source: [1] NSW Department of Planning and Environment Licensing System (2017)
[2] No porous rock data was included in the calculations of the 30th and 70th percentiles as this data was received after the categories were established

In addition to the 14 AALs listed for the Western Porous Rock in Table 5-1, there are three special purpose access licences for salt interception schemes that draw groundwater from the Western Porous Rock to reduce saline flows to the Murray River. They are collectively authorised to extract 14,582 ML per year.

Table 5-2 Consequence matrix and rankings for the NSW MDB Porous Rock (impacts on aquifer access licences)

		Number of AALs			
		Nil	**< 16**	**16 - 78**	**> 78**
Level of allocation	**Under or fully allocated**	Nil Oaklands Basin	Low Western Porous Rock	Low Sydney Basin MDB	Medium Gunnedah-Oxley Basin MDB
	Over allocated	Nil	Medium	High	High

SDL resource unit	Consequence ranking
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Medium

5.2.1. Confidence in data

The confidence in the data used for the consequence matrix is high according to the criteria in Table 2-5, as the data is measured and applicable to the specific groundwater sources and the scale of assessment. The greatest uncertainty is whether the metrics of 'number of AALs access licences' and 'Level of allocation' accurately reflect the level of dependence, sensitivity and value of the groundwater sources to describe the consequence.

It is acknowledged that this approach does not distinguish between uses of different priority or value. Options for assessing the consequence may include considering reliance on groundwater as distinct from surface water, as surface water may be accessible and currently used by groundwater extractors. If data on the relative reliance between surface and groundwater becomes available in the future, it may be useful to incorporate into the consequence matrix.

The following sections describe the analysis of the likelihood of causes and threats occurring. The likelihood rankings then feed into the overall risk determination.

5.3. Risk of climate change reducing recharge and groundwater availability (R4)

The pathway for impact is climate change causing reduced rainfall and runoff, changed timing of rainfall and increased evapotranspiration. These contribute to reducing recharge and groundwater availability.

Recharge to the NSW MDB Porous Rock occurs primarily through infiltration from rainfall, runoff and surface water within the outcropping areas. However, inflow can also occur from downward percolation of groundwater from overlying permeable strata that coincides with layers of the sedimentary sequences that have sufficient permeability for groundwater exchange to occur. The exception is the Oaklands Basin for which the aquifers do not outcrop and hence there is no direct recharge from rainfall or interaction with surface water features. Reduced rainfall, changed timing of rainfall and increased evapotranspiration can reduce both runoff to rivers and streams, and direct infiltration into the alluvium. Lower infiltration and groundwater recharge caused by climate change may reduce groundwater availability for consumptive users (AALs). This impact pathway is shown in Figure 5-2.

Because of the priority of access set by legislation, reduced water availability primarily affects AALs, while other types of access (BLR, LWU) with a higher priority of access are maintained to extract their full requirements or entitlement volumes. It is assumed that any existing BLR extraction has already affected groundwater availability, and that this has been allowed for in current management arrangements. Therefore, the risk focuses on any future changes that may further reduce groundwater availability for users.

Likelihood can be conceptualised as the predicted potential for climate change to cause sufficiently reduced rainfall, changed timing of rainfall, and increased evapotranspiration. This can reduce recharge to the groundwater systems. The likelihood metrics are discussed in more detail below.

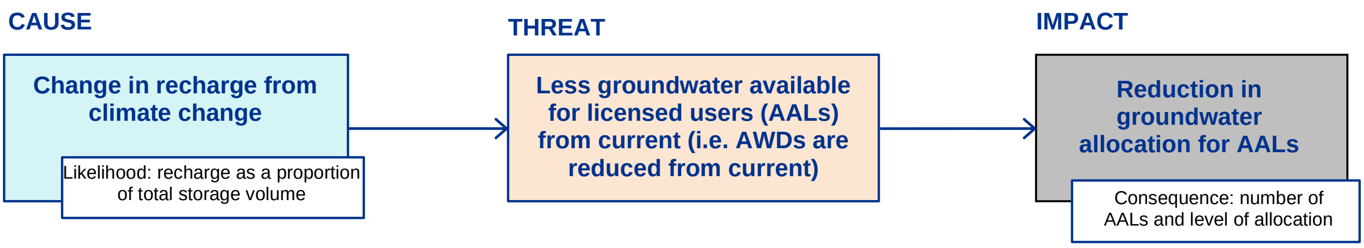


Figure 5-2 Impact pathway for risk of climate change reducing recharge and groundwater availability and impacting aquifer access licences

5.3.1. Determining the likelihood of the impact occurring

The likelihood of climate change causing a reduction in groundwater availability in the NSW MDB Porous Rock WRP area, for consumptive users, is described by the ratio of the total storage of the groundwater system to recharge; a measure of intrinsic aquifer resilience.

The ratio of aquifer storage (S) to aquifer recharge (R) gives an indication of the intrinsic aquifer resilience, or how likely the groundwater storage will change if there is a change in recharge condition, whether brought about by human activity or climate change (CSIRO and SKM, 2010a). An aquifer with a small S/R ratio is likely to be more sensitive to changes in recharge and discharge, whether by natural variations in climate or by extraction.

For the Western Porous Rock storage and current recharge volumes were taken from the Recharge Risk Assessment Method (RRAM) reports developed for the Murray-Darling Basin Authority's Sustainable Extraction Limits Program (CSIRO and SKM 2010a and b). For the Gunnedah-Oxley MDB, Sydney Basin MDB and Oaklands Basin values are not proved for these individual resource units in the RRAM reports and values from the relevant water sharing plan have been used. A current S/R ratio was calculated from these figures (Table 5-3). The RRAM reports also defined thresholds for changes in productive base and hence risks to the productive base of a groundwater system by the S/R ratio for each SDL resource unit, these risk categories are adopted in this report as shown in Table 5-4.

The likelihood rankings for impact on groundwater recharge volumes are provided in Table 5-5 and are low in all resource units.

A result cannot be calculated for the Oaklands Basin as there is no recharge data available. In this circumstance a medium result would be appropriate according to the criteria in Table 2-5, however as this resource unit does not outcrop, receives no direct recharge from rainfall and has no interaction with surface water features a likelihood result and ranking of low is appropriate and has been adopted in Table 5-4 and Table 5-5.

Table 5-3 Storage to recharge ratio information for the NSW MDB Porous Rock

SDL resource unit	Storage volume[1] GL/yr	Current recharge GL/yr	Current S/R Ratio
Oaklands Basin	410,420[2]	No data, does not receive recharge directly from rainfall or surface water features	Cannot be calculated
Sydney Basin MDB	134,305[2]	86[2]	1562
Gunnedah-Oxley Basin MDB	5,118,810[2]	411[2]	12455
Western Porous Rock	155,318[1]	134[1]	1159

Data Source:[1] CSIRO and SKM 2010; [2] WSPs

Table 5-4 Likelihood metrics and results for the NSW MDB Porous Rock (climate change impacting the productive base of a groundwater system)

Likelihood metric[1]	Metric category	Category definition[1]	SDL resource unit results [1]
Productive base of aquifer measured by Storage/Recharge ratio (S/R)[2]	Low	High S/R value (i.e. greater than 40)	Sydney Basin MDB Western Porous Rock MDB Gunnedah-Oxley Basin MDB Oaklands Basin (does not receive recharge directly from rainfall or surface water features)
	Medium	Medium S/R value (i.e. between 20 and 40)	
	High	Low S/R value (i.e. less than 20)	

Data source: [1]CSIRO and SKM 2010

Table 5-5 Likelihood matrix and rankings for the NSW MDB Porous Rock (climate change impacting the productive base of a groundwater system)

Productive base of aquifer S/R category		
	S:R >40	Low All
	S:R 20 - 40	Medium
	S:R <20	High

SDL resource unit	Likelihood ranking
Oaklands Basin	Low
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Low

5.3.2. Confidence in data

This assessment has been undertaken with consideration to the best available information on storage volumes and current average annual recharge. A limitation of the data and information used is the moderate confidence in the storage and recharge data according to the criteria in Table 2-5, as estimating these metrics at an SDL resource unit scale incurs some uncertainty. The metrics are an approximation of the productive base of the groundwater system, and as such, their applicability is moderate. As discussed in 5.3.1, no recharge data is available for the Oaklands Basin and a conservative medium ranking has been applied. Confidence in this ranking is low.

5.3.3. Existing water management actions and mechanisms

The WSPs for NSW MDB groundwater systems were developed in consultation with community stakeholders, and are applicable for 10 year periods. The WSPs recognise the effects of climate variability on groundwater levels by including provisions that manage the sharing of water within the limits of water availability on a long term average annual basis. Part 4 of Chapter 7 of the Basin Plan allows SDLs for groundwater SDL resource units to be adjusted by up to 5% to reflect new or improved information about the groundwater resources, including improved information on climate change impacts. For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

5.3.4. Risk outcomes

Combining the likelihood (Table 5-5) and consequence (Table 5-2) rankings provides the overall risk outcomes for climate change reducing recharge and groundwater availability. Risk outcomes are shown in Table 5-6 and are as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB, Western Porous Rock and Gunnedah-Oxley Basin MDB.

Table 5-6 Overall risk outcomes for impacts on aquifer access licence holders associated with climate change in the NSW MDB Porous Rock

		Likelihood		
		Low	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil
	Low	Low Sydney Basin MDB, Western Porous Rock	Low	Medium
	Medium	Low Gunnedah-Oxley Basin MDB	Medium	High
	High	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Low

5.4. Risk of growth in basic landholder rights reducing groundwater availability (R5)

The pathway for impact is increased extraction of groundwater under basic landholder rights (BLR) (as recognised by the number of BLR water supply work approvals, or number of completed bores) reducing the water available for other consumptive uses. If the increased BLR causes extraction to exceed the LTAAEL a reduced AWD could be triggered, reducing access by AAL holders (Figure 5-3).

For groundwater, BLR include both 'native title rights' and 'domestic and stock rights' (DPI Water 2017a) noting 'harvestable rights' (capture of rainfall runoff) does not apply. Groundwater BLR allows for:

- native title rights — anyone who holds native title rights may take and use groundwater for a range of personal, domestic and non-commercial purposes as determined under the federal *Native Title Act 1993*
- domestic and stock rights — owners or occupiers of land that is overlying an aquifer to take water without a licence for domestic (household) purposes or to water stock.

When water is taken under BLR (for example, domestic and stock rights) there is no requirement for an AAL or a water use approval, however a water supply work approval is required to construct a bore, well, spear point or excavation (DPI Water 2017b).

Each WSP provides an estimate of the water requirements for BLR for each groundwater source, noting that the volume of water extracted under these rights may increase during the life of the plan. The estimated volume of basic landholder rights in the plan area draws on the reasonable take and use zones and the domestic and stock consumption allowances. Some consideration was given to both surface and groundwater estimations simultaneously to avoid 'double counting' of these rights in the estimations. To estimate stock watering use in each water source, land use data was used to determine grazed area and the subsequent volume determined by applying a stock consumption allowance. Population and housing census data (ABS 2010) was used to calculate the number of houses in each water source, and a domestic consumption allowance was applied to estimate the total domestic water use for each water source. The calculation of basic rights was undertaken in a conservative manner, and in many cases potential growth in extraction was also considered in these calculations (DPI Water 2015).

Because of the priority of access set by legislation, reduced water availability primarily affects AALs, while other types of access (BLR, LWU) with a higher priority of access are maintained to extract their full requirements or entitlement volumes. Therefore the impact would be primarily felt by AAL licence holders.

It is assumed that any existing BLR extraction has already affected groundwater availability, and that this has been allowed for in current management arrangements. The risk focuses on any future changes that may further reduce groundwater availability for users.

Likelihood can be conceptualised in terms of the ratio of BLR to unassigned water, and total groundwater extraction in relation to the LTAAEL. The likelihood metrics are discussed in more detail below.

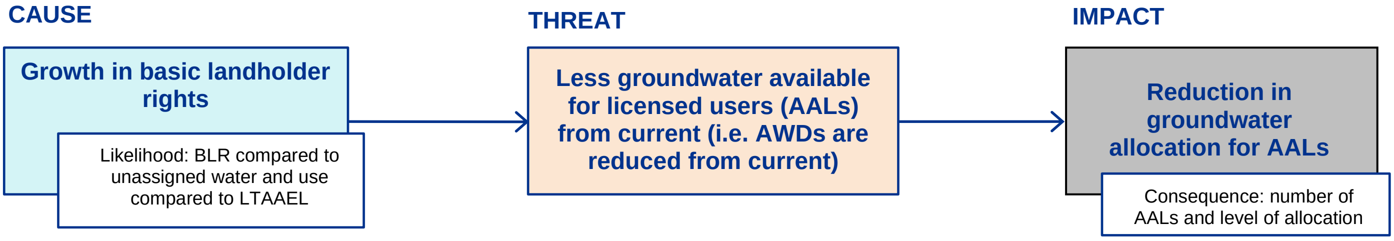


Figure 5-3 Impact pathway for risk of growth in basic landholder rights reducing groundwater availability and impacting aquifer access licences

5.4.1. Determining the likelihood of the impact occurring

The likelihood of growth in basic landholder rights causing a reduction in groundwater availability in the NSW MDB Porous Rock WRP area, which may then impact AWDs for consumptive users is described by the:

- ratio of existing BLR extraction to unassigned water
- extraction as a proportion of the SDL.

The potential for growth in BLR to affect AWDs was determined by comparing the BLR estimate to the volume of unassigned water to assess the scope for growth without impact on AWDs. The assumption made was that the greater the ratio of BLR to unassigned water, then the greater the likelihood that a growth in BLR would impact on licensed water users. For this risk assessment, unassigned water was calculated as SDL minus entitlement minus BLR estimate.

A comparison of average extraction (including BLR) was compared to the SDL. This indicates where low extraction could mitigate the impacts of growth in BLR extraction, even in area with no unassigned water.

There is no metered extraction data for the Sydney Basin MDB, as a conservative approach for this SDL resource unit the entitlement is assumed to be fully used. There is no entitlement for groundwater extraction in the Oaklands Basin; the likelihood is therefore nil.

Data on entitlement and extraction volumes is shown in Table 5-7. Likelihood categories and results are shown in Table 5-8.

Table 5-7 Data used for analysing the likelihood that growth in basic landholder rights will impact aquifer access licences in the NSW MDB Porous Rock

Data type	Western Porous Rock	Gunnedah-Oxley Basin MDB	Sydney Basin MDB	Oaklands Basin
SDL (ML/yr)[2]	226,000	127,500	19,100	2,500
Unassigned water (ML)	163,349	98,095	15,407	2,500
Entitlement (AALs) (ML/yr)[1]	35,514[5]	23,147	3,228	0
Entitlement (LWU) (ML/yr) [1]	390	480	0	0
LWU extraction (average, ML/yr)	390	480	0	0
LWU extraction/entitlement (%)	100	100	N/A	N/A
BLR (ML/yr)[2]	26,747	5,778	465	0
BLR/unassigned (%)[2]	16%	6%	3%	0%
BLR/SDL (%)	12%	5%	2%	0%
Ave annual extraction (ML/yr)[2]	5,912[4]	5,257[4]	3,228[3]	0

Data source: [1]NSW Water Accounting System (2017),[2] NSW Department of Planning and Environment Groundwater Data System (2017)

[3] No groundwater extraction data available for these SDL resource unit so assume extraction = entitlement

[4] Based on a maximum of 5 years extraction data

[5] includes salinity and water table management access licences All values in ML/yr unless stated

Table 5-8 Likelihood metrics and results in the NSW MDB Porous Rock (growth in basic landholder rights)

Likelihood metric	Metric category	Category definition	SDL resource unit
Ratio of existing BLR extraction to unassigned water	Nil	No entitlement for groundwater extraction	Oaklands Basin
	Low	BLR extraction : unassigned water <50%	Western Porous Rock Gunnedah-Oxley Basin MDB Sydney Basin MDB
	Medium	BLR extraction : unassigned water 50-80%	
	High	BLR extraction : unassigned water >80% or Unassigned water = 0	
Extraction as a proportion of the SDL	Low	Extraction < SDL	Oaklands Basin Western Porous Rock Gunnedah-Oxley Basin MDB Sydney Basin MDB
	Medium	Extraction = SDL	
	High	Extraction > SDL	

Within the SDL resource units of the NSW MDB Porous Rock WRP area:

- there are large volumes of unassigned water available in the Western Porous Rock, Gunnedah-Oxley Basin MDB and the Sydney Basin MDB SDL resource units and a smaller volume of unassigned water available in the Oaklands Basin.
- average annual extraction volume (which is metered) is significantly less than the SDL.
- BLR access as a proportion of the SDL is low in all SDL resource units and nil in the Oaklands Basin

Given the above, any increases in BLR extraction are unlikely to trigger reduced AWD in the short or long term. Likelihood rankings are shown in Table 5-9 and area as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB, Western Porous Rock and Gunnedah-Oxley Basin MDB.

Table 5-9 Likelihood matrix and rankings for the NSW MDB Porous Rock (growth in basic landholder rights)

		BLR : Unassigned water ratio			
		Nil	**<50%**	**50 - 80%**	**>80%**
Extraction as proportion of SDL	Extraction < SDL	Nil Oaklands Basin	Low Western Porous Rock, Gunnedah-Oxley Basin MDB, Sydney Basin MDB	Low	Medium
	Extraction = SDL	Nil	Low	Medium	High
	Extraction > SDL	Nil	Medium	High	High

SDL resource unit	Likelihood ranking
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Low

5.4.2. Confidence in data

This assessment has been undertaken with reference to data produced by NSW Department of Planning and Environment, metered groundwater extraction by licence holders, unassigned water volumes and SDLs as determined for water sharing plans. In the absence of BLR extraction data, a conservative approach was adopted, it was assumed the full volume allocated to BLR was used each year in each resource unit.

There is a high level of confidence in this data, apart from BLR extraction which is based on assumed extraction from bores, and has a moderate confidence level according to the criteria for assessing data confidence in Table 2-5. There is less confidence in the Sydney Basin MDB data as extraction by licence holders is not metered in this area.

5.4.3. Existing water management actions and mechanisms

There are currently no active BLR restrictions in place in the WRP area.

Under the WMA 2000, BLR are made up of domestic and stock rights, harvestable rights and native title rights. These rights are established and controlled under the WMA 2000 with WSPs recognising BLR within plan water sources and accounting for them within LTAAEL and SDL. Groundwater and surface water may be extracted under BLR without the need for a water access licence however the bore must have a work approval in place. The Minister has the ability to limit BLR under the WMA 2000 in certain circumstances such as periods of water shortage, excessive use, or to limit damage to groundwater resources.

Additionally where aquifers could be subject to high hydrologic stress through the proliferation of new domestic and stock rights as a result of the subdivision of land, BLR can be managed under the WMA 2000. This limits the growth in BLR when a landholding is subdivided, effectively allowing the reasonable use for the pre-subdivision landholding to be 'frozen' and divided among the lots in the subdivision. For information regarding the process of applying actions and mechanisms refer Schedule I of the NSW MDB Porous Rock WRP.

5.4.4. Risk outcomes

Combining the likelihood (Table 5-9) and consequence (Table 5-2) rankings provides the overall risk outcomes for growth in groundwater extraction under BLR. Risk outcomes are shown in Table 5-10 and are as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB, Western Porous Rock and Gunnedah-Oxley Basin MDB.

Table 5-10 Overall risk outcomes for impacts on aquifer access licence holders associated with growth in basic landholder rights in the NSW MDB Porous Rock

		Likelihood			
		Nil	**Low**	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil	Nil
	Low	Nil	Low Western Porous Rock, Sydney Basin MDB	Low	Medium
	Medium	Nil	Low Gunnedah-Oxley Basin MDB	Medium	High
	High	Nil	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Low

5.5. Risk of growth in local water utilities reducing groundwater availability (R6)

Growth in local water utility (LWU) requirements due to population increases can impact groundwater availability. The pathway for impacts associated with this risk is growth in LWU entitlement reducing the groundwater allocations made available to other licensed users of lower access priority (AALs). This impact pathway is shown in Figure 5-4.

Upon conversion of *Water Act 1912* town water supply licences to *Water Management Act 2000* LWU share component licences within the WSP, consideration was given to each individual town's potential population increase and growth in use of water. Similar to the calculation of basic landholder rights, LWU requirements were also assessed in a conservative manner, and in many cases potential growth in extraction was also considered.

Because of the priority of access set by legislation, reduced water availability primarily affects AALs, while other types of access with a higher priority of access are maintained to extract their full requirements or entitlement volumes. Therefore the impact would be primarily felt by AAL holders.

It is assumed that existing LWU extraction has already affected groundwater availability, and that this has been allowed for in current management arrangements. Therefore, the risk focuses on any future changes that may further reduce groundwater availability for users.

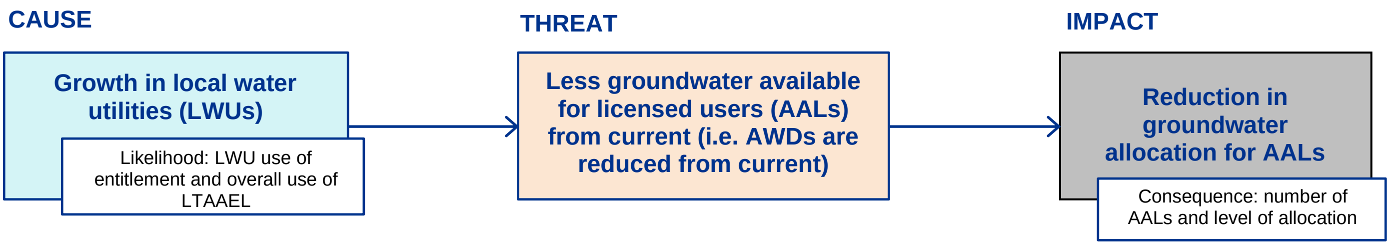


Figure 5-4 Impact pathway for risk of growth in local water utilities reducing groundwater availability and impacting aquifer access licences

5.5.1. Determining the likelihood of the impact occurring

The likelihood of growth in LWU extraction causing a reduction in groundwater availability in the NSW MDB Porous Rock, which may then impact AWDs for consumptive users (AALs) is described by the following ratios:

- LWU extraction to total LWU entitlement volume
- total groundwater extraction in relation to the SDL.

In the absence of detailed projections for population growth, to determine the likelihood of growth in extraction by local water utilities beyond existing entitlement, LWU extraction to LWU entitlement was compared.

The ratio of LWU to all licensed water entitlements in a water source (including aquifer licences and BLR) was also used. This approach assumes that the greater the ratio of LWU to entitlement, then the greater the likelihood that a growth in LWU will impact on licensed water users.

The metrics categories are shown in Table 5-11, and the likelihood rankings are in Table 5-12 and are as follows:

- nil in the Oaklands Basin and Sydney Basin MDB
- low in the Western Porous Rock and Gunnedah-Oxley Basin MDB.

The likelihood is considered nil in the Sydney Basin MDB and Oaklands Basin as there are no LWU water access licences within the resource units and they are not a target for this extraction type.

Table 5-11 Likelihood metrics and results for the NSW MDB Porous Rock (growth in local water utilities)

Likelihood metric	Metric category	Category definition	SDL resource unit results
Ratio of LWU extraction to total LWU entitlement volume[1]	Nil	No LWU entitlement	Sydney Basin MDB = 0% Oaklands Basin = 0%
	Low	< 50% of LWU entitlement used on average each year over the last 10 years	Western Porous Rock = 7% Gunnedah-Oxley Basin MDB = 33%
	Medium	50-80% of LWU entitlement used on average each year over the last 10 years	
	High	>80% of LWU entitlement used on average each year over the last 10 years	
Ratio of extraction to SDL[2]	Low	Average annual extraction over the last 10 years < SDL or = SDL	Western Porous Rock Gunnedah Oxley Basin MDB Sydney Basin MDB Oaklands Basin
	High	Average annual extraction over the last 10 years > LTAAEL	

Data source: [1]NSW Water Accounting System (2017),[2] Data source: NSW Department of Planning and Environment Groundwater Data System (2017)

Table 5-12 Likelihood matrix and rankings for the NSW MDB Porous Rock (growth in local water utilities)

		LWU extraction: LWU entitlement ratio			
		Nil	**<50%**	**50 - 80%**	**>80%**
High extraction as proportion of SDL	**Extraction < SDL**	Nil Sydney Basin MDB, Oaklands Basin	Low Western Porous Rock, Gunnedah-Oxley Basin MDB	Low	Medium
	Extraction > SDL	Nil	Medium	High	High

SLD Resource Unit	Likelihood ranking
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Low

5.5.2. Confidence in data

This assessment has been undertaken with reference to data produced by NSW Department of Planning and Environment on metered groundwater extraction by LWU licence holders, metered groundwater extraction by other licence holders, and SDLs. There is a high level of confidence in this data according to the criteria for assessing data confidence in Table 2-5

5.5.3. Existing water management actions and mechanisms

Access licences for LWU are specific purpose access licences under the WMA 2000 and entitlement is included in LTAAEL / SDL calculations. A new local water utility access licence can be applied for and granted under the WMA 2000 if the share and extraction components of the licence are the minimum required for the proposed use of the water. The minimum share and extraction component required is preferably demonstrated through an Integrated Water Cycle Management Strategy, a core component of which is a needs based assessment. Trade of local water utility licences is restricted.

Where there is no unassigned water there is no scope for LWU increases to be made without having an impact on AAL availability in the longer term, however all resource units within the WRP area have unassigned water availability. For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

5.5.4. Risk outcomes

Combining the likelihood (Table 5-12) and consequence (Table 2-5) rankings provides the overall risk outcomes for growth in LWU reducing groundwater availability. Risk outcomes are shown in Table 5-13 and are as follows:

- nil in the Oaklands Basin and Sydney Basin MDB
- low in the Western Porous Rock and Gunnedah-Oxley Basin MDB.

There is nil risk associated with growth in LWU use in the Sydney Basin MDB and Oaklands Basin as there are no LWU water access licences in these resource units.

Table 5-13 Overall risk outcomes for impact on aquifer access licences associated with growth in local water utilities in the NSW MDB Porous Rock

		Likelihood			
		Nil	**Low**	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil	Nil
Consequence	**Low**	Nil Sydney Basin MDB	Low Western Porous Rock	Low	Medium
Consequence	**Medium**	Nil	Low Gunnedah Oxley Basin MDB	Medium	High
Consequence	**High**	Nil	Medium	High	High

SDL resource unit	Risk outcome
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Low

5.6. Risk of increases in irrigation efficiency and improved water delivery reducing recharge (R7)

The pathway for impact is increased irrigation efficiency causing reduced leakage from water delivery systems, and reduced leaching below the root zone of crops. This may decrease recharge to underlying aquifers and reduce the groundwater available for consumptive users, as summarised in Figure 5-5.

Irrigation efficiencies can be expected to continue to increase over time as drought resistant crops, water delivery systems, water application methods and water application scheduling continue to improve. On this basis, the likelihood of increased irrigation efficiency can be expected.

The impacts of inefficient irrigation (increased recharge and rising water tables) have been well documented within some irrigated areas of the Murray-Darling Basin, and the benefits of increased efficiency, particularly over the last 20 years, have been realised (reduced recharge and falling water tables). On this basis the likelihood of increased irrigation efficiency reducing recharge is also high, but the extent to which this occurs and impacts upon the availability of groundwater for consumptive users is subject to:

- extent of unlined leaky delivery systems being replaced by improved methods
- extent of irrigated area as a proportion of the groundwater resource unit area
- volume of irrigation accessions as a proportion of total recharge

Likelihood can be conceptualised in terms of both the extent of irrigated area as a proportion of the groundwater resource unit area, and volume of irrigation accessions as a proportion of total recharge.

Recharge from irrigation is generally small in relation to other sources of recharge, such as river leakage or floodwater infiltration given the large irrigation efficiency gains made in the last few decades. In addition, irrigation is largely confined to river corridors within the NSW MDB Porous Rock WRP area.

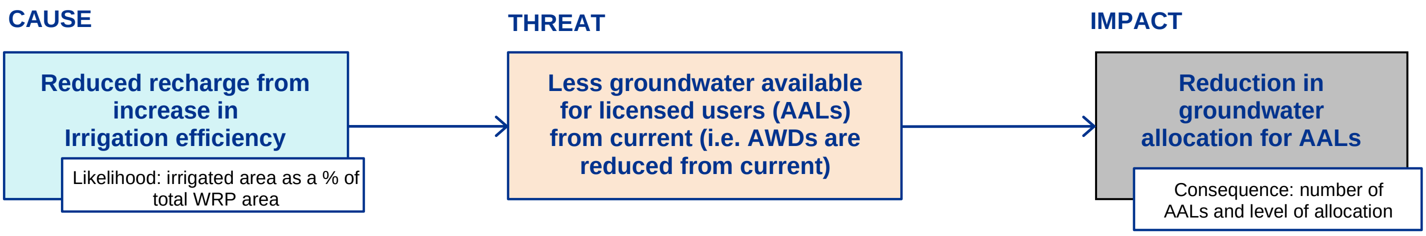


Figure 5-5 Impact pathway for risk of increases in irrigation efficiency and improved water delivery reducing recharge and impacting aquifer access licences

5.6.1. Determining the likelihood of the impact occurring

The likelihood of increased irrigation efficiency causing a reduction in recharge in the NSW MDB Porous Rock WRP area, which may then impact groundwater availability for consumptive users is described by the percentage of overall water source area that has overlying irrigation.

Change in recharge due to increased irrigation efficiency was predicted by determining the percentage of each groundwater source which is overlain by irrigation. It was then conservatively assumed that efficiency upgrades would reduce the recharge to the groundwater source by the same proportion.

In reality, recharge would not be affected to this extent, as efficiency may not reach 100%, some recharge leakage would still occur, and irrigation leakage generally does not comprise a large proportion of the overall recharge. The metric categories are defined to reflect what would be considered a low reduction in recharge (<10%) to what would be a significant reduction in recharge (>30%).

If there is no (or negligible) irrigation overlying a groundwater resource, or if the resource does not receive recharge directly from irrigation, there is no potential for improvements in irrigation efficiency to impact resource availability. To account for these circumstances in the risk analysis, a ‘nil’ likelihood category and ranking have been included.

Likelihood metrics and results are shown in Table 5-14 and likelihood rankings in Table 5-15. The likelihood rankings are as follows:

- nil in the Oaklands Basin, Sydney Basin MDB and the Western Porous Rock
- low in the Gunnedah-Oxley MDB.

Note the Oaklands Basin is completely buried and does not receive recharge directly from irrigation.

Table 5-14 Likelihood metrics and results for the NSW MDB Porous Rock (increases in irrigation efficiency)

Likelihood metric	Metric category	Category definition	SDL resource unit results[1]
Percentage of overall WRP area under irrigation	Nil	<1%	Western Porous Rock = 0.4% Sydney Basin MDB = 0.1% Oaklands Basin[2]
	Low	1 - 10%	Gunnedah-Oxley Basin MDB = 5%
	Medium	10 - 30%	
	High	>30%	

Data source: [1] NSW Department of Planning and Environment 2018 and groundwater source shapefile
[2] SDL resource unit is completely buried

Table 5-15 Likelihood matrix and rankings for the NSW MDB Porous Rock (increases in irrigation efficiency)

Percentage of overall catchment area irrigated	**< 1%**	Nil Sydney Basin MDB, Western Porous Rock, Oaklands Basin
	1 - 10%	Low Gunnedah-Oxley Basin MDB
	-10 - 30%	Medium
	> 30%	High

SDL resource unit	Likelihood ranking
Oaklands Basin	Nil
Western Porous Rock	Nil
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Low

5.6.2. Confidence in data

This assessment references irrigation data from the NSW Landuse 2013 ALUM dataset (NSW Department of Industry 2018) that is based on field data and remote sensing. This data has a moderate confidence according to the criteria in Table 2-5. With irrigation intensity being low across the area, there is high confidence in the data used to inform this component of the risk assessment.

This assessment references information from groundwater modelling of NSW groundwater systems which has shown recharge from irrigation to generally be small in comparison to that from each of rainfall and river leakage. With irrigation intensity being low across the area, there is high confidence in the data used to inform this component of the risk assessment according to the criteria in Table 2-5.

A limitation is the assumption that the likelihood of reduced recharge from an increase in irrigation efficiency can be gauged by the overlying irrigated area as a percentage of resource unit area. The applicability of these metrics is also low; however given the information available, this is considered a valid approach.

5.6.3. Existing water management actions and mechanisms

Groundwater in much of the Porous Rock is of high salinity and is not a target for irrigation. Groundwater development within the Gunnedah-Oxley Basin MDB is concentrated around the Spring Ridge area in the Upper Mooki River catchment. Applications for new entitlements in the Oxley Basin were embargoed from June 2006 and remained in place until replaced by restrictions in the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* which commenced in 2012.

Within the Murray River floodplain groundwater levels in the shallow aquifers are influenced by river regulation, irrigation and groundwater extraction which is primarily from the operation of the salt interception schemes (refer to Table 3-2). Existing WSP strategies adapt groundwater extraction to any reduction in recharge through the long-term average extraction limit mechanism. For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

5.6.4. Risk outcomes

Combining the likelihood (Table 5-15) and consequence Table 5-2) rankings provides the overall risk outcomes for reduced recharge from irrigation impacting aquifer users. Risk outcomes are shown in Table 5-16 and are as follows:

- nil in the Oaklands Basin, Sydney Basin MDB and Western Porous Rock
- low in the Gunnedah-Oxley Basin MDB.

Table 5-16 Overall risk outcomes for impacts on aquifer access licence holders associated with increases in irrigation efficiency in the NSW MDB Porous Rock

		Likelihood			
		Nil	**Low**	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil	Nil
	Low	Nil Sydney Basin MDB, Western Porous Rock	Low	Low	Medium
	Medium	Nil	Low Gunnedah-Oxley Basin MDB	Medium	High
	High	Nil	Medium	High	High

SDL resource unit	Risk outcome
Oaklands Basin	Nil
Western Porous Rock	Nil
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Low

5.7. Risk in growth of plantation forestry intercepting recharge (R8)

Plantation forestry involves the establishment and management of planted forests for environmental purposes and or commercial timber production. The pathway for potential impacts to groundwater resources is the interception of recharge (and rainfall) by plantation trees, which reduces the volume of groundwater available to consumptive users, as described in Figure 5-6. Plantations may intercept recharge before it reaches the water table, and/or draw water directly from the water table, thereby reducing the pool of groundwater available for allocation.

The NSW risk assessments for the overlying surface water resource units (listed in Table 3-1) also consider risk from growth in commercial plantations on streamflow and groundwater recharge for two receptors, the environment (all reports section 4.5.2) and other water users (all reports section 8.2.2). These risks are assessed for all overlying regulated and all unregulated rivers.

It is assumed that any existing plantations have already affected recharge and therefore groundwater availability, and that this has been allowed for in current management arrangements and in determining the sustainable diversion limit. Therefore, the risk focuses on any future changes in plantations that may further reduce groundwater availability for users if there is a subsequent reduction in the plan's extraction limit.

Likelihood can be conceptualised as the predicted increase in plantation forestry as a proportion of the land area that overlies and provides direct recharge to the WRP aquifers, and the land area that provides runoff and through flow to the WRP aquifers (i.e. the growth in plantation forestry area as a percentage of overall catchment area). The likelihood conceptualisation and metrics are discussed in more detail below.

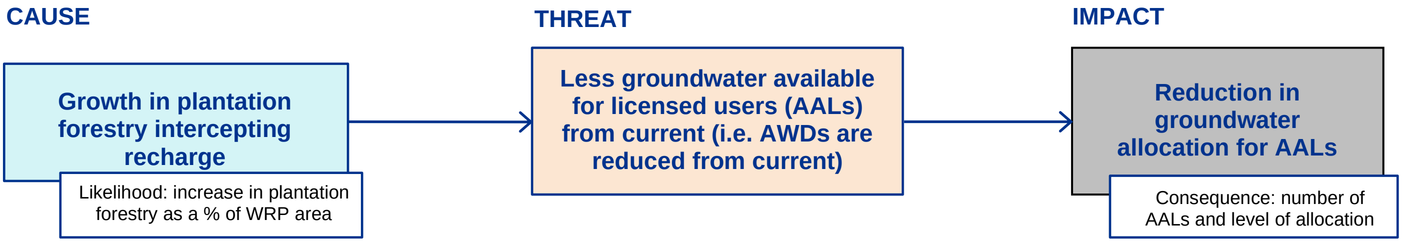


Figure 5-6 Impact pathway for risk of growth in plantation forestry intercepting recharge and impacting aquifer access licences

5.7.1. Determining the likelihood of the impact occurring

The likelihood of an increase in plantation forestry intercepting recharge and reducing groundwater availability is described by the growth in plantation forestry area as a percentage of the overall catchment area. It is assumed that recharge occurs evenly over the catchment, such that the proportion of growth of plantation area estimated relates linearly to the proportion of reduction in groundwater recharge for each water source.

The risk categories were set to reflect what would be a significant decline in recharge, where if the reduction in recharge was less than 10% (i.e. from a growth in plantation area that occupies an additional 10% of the groundwater source area) it would be considered a negligible likelihood of impact, and if greater than 30% (from a growth in plantation area that occupies an additional 30% of the groundwater source area), it would be considered a high likelihood of impact on recharge with potential to impact groundwater extractors.

Where there is no predicted growth in plantation area, there is no potential for additional future impact. A 'nil' category has been included in Table 5-17 to reflect this. Resource units that are located at a considerable distance from areas of predicted plantation forestry growth will have a reduced recharge interception impact potential and the 'nil' category has also been applied in these circumstances. As noted in section 5.7 it is assumed that any existing plantations have already affected recharge and therefore groundwater availability, and that this has been allowed for in current management arrangements and in determining the sustainable diversion limit.

The extent of each SDL resource unit of the NSW Murray-Darling Basin Porous Rock WRP areas were compared to the Murray-Darling Basin reporting areas in order to assign the correct change in predicted commercial forestry plantations for the MDB reports.

The Western Porous Rock SDL resource unit is predominately located within the Murray reporting region, with some small parts included in the Barwon-Darling reporting region. CSIRO (2008) predict no change in the area of commercial forestry plantations in the Barwon-Darling catchment. The area of commercial forestry plantations in the Murray region is estimated to be 53,000 ha (in the upper catchment), with a projected increase by 33,000 ha (62 percent increase) by 2030 (CSIRO, 2008). This increase is predicted to occur in the upper catchment, not in the area of the Western Porous Rock SDL resource unit.

The Sydney Basin MDB is located within the Macquarie-Castlereagh reporting region and the Gunnedah-Oxley Basin MDB SDL resource unit is located across parts of the Macquarie-Castlereagh, Namoi and Gwydir reporting regions. No change in the area of commercial forestry plantations is predicted across these catchments (CSIRO, 2008).

The Oaklands Basin SDL resource unit underlies the Murrumbidgee reporting region. CSIRO (2008) estimated that the area of commercial forestry plantations in the Murrumbidgee region to be 136,700 ha (less than 2 percent of the region), with a projected increase of 17,000 ha by 2030. This increase would be expected to occur in the upland subcatchments, not in the area overlying the Oaklands Basin.

Therefore, all SDL resource units in the NSW Murray-Darling Basin Porous Rock WRP areas are assigned to the ‘nil’ category, as no increase in the area of commercial forestry plantations is predicted across these catchments. (Table 5-18).

Table 5-17 Likelihood metrics and results for the NSW MDB Porous Rock (growth in plantation forestry)

Likelihood metric	Metric category	Category definition	SDL resource unit results [1]
Growth in plantation forestry area	Nil	No predicted growth in plantation forestry area / Resource units located at a considerable distance from areas of predicted plantation forestry growth	All
	Low	Predicted growth 1 - 10% of catchment area	
	Medium	Predicted growth 10 - 30% of catchment area	
	High	Predicted growth > 30% of catchment area	

Data source: [1] CSIRO 2008

Table 5-18 Likelihood matrix and rankings for the NSW MDB Porous Rock (growth in plantation forestry)

Predicted growth in plantation area as % of groundwater source area		
	0%	Nil All
	1 - 10%	Low
	10 - 30%	Medium
	>30%	High

SDL resource unit	Likelihood ranking
Oaklands Basin	Nil
Western Porous Rock	Nil
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Nil

5.7.2. Confidence in data

This assessment has been undertaken with consideration to the processes of:

- Rainfall and recharge interception by terrestrial vegetation
- Uptake of groundwater by terrestrial vegetation.

The assessment also references information on potential plantation increase within the catchments (Lower Murrumbidgee, Macquarie-Castlereagh, Namoi, Gwydir, Lower Murray and Barwon-Darling). Confidence in the data used to predict growth in plantation area is low according to the criteria in Table 2-5, as the modelled predictions have high uncertainty. Also, the assumption that a growth in plantation size will result in the same percentage reduction in recharge introduces uncertainty, as the area where plantations occur in the future may not be significant recharge areas, and therefore recharge may not be significantly impacted. The metric is conservative however, and therefore results are likely to over-estimate the impact, particularly when predicted annual average runoff impacts, plantation forestry location and infiltration rates are considered.

5.7.3. Existing water management actions and mechanisms

Plantation establishment and forestry operations on both Crown Land (including state forests) and freehold land are regulated by the *Plantations and Reafforestation Act 1999* (NSW) (PRA), and the *Plantations and Reafforestation Regulation (Code) 2001*. The regulation establishes buffer zones around rivers, wetlands and drainage lines or depressions and manages runoff to prevent stream degradation. These measures contribute to the protection of stream derived recharge and wetlands dependent on groundwater. The Department of Primary Industries' Forestry Division has responsibility for authorising plantations, and for auditing plantation establishment and forest operations for compliance. A NSW Commercial Plantations Policy is in development and is expected to address potential forestry impacts on ground and surface waters.

Compliance with the PRA is considered to be high as it provides a basis for legal harvesting. The PRA and regulations exclude the consideration of water impacts from the assessment process. However, scope for amending the PRA will be considered as part of NSW response to its interception obligations under the NWI and COAG Water Reform agenda. For information regarding the process of applying actions and mechanisms refer to Table I-3 (issues column, other users) in Schedule I of the NSW MDB Porous Rock WRP.

5.7.4. Risk outcomes

Combining the likelihood and consequence rankings provides the overall risk outcomes for growth in plantation forestry impacting aquifer users as nil, as there is no predicted increase in plantation area and therefore no potential for additional impacts to occur (Table 5-19).

Table 5-19 Overall risk outcomes for impacts on aquifer access licence holders associated with growth in plantation forestry in the NSW MDB Porous Rock

		Likelihood			
		Nil	**Low**	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil	Nil
	Low	Nil Western Porous Rock, Sydney Basin MDB	Low	Low	Medium
	Medium	Nil Gunnedah-Oxley Basin MDB	Low	Medium	High
	High		Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Nil
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Nil

5.8. Risk of growth in mining reducing groundwater availability (QL4)

This section considers the potential for impacts from growth in mining to intercept recharge and reduce the availability of groundwater for consumptive users.

Aquifer interference activities such as mining may take water from the water source in which they exist as well as connected groundwater and surface water sources. Even where there is no take of water, mining can still affect the functioning of aquifers which can impact water users and dependent ecosystems.

The approach taken in this document is to assess risk with groundwater management in place. While a conceptual pathway for potential impacts to occur can be identified (Figure 5-7), in practice the NSW approach is to require all volumetric impacts to be accounted for by licence under the extraction limit of the relevant water sources. Any increase in take or reduction in recharge through growth in mining related activities would require an access licence to be held by the proponent to account for this volume.

With regard to current risks from licensed take associated with mining activities impacting AALs this is incorporated into all risks associated with groundwater take (i.e. risks R1 (section 4.3), R2 (section 4.4), R3 (section 4.6), QL1 (section 4.6), QL2 (section 4.7). However it is recognised this approach does not identify the potential for growth in mining to reduce groundwater availability.

The Australian Government's Bioregional Assessments Program covering coal mining and coal seam gas and Geological and Bioregional Assessment Program covering shale and tight gas are independent, scientific assessments of the potential cumulative impacts of coal and unconventional gas developments on the environment, including water-dependent ecosystem and social and economic impacts. The assessments target regions with significant coal deposits and focus on those regions that are subject to significant existing or anticipated mining activity and on those areas identified by governments through the National Partnership Agreement on Coal Seam Gas and Large Coal Mining Development. Results are reported for the regional water table, which comprises the alluvial aquifers as well as weathered and fractured rock aquifers. This information has been used to provide outcomes for this risk.

The Sydney Basin and the Northern Inland Catchments bioregions have undergone assessment by the Bioregional Assessments program. The Sydney Basin MDB resource unit is within the western coalfields of the Sydney Basin bioregion and the Gunnedah-Oxley Basin MDB is within the Northern Inland Catchments bioregion. These regions contains substantial coal and coal seam gas-bearing geological sequences. The Namoi subregion of the Northern Inlands Catchments bioregion has active coal mines. Detailed regional modelling was not completed for the Sydney Basin bioregion. The coal seam gas potential of the Western Coalfields is low.

The Gunnedah-Oxley Basin MDB extends across the NSW subregions of the Northern Inland Catchments Bioregion. Within the Gwydir (including NSW Border Rivers) and Central West subregions there is limited potential for additional coal resource development. Within the Namoi catchment mining activities comprise less than one percent of the total catchment area (Welsh et al. 2014), although the region contains substantial coal and coal seam gas-bearing geological sequences. Current coal and CSG development and exploration are primarily in the central and eastern parts of the subregion (Commonwealth of Australia, 2018).The Commonwealth Government Bioregional Assessment for the Namoi subregion identified six baseline (at 2012) coal mines in the region, including one underground mine (Northey et al. 2014). As of January 2018, no further coal mines had been approved however there have been ten additional coal resource developments (e.g. three expansions to open-cut mines, three new open-cut mines). Of the ten developments, eight were incorporated into the hydrological modelling with the six baseline mines (Commonwealth of Australia, 2018a). Six coal seam gas (CSG) exploration and pilot testing developments had commenced in the Namoi catchment, however only the Narrabri Gas Project development is currently under consideration and is included in the modelling.

The Oaklands Basin is not within a bioregion identified in the Bioregional Assessments Program but does contain substantial coal reserves. Given the resource unit lies below the Murray Alluvium and Murrumbidgee Alluvium shallow and deep resource units there is no foreseeable development within the terms of the relevant alluvial WSPs. The Western Porous Rock resource unit is not within a bioregion identified in the Bioregional Assessments Program but does contains mineral sand mines in operation near Pooncarie (Senior 2019).

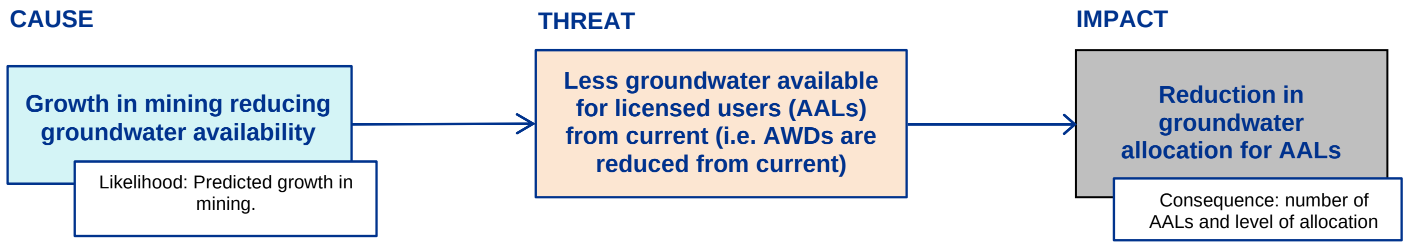


Figure 5-7 Impact pathway for risk of growth in mining reducing groundwater availability and impacting aquifer access licences

5.8.1. Confidence in data

This assessment does not calculate risk, but relies on the findings of an independent assessment of the potential for growth in coal seam gas and coal mining to provide a risk outcome. As such the potential for growth in all mining activities is not addressed and therefore the risk outcomes have moderate data confidence according to the criteria in Table 2-5.

5.8.2. Existing water management actions and mechanisms

In NSW, the impacts of mining and coal seam gas activities are assessed under the *Environmental Planning and Assessment Act 1979*. If approved, these developments are conditioned to mitigate impacts on water and related resources. As part of the development approval process, proponents must assess not only their process requirements for water take, but also the impact the activity may have on the quantity of water in all water sources. This includes impacts on immediate or adjacent groundwater sources both directly and indirectly via interception or recharge and/or inducing groundwater flows.

Access licences under the WMA 2000 must be purchased for any impacts on the quantity of water in immediate or nearby water sources. In the porous rock WRP area, licences may be purchased via the market, or if available, through a water release process via controlled allocation. As such, these activities are no different to any other type of groundwater take and are considered outside of the ‘interception’ construct of the Basin Plan.

The NSW Aquifer Interference Policy details the water licensing and impact assessment processes for aquifer interference activities under the WMA 2000 and other relevant legislation. The assessment criteria are called 'minimal impact considerations' and include impacts on surface water systems, connected alluvial aquifers, various groundwater impacts and water-dependent assets. 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.

5.8.3. Risk outcomes

The Bioregional Assessments Program regional scale modelling found it is very unlikely (less than 5% chance) that the Namoi subregion will experience drawdown in the regional water table of greater than 0.2 m as a result of additional coal resource development. The year when maximum change is expected to be reached will vary throughout the subregion increasing with distance from the mines and is most likely to occur during the decades after mining activity ceases (Janardhanan et al, 2018).

Based on the Bioregional Assessments Program findings a risk outcome of low has been adopted in this report for all resource units based on the capacity for growth in mining reducing groundwater availability within the term of the water sharing plan (i.e. the next 10 years) as shown in Table 5-20.

With regard to current risks from licensed take associated with mining activities, this is incorporated into all risks associated with groundwater take (i.e. risks R1 (section 4.3), R2 (section 4.4), R3 (section 4.6), QL1 (section 4.6), QL2 (section 4.7), R9, R10 (section 6.3).

These outcomes should be considered in conjunction with the existing water management actions and mechanisms described in section 5.8.3 and in the NSW MDB Porous Rock WRP section 5.6.

Table 5-20 Overall risk outcomes for impacts on aquifer access licence holders associated with growth in mining in the NSW MDB Porous Rock

SDL resource unit	Risk Outcome
Oaklands Basin	Low
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Low

6. Risk to water available for the environment

6.1. Background

The Basin Plan establishes objectives in relation to environmental outcomes (section 5.02 and 5.03). These include protecting and restoring water-dependent ecosystems and functions, and ensuring they are resilient to risks and threats.

The Murray-Darling Basin Authority considers an environmental asset as tangible, such as a location or a species. Environmental assets of the Basin include wetlands, floodplains, rivers or iconic aquatic species and can be surface water and/or groundwater–dependent. They include water-dependent ecosystems, ecosystem services, and sites with ecological significance (Murray-Darling Basin Authority 2010). Schedule 8 of the Basin Plan lists the criteria for identifying an environmental asset.

Ecosystem functions are the key physical, chemical and biological processes that support the Basin's environmental assets, and include the transport of nutrients, organic matter and sediment in rivers, wetting and drying cycles, and provision for migration and recolonisation by plants and animals along rivers and across floodplains (Murray-Darling Basin Authority 2010). Schedule 9 of the Basin Plan lists the criteria for identifying an ecosystem function.

Department of Planning and Environment defines ecosystems that depend on groundwater as '*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*' (modified from Richardson et al. 2011 in Kuginis et al. 2016). These ecosystems include environmental assets defined by the MDBA (Murray-Darling Basin Authority 2010).

This risk assessment considers risk to priority environmental assets and ecosystem functions that are dependent on groundwater, including assets that are dependent solely on groundwater and those that are dependent on both surface and groundwater. Risk to the capacity to meet environmental watering requirements (EWRs) is also considered.

Note the risk assessments for the Gwydir, Macquarie-Castlereagh, NSW Border Rivers, Murrumbidgee, Namoi and NSW Murray and Lower Darling WRP areas (Department of Industry 2018a-c, Department of Planning, Industry and Environment 2019a-c) consider risk to surface water dependent priority environmental assets and ecosystem functions including risk to the capacity to meet their EWRs.

There are a wide variety of groundwater–dependent ecosystems (GDEs). A simple guide to GDE type is included in Table 6-1. The definition used here for baseflows is persistent (low) flows that continue after rain has stopped as a result of connection to groundwater.

Table 6-1 Simple guide to groundwater–dependent ecosystem type

Location	Groundwater location	Surface water dependency	Example ecosystems	Impact receptor
Subterranean	Subsurface	Nil	Karsts, aquifers	GDEs
Terrestrial	Subsurface	Over bank flows	Terrestrial vegetation communities	
Aquatic	Surface expressed	Nil	Springs	
	Surface expressed	Over bank flows	Floodplain wetlands	
	Surface expressed (as baseflow)	Instream flows above baseflow	Rivers and streams, riparian vegetation and terminal wetlands	Groundwater–dependent instream ecological values

There are a number of causes and threats that could potentially impact the availability of water for assets and functions that have reliance on groundwater. In the NSW MDB, these risks include:

- erosion of groundwater in local areas by high extraction intensity and local drawdown impacts

- climate change causing lower rainfall and/or recharge
- interception activities.

Risks to the availability of water for the environment and risks to the capacity to meet environmental watering requirements (EWRs) are assessed in terms of 'threats' and associated impact pathways. In groundwater sources across the NSW MDB, two key threats have been identified, comprising lower groundwater levels reducing:

- access by GDEs
- discharge to connected streams (baseflows).

The potential impacts considered here are the reduction in:

- GDE value
- groundwater-dependant instream ecological values for assets and functions reliant on baseflows.

The combination of causes, threats and impacts result in impact pathways as shown in Figure 6-1. These risks are analysed in the following sections.

Section 6.2 describes how the consequence ranking to the environment was determined. The following sections then describe the analysis of the likelihood of causes and threats occurring. The likelihood and consequence rankings are then combined to provide the overall risk determination.

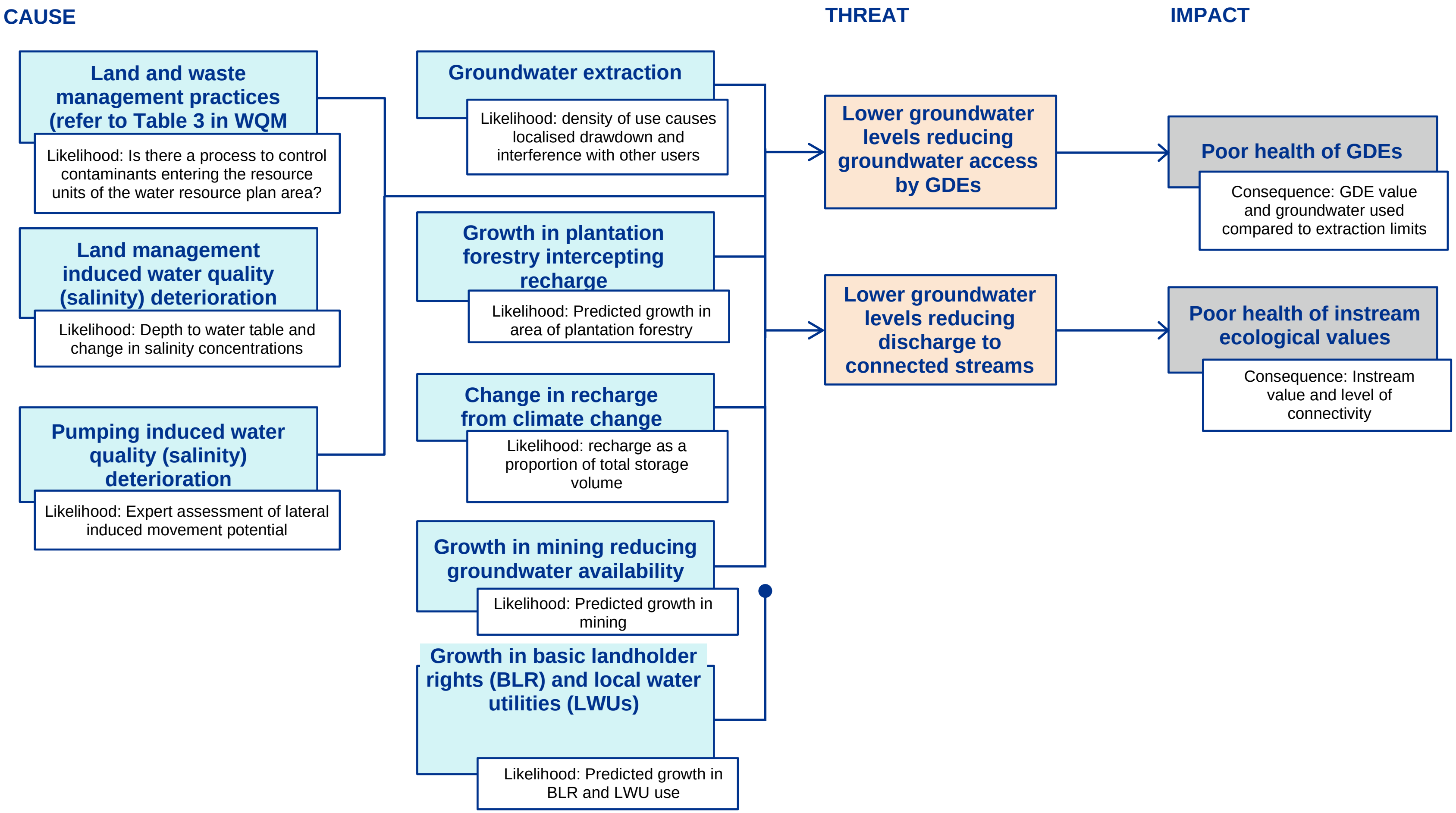


Figure 6-1 Impact pathways for risk to the environment and to water available for the environment (groundwater–dependent ecosystems and instream ecological values)

6.1.1. Environmental watering requirements in a groundwater context

This section sets out how assessment of the risk to water available for the environment has also addressed the Basin Plan requirement in section 10.41(2)(a) for the risk assessment to assess risks to the capacity to meet environmental watering requirements (EWRs).

Environmental watering has a specific meaning under the *Water Act 2007* which is the delivery or use of environmental water to achieve environmental outcomes In NSW groundwater SDL resource units, there is very little held environmental water entitlement. Predominantly environmental water is both planned and passive (i.e. remaining in the groundwater system and protected by a variety of mechanisms such as bore setbacks from GDEs and streams, limits to extraction to manage water levels at a groundwater source or finer scale if required, and SDLs or LTAAELs to manage water levels in the long term, refer to the NSW MDB Porous Rock WRP section 4.1.1 for a full description).

Environmental watering requirements (EWR) are defined by section 1.07 of the Basin Plan as 'the environmental watering requirements of a priority environmental asset or ecosystem function'. These are identified using methods in the Basin Plan Chapter 8, Part 5 via the LTWP and may include where relevant the extent and thresholds for any groundwater dependency (Basin Plan 8.51(2)(f)).

It is not anticipated NSW LTWPs will identify groundwater features such as degree of groundwater dependency or groundwater levels as EWRs for specific priority groundwater–dependent assets or functions prior to WRP commencement.

This does not imply groundwater–dependent ecosystems do not have requirements for access to environmental water, or that EWRs will not be set in the future. Rather, it reflects a paucity of adequate fundamental ecological information and data from which to determine groundwater based EWRs, and the predominance of non-discretionary planned environmental water over held environmental water in NSW groundwater resource units.

In the absence of identified groundwater EWRs such as the extent and thresholds for groundwater dependence for priority environmental assets and ecosystem functions, the NSW approach to assessing risk to the capacity to meet EWRs is to assess the risk of insufficient water available for the environment using the threat of groundwater extraction or interception activities lowering groundwater levels. Impacts are assessed for both groundwater–dependent ecosystems and instream ecological values. Risks to surface water EWRs from surface water extraction or interception are considered in detail in sections 4.3 - 4.3.1 of the relevant surface water risk assessments. Both approaches have regard to the EWRs identified in the Basin Plan section 10.26.

The approach to the identification of groundwater–dependent ecosystems and instream ecological values inherently considers environmental watering requirements by using depth to water table as a limit for the identification of high probability groundwater dependent ecosystems. Where reliance on groundwater to an approximate depth or depth range is known, this is reflected in the probability category limits. Risk outcomes in section 6 of this document have been calculated for high probability ecosystems. For more information on the identification process refer to Kuginis et al. 2016.

There are however, some circumstances where groundwater extraction may compromise identified surface water EWRs that jointly support priority environmental assets and functions dependent on groundwater. The sections below discuss types of assets and functions and their dependence on surface and groundwater EWRs. The following sections address the risk to surface water EWRs from groundwater extraction by assessing the risk to groundwater available for the environment. Two receptors for the risks are used, GDEs and groundwater dependent instream ecological values. Refer to Table 6-1 for a simple description of GDE attributes and to Appendix C for information regarding alignment of priority environmental assets and functions with Basin Plan Schedules 8 and 9.

6.1.1.1. Environmental water requirements for groundwater–dependent ecosystems entirely dependent on groundwater

These assets include aquatic GDEs such as springs that are dependent on surface expressed groundwater and subterranean GDEs such as karsts that are dependent on subsurface groundwater. The environmental water requirements for these assets are entirely groundwater based and as described in section 6.1.1 are not expected to be expressed as EWRs in LTWPs due to data paucity. The risk to water available for the environment examined in this section of the report should be considered to also address the risks to the capacity to meet groundwater EWRs for these PEAs and PEFs. See the GDE sections of this report for consideration of risk associated with these EWRs.

The existing groundwater management approach for these assets in the absence of any defined groundwater EWRs, is to maintain connectivity between priority environmental assets (PEAs) and groundwater by limiting extraction-induced drawdown impacts spatially and temporally.

6.1.1.2. Environmental water requirements for groundwater–dependent ecosystems and instream ecological values dependent on groundwater and surface water

These assets depend on both ground and surface water and include those dependent on:

- instream flows such as aquatic GDEs (e.g. riverine vegetation or terminal wetlands and in-stream ecosystems also dependent on groundwater derived baseflows)
- over bank flooding such as terrestrial GDEs (e.g. vegetation stands also dependent on subsurface groundwater), and aquatic GDEs (e.g. floodplain wetlands also dependent on surface expressed groundwater).

GDEs dependent on instream flows have relevant surface water EWRs. Where identified, these are expressed in LTWPs. For example, those EWRs identified in LTWPs as occurring above baseflow up to bank full levels provide these GDEs with their primary source of water, whereas groundwater derived baseflows support instream GDEs when surface flows are low. The groundwater management approach to not compromising instream flows is to maintain and manage the connectivity between surface and groundwater resource units. This risk assessment considers risk of groundwater extraction impacting groundwater derived baseflows which aligns with the surface water baseflow EWRs. See the instream ecological values sections of this report for consideration of risk associated with these EWRs.

GDEs dependent on over bank flooding do have relevant surface water EWRs expressed in LTWPs where they have been identified. For example, those surface water EWRs described in the LTWPs as over bank flows with short and long-term recurrence intervals provide these GDEs with additional ecological functions such as recruitment to support a healthy age structure of the vegetation community, a function that cannot be supplied by groundwater (see Table 6-2). The existing groundwater management approach to not compromising these overbank EWRs is to maintain the connectivity between the GDEs and the groundwater resource which supports them during the periods between over bank flows. See the GDE sections of this report for consideration of risk associated with these EWRs.

Table 6-2 Long-term watering plan environmental watering requirements that may benefit priority environmental assets and priority environmental functions dependent on both groundwater and surface water

Risk to water available for the environment	Indicative long term watering plan[1] environmental watering requirements	
Related GDE type[2] and report sections	**EWR Reference**	**LTWP Ecological objectives related to groundwater**
Instream ecological values Rivers and streams, and their environmental assets and functions that are dependent on **groundwater derived baseflows** and larger surface derived instream flows	Cease-to-flow Very-low flow Baseflow Small fresh Large fresh Bank full	NV1 Maintain the extent and viability of non-woody vegetation communities occurring within and closely fringing channels NV3 Maintain the extent and maintain or improve the condition of river red gum and river cooba communities closely fringing river channels EF1 Provide and protect a diversity of refugia across the landscape. EF2 Create quality instream and floodplain habitat EF3 Provide movement and dispersal opportunities within catchments for water-dependent biota to complete lifecycles. EF5 Support instream and floodplain productivity EF6 Support groundwater conditions to sustain groundwater–dependent biota. EF7 Support mobilisation and transport of sediment, carbon and nutrients along channels, between channels and floodplains, and between catchments. EF8 Increase the contribution of flows into the Murray and Barwon-Darling from tributaries
Groundwater–dependent ecosystems Terrestrial vegetation communities and other floodplain environmental assets and functions dependent on **subsurface and surface expressed groundwater** and over bank flows	Overbank flow Overbank - Small wetland inundation Overbank - Large wetland inundation	NV2 Maintain the extent and viability of non-woody vegetation communities occurring in wetlands and on floodplains NV4 Maintain the extent and maintain or improve the condition of native woodland and shrubland communities on floodplains EF1 Provide and protect a diversity of refugia across the landscape. EF2 Create quality instream and floodplain habitat EF3 Provide movement and dispersal opportunities within catchments for water-dependent biota to complete lifecycles. EF5 Support instream and floodplain productivity EF6 Support groundwater conditions to sustain groundwater–dependent biota. EF7 Support mobilisation and transport of sediment, carbon and nutrients along channels, between channels and floodplains, and between catchments. EF8 Increase the contribution of flows into the Murray and Barwon-Darling from tributaries

[1] Information indicative of provisions in the NSW Border Rivers, Gwydir, Namoi, Macquarie-Castlereagh, Murrumbidgee and NSW Murray and Lower Darling LTWPs. See individual plans for specific EWRs (OEH 2018a-c, 2019, NSW Department of Planning and Environment 2019d, e)

[2] Refer to Table 6-1

6.2. Assigning a consequence ranking

The risks analysed in this section have two potential receptors, being GDEs and instream ecological values that are dependent on baseflows connected to groundwater. This section describes the consequences of impacting these receptors via a number of causes.

Methods to classify ecological assets that are dependent on groundwater are less advanced than for surface water assets. For example, river value assessment is a wide-spread practice in Australia, and has been implemented in many states and territories as a means to focus resources to improve river health through management practices (Bennett et al. 2002; Macgregor et al. 2011). NSW has a long history of river health assessment commencing in 1998.

More recently, the NSW Department of Planning and Environment adopted the High Ecological Value Aquatic Ecosystem (HEVAE) Framework (Aquatic Ecosystems Task Group 2012) as a progressive step to replace other instream value frameworks previously used. The HEVAE Framework is considered a best practice approach to identifying environmental assets (Murray-Darling Basin Authority 2014). The HEVAE assessment formed a key part of the NSW Department of Planning and Environment's risk assessment process for surface water resources to meet Basin Plan requirements, as the consequence component. It has also been used as a basis for classifying the value of groundwater–dependent ecological assets. HEVAE values were assigned at a vegetation patch or river reach scale; a decision tree was then used to assign a consequence ranking for each SDL resource unit (Figure 6-2).

6.2.1. HEVAE for groundwater–dependent ecosystems

Department of Planning and Environment - Water developed a method to assign an ecological value to the high probability (of groundwater dependence) GDEs based on the HEVAE framework (Aquatic Ecosystems Task Group 2012). This approach aligns with that used for surface water.

The GDE HEVAE method provides a scientifically robust, systematic, repeatable and transparent process to assign an ecological value at the vegetation patch scale for GDEs. Ecological value is the perceived importance of an ecosystem. This is underpinned by the biotic and/or abiotic components and processes that characterise that ecosystem. In the HEVAE framework, ecological values are those identified as important through application of the criteria and identification of critical components and processes in describing the ecological character of the ecosystem (Aquatic Ecosystems Task Group 2012).

The criteria used in the HEVAE framework align to criteria listed in Schedules 8 and 9 of the Basin Plan for identifying ecological assets and ecosystem functions. The alignment of the two sets of criteria is provided in Appendix C.

HEVAE scores were assigned using the same data and mobility weightings used by the Office of Environment and Heritage (OEH) to identify environmental assets for the relevant long term watering plans. Native vegetation assets mapped by OEH in the LTWPs include the high probability GDEs mapped by Department of Planning and Environment - Water, ensuring that high probability GDEs align with PEAs. It is assumed that any river that has a baseflow component of its flow regime is groundwater–dependent.

Department of Planning and Environment - Water has proposed the mapped extent of very high and high ecological value, high probability terrestrial vegetation GDEs and associated wetlands be recognised in WSPs. This approach is consistent with the NSW macro planning approach (DPI Water 2015) which has been used previously in the development of WSP rules and allows further rules limiting extraction near GDEs to be applied via WSPs and described in WRPs.

It is important to note that the recently identified groundwater–dependent PEAs include vegetation that has a high probability of groundwater reliance; these assets may be dependent on both ground and surface water.

A five class or category system was adopted to display the four criteria (distinctiveness, diversity, vital habitat and naturalness) and overall standardised score HEVAE outputs (very high to very low). Representativeness was not applied to the dataset due to the insufficient data available. Using this type of class or category system is an accepted practice in waterway assessment (Bennett et al. 2002; Macgregor et al. 2011; Healey et al. 2012). A standardised GDE HEVAE method was applied to every WRP area. Detailed methodology is provided in Dabovic et al. (2019). The criteria and indicators used in the GDE HEVAE methods are shown in Figure 6-2.

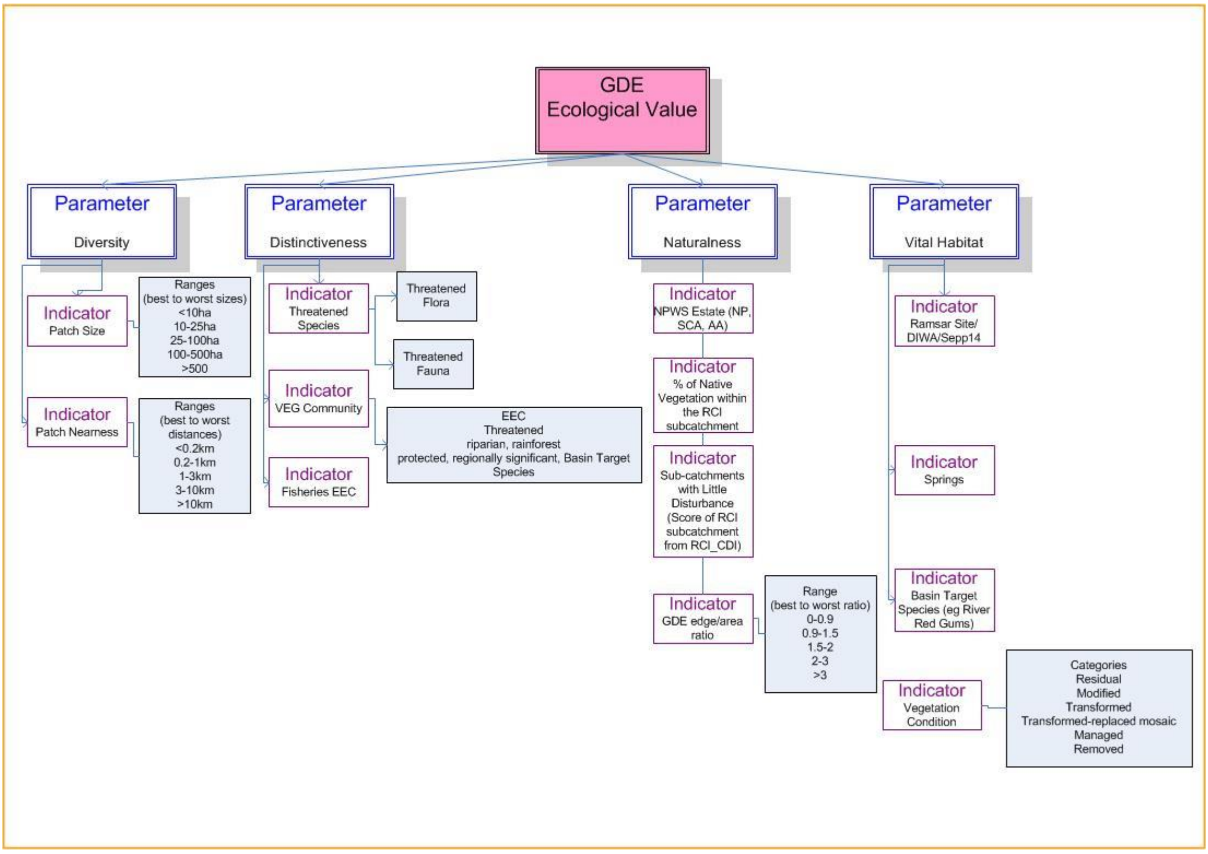


Figure 6-2 HEVAE criteria and associated attributes used to assign an ecological value to groundwater–dependent ecosystems

6.2.1.1. Consequence decision tree

HEVAE values were assigned at a vegetation patch scale. The decision tree was then used to assign a HEVAE consequence score for resource unit, groundwater source or groundwater management zone. Ramsar/ Directory of Important Wetlands in Australia (DIWA) habitat was prioritised. Non-Ramsar high and very high value vegetation patches were ranked according to extraction pressure and presence of threatened species. Each bifurcation in the decision tree was annotated to allow each score to be tracked through the decision tree during the assessment. The decision tree and the rationale for each bifurcation are provided in Appendix E

The NSW MDB Porous Rock supports significant GDEs of high and very high ecological value, including wetlands, springs and vegetation ecosystems (Figure 6-3). As the Oaklands Basin is completely buried it has no identified groundwater dependent ecosystems and so HEVAE scores or resultant HEVAE consequence values cannot be calculated.

The Gunnedah-Oxley Basin MDB and Sydney Basin MDB SDL resource units are largely characterised by vegetation communities of endangered ecological communities, Basin target vegetation species (Murray-Darling Basin Authority 2014) of river red gums and Directory of Important Wetlands in Australia (DIWA)/Ramsar wetlands (associated with Lake Goran). The Gunnedah-Oxley Basin MDB also includes several significant GDEs which are classified as springs and are identified in the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*. Generally the GDE communities with high ecological value have large vegetation patches, are highly connected and have a high number of threatened species.

Vegetation communities for these resource units include black tea tree-river oak-wilga riparian communities, red gum-yellow box woodlands, narrow-leaved ironbark-white cypress pine-buloke woodlands, poplar box-yellow box-western grey box woodlands, river red gum woodlands, shallow freshwater wetlands, white bloodwood-red ironbark-black cypress pine woodlands, white box woodlands, rough-barked apple-red gum-yellow box woodlands, western grey box-cyprus pine woodlands, yellow box woodlands, and fuzzy box woodlands.

The Western Porous Rock SDL resource unit also is characterised by endangered ecological communities, DIWA/Ramsar wetlands (associated with Menindee Lakes), extensive connected riparian corridors and Basin target vegetation species (Murray-Darling Basin Authority 2014) of river red gums. Generally the GDE communities with high ecological value have large vegetation patches, are highly connected (along riparian corridors) and have a moderate number of threatened species present especially in the wetland areas.

Vegetation communities for this resource unit include black blue bush shrublands, black box-lignum wetlands, black box woodland wetlands, canegrass swamps, lignum shrubland wetlands, nitre goosefoot shrubland wetlands, permanent and semi-permanent wetlands, river red gum-lignum woodland wetlands and river red gum woodland wetlands.

HEVAE consequence scores for GDEs across the NSW MDB Porous Rock ranged from nil to very high (Table 6-3, Figure 6-3). The HEVAE consequence score range (very high to very low) was converted to low, medium and high consequence categories and shown as the metric ‘HEVAE consequence score (GDE)’ in Table 6-3.

6.2.1.2. Consequence ranking for groundwater–dependent ecosystems

The consequence of impacts on GDEs is described in this risk assessment using:

- the HEVAE consequence scoring framework for GDEs
- current extraction pressure within the water source.

Sensitivity is considered to be higher where the current extraction pressure is higher (i.e. where the average annual extraction volume is close to the LTAAEL). As discussed above, the HEVAE framework has been used to assign an ecological value to GDEs. Ecological value is the perceived importance of an ecosystem. This is underpinned by the biotic and/or abiotic components and processes that characterise that ecosystem. Therefore, those groundwater sources where GDEs have a high or very high HEVAE consequence score, and higher than LTAAEL historical groundwater extraction will have a higher consequence ranking than those groundwater sources where GDEs also have a high or very high HEVAE consequence score but have lower than LTAAEL historical groundwater extraction.

To determine the impact on ecological functions and assets reliant on groundwater, consideration was given to where and how much extraction pressure (individual licence entitlement) had occurred and whether extraction pressure had the potential to influence the GDE HEVAE consequence score. The assumption was that if there was high extraction pressure then there was a potential for a decrease in groundwater level with subsequent potential for impact on GDEs. This was assessed by determining the change in groundwater levels from the period 1974-1987 to the 2015/16 water year. The period 1974-1987 was assumed to be representative of natural groundwater levels. This assessment is shown as the metric ‘Extraction compared to SDL’ in Table 6-3.

Consequence metrics and results are shown in Table 6-3 with HEVAE derived GDE ecological value mapped in Figure 6-3. Consequence rankings for the NSW MDB Porous Rock are provided in Table 6-4 and are as follows:

- nil in the Oaklands Basin
- low in the Gunnedah-Oxley Basin MDB, Sydney Basin MDB and Western Porous Rock.

Note a HEVAE consequence score was not determined for the Oaklands Basin. This resource unit is completely buried and considered disconnected from surface waters. It has no dependent GDEs or instream ecological values. As there are no environmental risk receptors, and there is no licenced or basic landholder rights extraction, there is no potential for impacts to occur and a nil consequence ranking has been determined.

Table 6-3 Consequence metrics and results in the NSW MDB Porous Rock (groundwater–dependent ecosystems)

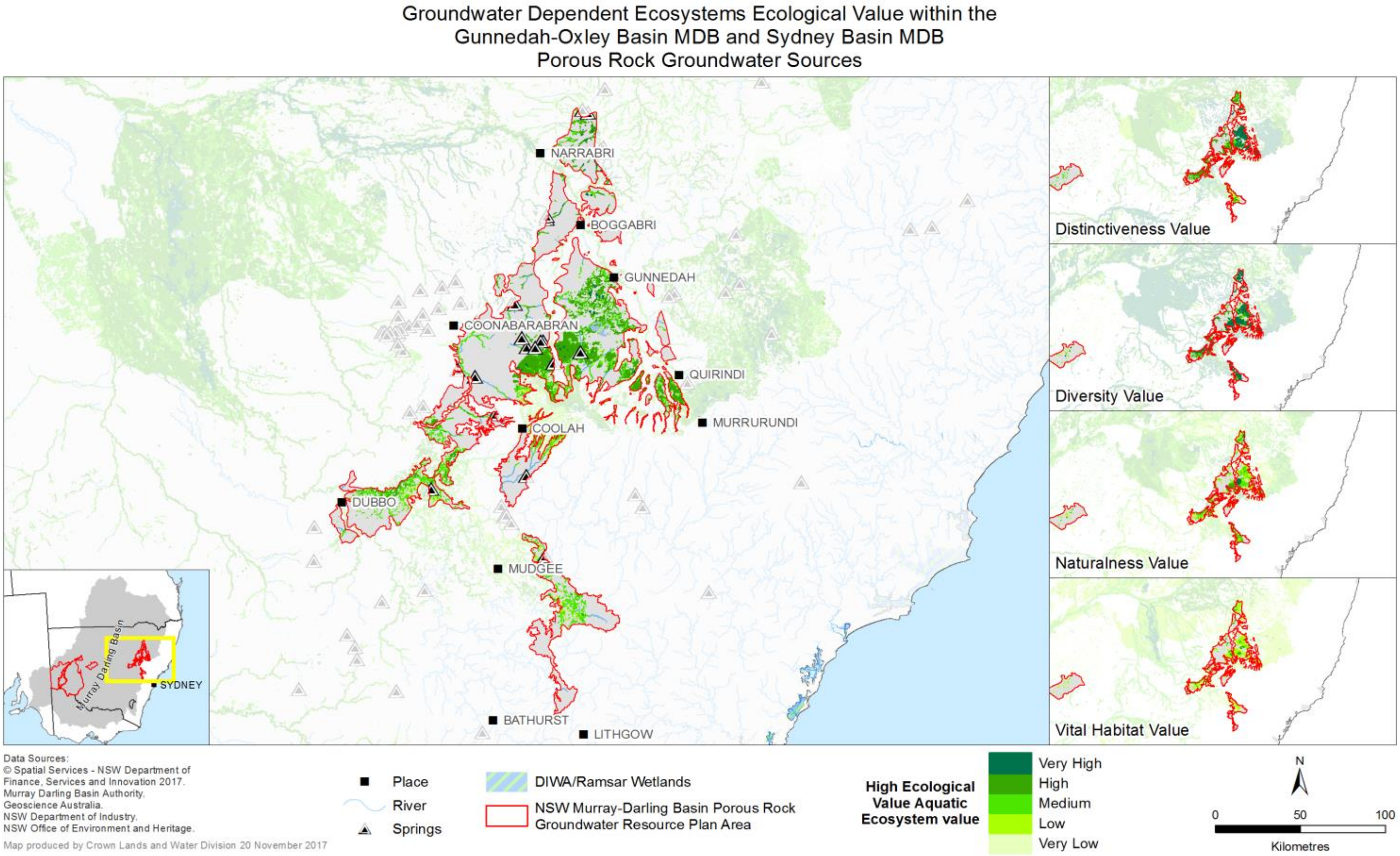
Metric	Metric Category	Metric category definition	SDL resource unit results [1]
HEVAE consequence score (GDE)	Nil	Not determined due to disconnected nature of SDL resource unit	Oaklands Basin
	Low	Low, very low GDE HEVAE score	
	Medium	Medium GDE HEVAE score	Sydney Basin MDB
	High	High, very high GDE HEVAE score	Western Porous Rock Gunnedah-Oxley Basin MDB
Extraction compared to SDL[2]	Nil	No extraction	Oaklands Basin
	Low	Extraction < SDL	Sydney Basin MDB Western-Porous Rock Gunnedah-Oxley Basin MDB
	Medium	Extraction = SDL	
	High	Extraction > SDL	

Data source: [1] Data source: HEVAE scoring framework for GDEs (Dabovic et al, 2019),[2] Data source: DPIE-Water Groundwater Data System (2017)

Table 6-4 Consequence matrix and rankings in the NSW MDB Porous Rock (groundwater–dependent ecosystems)

		Extraction versus LTAAEL			
		No extraction	**Extraction < LTAAEL**	**Extraction = LTAAEL**	**Extraction > LTAAEL**
HEVAE consequence score	**No connectivity with GDEs**	Nil Oaklands Basin	Nil	Nil	Nil
	Very low / low	Nil	Low	Low	Medium
	Medium	Nil	Low Sydney Basin MDB	Medium	High
	High / very high	Nil	Medium Western Porous Rock, Gunnedah-Oxley Basin MDB	High	High

SDL resource unit	Consequence ranking
Oaklands Basin	Nil
Western Porous Rock	Medium
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Medium



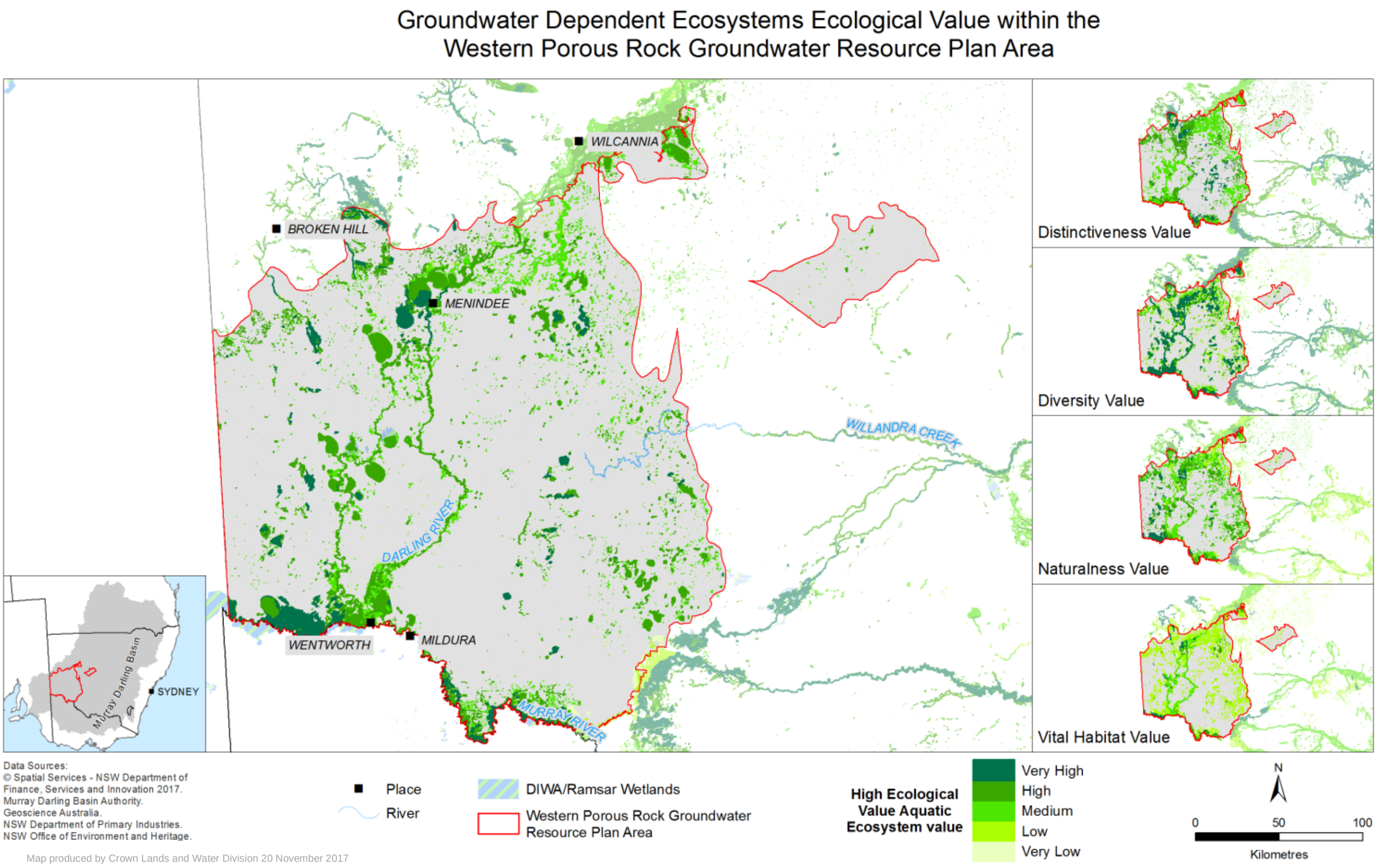


Figure 6-3 Groundwater–dependent ecosystems ecological value in the NSW MDB Porous Rock

6.2.2. HEVAE for instream ecological values

A standardised HEVAE method for instream ecological values was applied to every surface water resource in the NSW MDB. Detailed methodology is provided in Healey et al. (2018) and discussed in the relevant surface water risk assessments (NSW Department of Industry 2018a-c, NSW Department of Planning, Industry and Environment 2019a-c).

The criteria used in the HEVAE framework align to the criteria listed in Schedules 8 and 9 of the Basin Plan for identifying ecological assets and ecosystem functions. The alignment of the two sets of criteria is provided in Appendix D. The assigning of HEVAE scoring was developed using the same data and mobility weights used by the Office of Environment and Heritage (OEH) to identify environmental assets and functions for LTWPs.

HEVAE values were assigned at a surface water reach scale. The decision tree was then used to assign a consequence score at a groundwater water source scale or groundwater management zone (Figure 6-4). The key criteria and indicators used in the HEVAE method for instream ecological values are also shown in Figure 6-4. Note that the same flow sensitivity weights were applied as those developed during the WSP macro planning process when specific weights were linked to the flow sensitivity of in-stream dependent threatened species, populations and communities (NSW Office of Water 2010; DIPNR 2005).

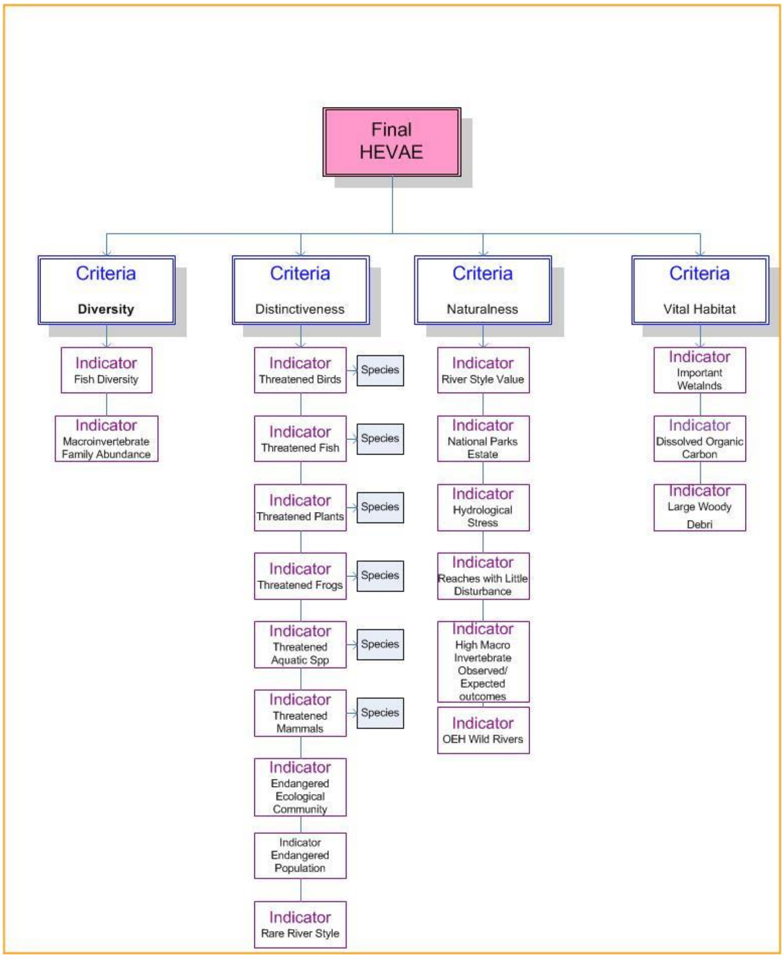


Figure 6-4 HEVAE criteria and associated attributes used to assign an instream ecological value

6.2.2.1. Consequence decision tree

Similar to the approach for GDEs, a decision tree was used to consider the impact of extraction pressure on instream ecological assets and functions. The decision tree prioritised Ramsar habitat. Non-Ramsar high and very high value reaches were ranked according to whether they were upstream or downstream of extraction, and whether freshwater-dependent fauna and flora occurred in the assessment area. The rationale for each bifurcation are provided in Appendix E of this document. The HEVAE consequence scores are shown in Table 6-5, Figure 6-5.

For the resource units within the NSW MDB Porous Rock, instream ecological values supported by groundwater derived base flows were largely medium with a nil result for Oaklands Basin to reflect the disconnected nature of the resource. The HEVAE consequence score range (very high to very low) was converted to low, medium and high consequence categories and presented as the metric 'HEVAE consequence score for instream ecological values' in Table 6-5.

6.2.2.2. Consequence ranking for instream ecological values

The consequence of impacts on instream ecological values is described using the:

- HEVAE consequence scoring framework for instream values
- level of connectivity between the groundwater source and surface waters.

The logic of these metrics is that the higher the level of connectivity with a surface water source, the greater the potential impact on instream values from groundwater extraction. If there is high surface water-groundwater connectivity, any change to groundwater extraction is likely to result in an impact on the condition of instream values.

In NSW, groundwater sources are considered as potentially highly connected if the:

- water table is sufficiently shallow for the aquifer to be hydraulically connected to the river/creek bed, either as a losing or gaining stream
- average saturated thickness of the aquifer is no more than 30 m
- average width of the alluvial aquifer is no more than 4 km (DPI Water 2015).

For the purposes of groundwater management consideration is also given to whether the river system is regulated or unregulated. Three categories of river reaches were determined for management of highly connected alluvial groundwater systems:

- regulated river reaches are managed as highly connected systems
- unregulated perennial reaches which have permanent or persistent flow are also managed as highly connected systems
- unregulated non-perennial reaches are managed as less highly connected systems.

The Western Porous Rock, Gunnedah-Oxley Basin MDB, and Sydney Basin MDB resource units are considered to have low levels of hydraulic connection to overlying surface waters with no connection for the Oaklands Basin (Table 6-5). All LTAAELs / SDLs set for groundwater sources within the Basin in NSW are based on the previous levels of extraction that occurred prior to the commencement of the relevant WSPs. These levels of groundwater pumping are considered to have acceptable impacts on surface water sources (DPI Water 2015).

Consequence metrics and results are shown in Table 6-5 with HEVAE derived instream ecological value mapped in Figure 6-5. Consequence rankings for the NSW MDB Porous Rock are provided in Table 6-6 and are as follows:

- nil in the Oaklands Basin
- low in the Western Porous Rock and Gunnedah-Oxley Basin MDB
- medium in the Sydney Basin MDB.

Refer to section 3.3.2 for further information regarding level of connectivity and resource management approach.

Table 6-5 Consequence metrics and results and results in the NSW MDB Porous Rock (instream ecological value)

Metric	Metric Category	Metric category definition	SDL resource unit results
HEVAE consequence score for instream ecological values [1]	Nil	Not determined due to disconnected nature of SDL resource unit	Oaklands Basin
	Low	Low, very low instream ecological values HEVAE score	
	Medium	Medium instream ecological values HEVAE score	Western Porous Rock Gunnedah-Oxley Basin MDB Sydney Basin MDB
	High	High, very high instream ecological values HEVAE score	
Level of surface water – groundwater connection	Nil	No surface water connectivity	Oaklands Basin
	Low	Not highly connected	Western Porous Rock Gunnedah-Oxley Basin MDB Sydney Basin MDB
	Medium	Less highly connected Unregulated non-perennial	
	High	Highly connected Regulated and unregulated perennial	

Data source: [1] HEVAE scoring framework for instream ecological values (Healey et al. 2018)

[2] As defined in DPI Water 2015

Table 6-6 Consequence matrix and rankings in the NSW MDB Porous Rock (instream ecological value)

		Level of surface water-groundwater connectivity			
		No surface water connectivity	**Not highly connected**	**Less highly connected**	**Highly connected**
HEVAE consequence score	**Not determined**	Nil Oaklands Basin	Nil	Nil	Nil
	Very low / low	Nil	Low	Low	Medium
	Medium	Nil	Low Western Porous Rock, Sydney Basin MDB, Gunnedah-Oxley Basin MDB	Medium	High
	High / very high	Nil	Medium	High	High

SDL resource unit	Consequence Ranking
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Medium
Gunnedah-Oxley Basin MDB	Low

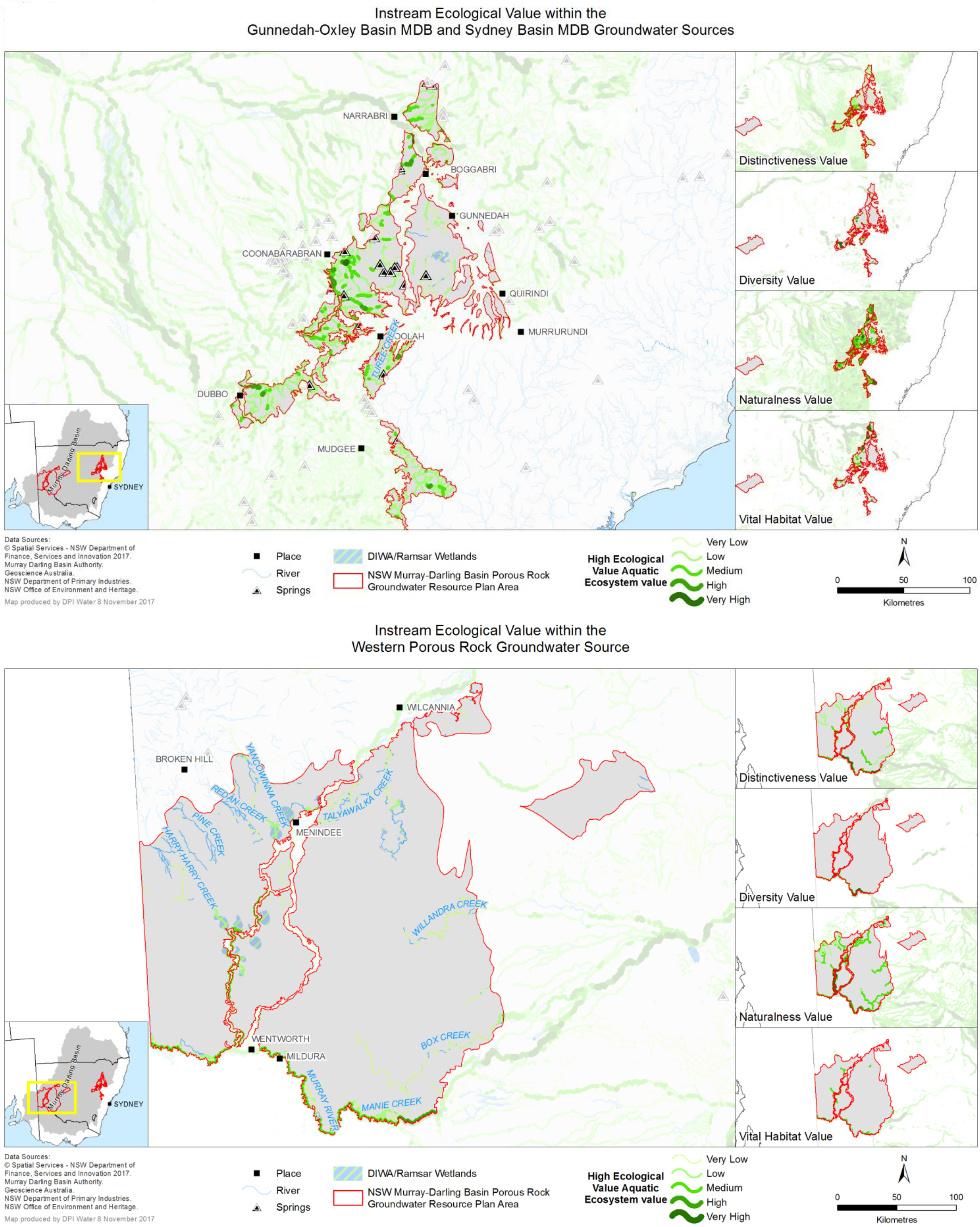


Figure 6-5 Instream ecological value in the NSW MDB Porous Rock

6.2.3. Confidence in data

The confidence in the data used for the environmental consequence matrices is high according to the criteria in Table 2-, as the assessments are based on numerical models with a high degree of certainty. The data is applicable to the specific groundwater sources and the scale of assessment. The HEVAE approach is based on a nationally accepted framework with sound evidence to support the metrics and weightings used and has been considered a “best practice” approach to identifying environmental assets (Murray-Darling Basin Authority 2014).

The following sections describe the analysis of the likelihood of causes and threats occurring. The likelihood rankings then feed into the overall risk determination.

6.3. Risk of groundwater extraction causing local drawdown (R9, R10)

The pathway for impacts associated with local drawdown reducing groundwater availability is through lower groundwater levels than current, reducing access by GDEs or reducing discharge to connected streams (the threat). This may result in the reduction of health of GDEs or instream ecological values (the impact) in areas of local drawdown. The impact pathways for the environment are shown in Figure 6-6.

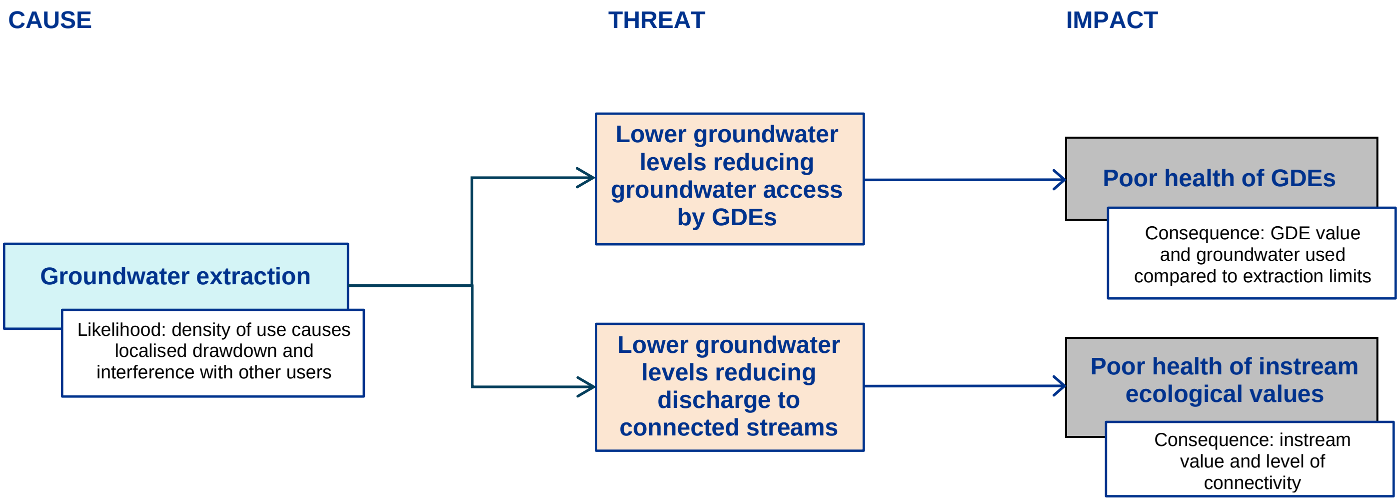


Figure 6-6 Impact pathway for risk of local groundwater drawdown reducing water levels and impacting access by the environment

6.3.1. Determining the likelihood of the impact occurring

The likelihood of groundwater extraction causing local drawdown in the NSW MDB Porous Rock WRP area, which may then impact access by the environment, is described in more detail in section 4.5.

The likelihood metrics and rankings are provided below (Table 6-7; Table 6-8). Likelihood rankings are as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB
- medium in the Western Porous Rock
- high in the Gunnedah-Oxley Basin MDB.

Table 6-7 Likelihood metrics and results in the NSW MDB Porous Rock (groundwater extraction density)

Likelihood metric	Metric category	Category definition	SDL resource unit results [1]
Groundwater extraction density score	Nil	No aquifer access licences	Oaklands Basin
	Low	Groundwater extraction density score < 14,168 (i.e. <30th percentile of extraction density for all NSW MDB metered bores)	Sydney Basin MDB = 7,026
	Medium	Groundwater extraction density score 14,168 – 72,072 (i.e. 30th – 70th percentile of extraction density for all NSW MDB metered bores)	Western Porous Rock = 48,750
	High	Groundwater extraction density score > 72,072 (i.e. >70th percentile of extraction density for all NSW MDB metered bores)	Gunnedah-Oxley Basin MDB = 94,522

Data source: [1]Groundwater extraction density mapping based on data from NSW Department of Planning and Environment Groundwater Data System (2017)

Table 6-8 Likelihood matrix and rankings for the NSW MDB Porous Rock (groundwater extraction density)

Groundwater extraction density score		
	No aquifer access licences	Nil Oaklands Basin
	Low density (<14,168)	Low Sydney Basin MDB
	Moderate density (14,168 – 72,072)	Medium Western Porous Rock
	High density (>68,600)	High Gunnedah-Oxley Basin MDB

SDL resource unit	Likelihood ranking
Oaklands Basin	Nil
Western Porous Rock	Medium
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	High

6.3.2. Confidence in data

This assessment has been undertaken with reference to data produced by Department of Planning and Environment on metered groundwater extraction by licence holders. Production bore locations are identified throughout NSW, and licensed groundwater extraction is metered in to an accuracy that is more than sufficient for this assessment. The confidence in the data used for the likelihood metrics is therefore high according to the criteria in Table 2-5 for the Western Porous Rock and Gunnedah–Oxley Basin where extraction data is available.

As there are no aquifer access licence holders in the Oaklands Basin there are no production bores and therefore no extraction data. Confidence in the nil rating is high as access licences are managed through rigorous departmental processes.

Licensed groundwater extraction is not metered in the Sydney Basin MDB and groundwater extraction has been estimated for the Sydney Basin MDB. The confidence in the data used for the likelihood metrics is therefore medium for this resource unit.

6.3.3. Existing water management actions and mechanisms

It is recognised that any potential consequences to individual GDEs from groundwater extraction should be assessed at a local or asset scale to properly quantity the level of risk and consider all contributing factors. Refer to Schedule I of the NSW MDB Porous Rock WRP for further information on the application of the following actions and mechanisms.

6.3.3.1. Environmental water

In NSW, water is reserved for the environment in groundwater sources as planned environmental water in water sharing plans via at least two of the following ways (these are consistent with section 6 of the *Water Act 2007* and *Position Statement 3A Determining Planned Environmental Water*, also see the NSW MDB Porous Rock WRP for formal identification of environmental water) by reference to the:

- commitment of the physical presence of water in the water source
- long-term average annual commitment of water as planned environmental water
- water that is not committed after basic landholder rights (BLR) and for sharing and extraction under any other rights have been met.

At the time of writing, there was no held environmental water (HEW) in the NSW MDB Porous Rock WRP area. Further description of environmental water is contained in section 4 of the NSW MDB Porous Rock WRP.

6.3.3.2. Groundwater–dependent ecosystems

There are various rules and arrangements in place in groundwater WSPs that relate to planned environmental water and its protection; however there is no discretionary (or physical) ability to direct or use groundwater planned environmental water for the management of groundwater–dependent environmental assets. Instead groundwater–dependent assets are managed through the following protections in water sharing plans, dependent on the asset's ecological value:

- management of extraction to SDL/LTAAEL limits impacts on all GDEs (high priority or otherwise) at the water source scale
- management of potential impacts on High Priority GDEs through a mechanism that incorporates GDEs into WSPs and then provides protection from unacceptable impacts of extraction via setback distances for new bores
- the groundwater trade and new bore assessment process based on both the WMA 2000 and the *Water Management (General) Regulation 2018* considers additional extraction related impacts and may result in additional water supply work approval conditions
- mechanisms to limit potential impacts on GDEs at a local area scale and on a temporary basis where unacceptable drawdown impacts become apparent.

6.3.3.3. Groundwater–dependent instream ecological values

The level of impact on the hydraulic relationships and properties between the groundwater systems and connected surface water systems (and between these groundwater systems and others, and within these groundwater systems) was considered in setting both LTAAELs and the SDLs for these SDL resource units. The management of extraction to these limits will ensure these hydraulic relationships are maintained to the acceptable level of impacts determined during that assessment.

Groundwater access rules also consider connectivity to manage seasonal impacts on surface water flows. In highly connected systems where groundwater pumping could potentially impact on seasonal surface water flows, groundwater access rules are in place. These rules reflect the degree of connectivity and the time lag between extraction and impact and are as follows:

- some groundwater sources have a high degree of hydraulic connection with surface water but the time lag of the impact on the surface water body is greater than one irrigation season, and thus they are defined as 'less highly connected'. For these systems, restricting the daily or annual groundwater access does not correspond to an improved outcome for the surface water flow in that season, so alternate management options (linking of AWDs as described earlier) are applied to address these longer term impacts.
- groundwater sources that are defined as being 'less highly connected' may still have generic rules which recognise there may be some level of connection to surface water. These rules may limit existing

extraction in the immediate vicinity of the surface water or be restricted to the management of new extraction and placement of works.

- alluvial groundwater systems that are highly connected to regulated systems have specific rules that recognise the level of connectivity based on management through linked AWDs. AWDs for aquifer access licences are linked to the AWDs for associated regulated river access licences, recognising that a component of groundwater recharge is derived from the regulated river system.
- alluvial groundwater systems that are highly connected to perennial unregulated systems have specific rules that recognise the level of connectivity based on daily access linking their management to the associated unregulated surface water daily access rules.
- trade between surface and groundwater is prohibited in NSW.

The degree of connectivity and (any) associated rules to manage seasonal impacts on surface water flows have been identified in section 6.2.2.2 of this report, also refer to the NSW MDB Porous Rock WRP sections 2.2, 3, 4.1 and 4.2.

6.3.4. Risk outcomes

6.3.4.1. Groundwater–dependent ecosystems

Combining the likelihood (Table 6-8) and consequence (Table 6-4) rankings provides the overall risk outcomes for local drawdown impacting groundwater access by GDEs (Table 6-9). Risk outcomes are as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB
- medium in the Western Porous Rock
- high in the Gunnedah-Oxley Basin MDB.

Table 6-9 Overall risk outcomes for impacts on groundwater–dependent ecosystems associated with local drawdown in the NSW MDB Porous Rock

		Likelihood		
		Low	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil
	Low	Low Sydney Basin MDB	Low	Medium
	Medium	Low	Medium Western Porous Rock	High Gunnedah-Oxley Basin MDB
	High	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Medium
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	High

6.3.4.2. Instream ecological values

Combining the likelihood (Table 6-8) and consequence (Table 6-6) rankings provides the overall risk outcomes for local drawdown impacting instream ecological values (Table 6-10). Risk outcomes are as follows:

- nil in the Oaklands Basin
- low in the Sydney Basin MDB and Western Porous Rock
- medium in the Gunnedah-Oxley Basin MDB.

Table 6-10 Overall risk outcomes for impacts on instream ecological values associated with local drawdown in the NSW MDB Porous Rock

		Likelihood		
		Low	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil
	Low	Low Sydney Basin MDB	Low Western Porous Rock	Medium Gunnedah-Oxley Basin MDB
	Medium	Low	Medium	High
	High	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Medium

6.4. Risk of growth in plantation forestry intercepting recharge (R11, R12)

Plantation forestry involves the establishment and management of planted forests for environmental purposes and or commercial timber production. The pathway for potential impacts on groundwater resources associated with growth in plantation forestry is the interception of recharge (and rainfall) by plantation trees, which reduces the volume of groundwater available to the environment, as described in Figure 6-7. Plantations may intercept recharge before it reaches the water table, and/or draw water directly from the water table, thereby reducing the quantity of groundwater available for the environment.

The NSW risk assessments for the overlying surface water resource units (listed in Table 3-1) also consider risk from growth in commercial plantations on streamflow and groundwater recharge for two receptors, the environment (all reports section 4.5.2) and other water users (all reports section 8.2.2). These risks are assessed for all overlying regulated and unregulated rivers.

It is assumed that any existing plantations have already affected recharge and therefore groundwater availability, and that this has been allowed for in current management arrangements and in determining the sustainable diversion limit. Therefore, the risk focuses on any future changes in plantations that may further reduce groundwater availability for the environment.

Likelihood can be conceptualised as the predicted increase in plantation forestry as a proportion of the land area that overlies and provides direct recharge to the WRP aquifers, and the land area that provides runoff and through flow to the WRP aquifers (i.e. the growth in plantation forestry area as a percentage of overall catchment area). The likelihood conceptualisation and metrics are discussed in more detail below and in section 5.7.1.

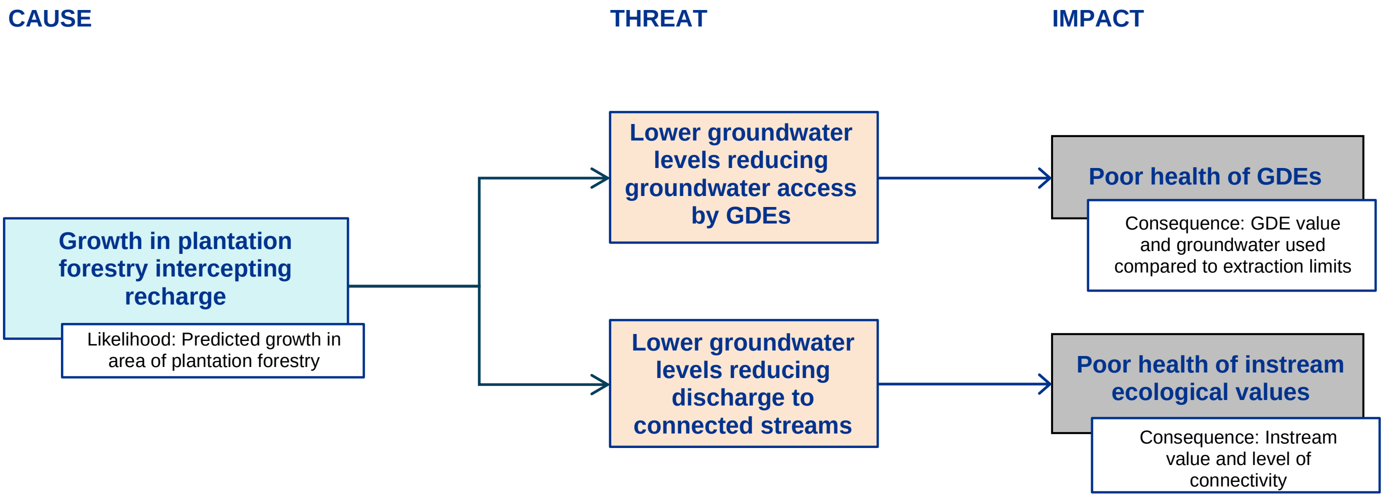


Figure 6-7 Impact pathway for risk of growth in plantation forestry intercepting recharge and reducing groundwater availability for the environment

6.4.1. Determining the likelihood of the impact occurring

The likelihood metrics are discussed in more detail in section 5.7. The metrics applied assume that recharge occurs evenly over the whole WRP and surrounding catchment area, such that the proportion of growth of plantation area relates linearly to the proportion of reduction in groundwater recharge.

Refer to section 5.7.1 for discussion of the limitations of this approach. The likelihood metrics and rankings are provided below (Table 6-11; Table 6-12), likelihood rankings are nil in all resource units.

Table 6-11 Likelihood metrics and results for the NSW MDB Porous Rock (growth in plantation forestry)

Likelihood metric	Metric category	Category definition	SDL resource unit results [1]
Growth in plantation forestry area	Nil	No predicted growth in plantation forestry area / Resource units located at a considerable distance from areas of predicted plantation forestry growth	All (0%)
	Low	Predicted growth 1 - 10% of catchment area	
	Medium	Predicted growth 10 - 30% of catchment area	
	High	Predicted growth > 30% of catchment area	

Data source: [1]CSIRO 2008

Table 6-12 Likelihood matrix and rankings for the NSW MDB Porous Rock (growth in plantation forestry)

Predicted growth in plantation area as % of SDL resource unit area		
	0%	Nil Oaklands Basin MDB Western Porous Rock Sydney Basin MDB Gunnedah-Oxley Basin MDB
	1 - 10%	Low
	10 - 30%	Medium
	>30%	High

SDL resource unit	Likelihood ranking
Oaklands Basin MDB	Nil
Western Porous Rock	Nil
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Nil

6.4.2. Confidence in data

This assessment has been undertaken with consideration to the processes of:

- rainfall and recharge interception by terrestrial vegetation
- uptake of groundwater by terrestrial vegetation.

The assessment also references information on potential plantation increase within the NSW MDB Porous Rock WRP area. Confidence in the data used to predict growth in plantation area is low according to the criteria in Table 2-5, as the modelled predictions have high uncertainty. Also, the assumption that a growth in plantation size will result in the same percentage reduction in recharge introduces uncertainty, as the area where plantations occur in the future may not be significant recharge areas, and therefore recharge may not be significantly impacted. The metric is conservative however, and therefore results are likely to over-estimate the impact particularly when predicted annual average runoff impacts, plantation forestry location and infiltration rates are considered.

6.4.3. Existing water management actions and mechanisms

Plantation establishment and forestry operations on both Crown Land (including state forests) and freehold land are regulated by the *Plantations and Reafforestation Act 1999* (NSW) (PRA), and the *Plantations and Reafforestation Regulation (Code) 2001*. The regulation establishes buffer zones around rivers, wetlands and drainage lines or depressions and manages runoff to prevent stream degradation. These measures contribute to the protection of stream derived recharge and wetlands dependent on groundwater. The Department of Primary Industries' Forestry Division has responsibility for authorising plantations, and for auditing plantation establishment and forest operations for compliance. A NSW Commercial Plantations Policy is in development and is expected to address potential forestry impacts on ground and surface waters.

Compliance with the PRA is considered to be high as it provides a basis for legal harvesting. The PRA and regulations exclude the consideration of water impacts from the assessment process. However, scope for amending the PRA will be considered as part of the NSW response to its interception obligations under the NWI and COAG Water Reform agenda. For information regarding the process of applying actions and mechanisms refer to Table I-3 (issues column, other users) in Schedule I of the NSW MDB Porous Rock WRP.

6.4.4. Risk outcomes

6.4.4.1. Groundwater–dependent ecosystems

Combining the likelihood (Table 6-12) and consequence rankings (Table 6-4) provides the overall risk outcomes for growth in plantation forest impacting groundwater access by GDEs. Risk outcomes for all resource units are nil. As there is no predicted increase in plantation area, there is no potential for any additional impacts to occur (Table 6-13).

Table 6-13 Overall risk outcomes for impacts on groundwater–dependent ecosystems associated with growth in plantation forestry in the NSW MDB Porous Rock

		Likelihood			
		Nil	Low	Medium	High
Consequence	Nil	Nil Oaklands Basin	Nil	Nil	Nil
Consequence	Low	Nil Sydney Basin MDB	Low	Low	Medium
Consequence	Medium	Nil Western Porous Rock, Gunnedah-Oxley Basin MDB	Low	Medium	High
Consequence	High	Nil	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Nil
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Nil

6.4.4.2. Instream ecological values

Combining the likelihood (Table 6-12) and consequence rankings (Table 6-6) provides the overall risk outcomes for growth in plantation forest impacting groundwater access by instream ecological values. Risk outcomes for all resource units are nil. As there is no predicted increase in plantation area, there is no potential for any additional impacts to occur (Table 6-14).

Table 6-14 Overall risk outcomes for impacts on instream ecological values associated with growth in plantation forestry in the NSW MDB Porous Rock

		Likelihood			
		Nil	**Low**	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil	Nil
	Low	Nil Western Porous Rock, Sydney Basin MDB, Gunnedah-Oxley Basin MDB	Low	Low	Medium
	Medium	Nil	Low	Medium	High
	High	Nil	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Nil
Sydney Basin MDB	Nil
Gunnedah-Oxley Basin MDB	Nil

6.5. Risk of climate change reducing recharge and groundwater availability (R13, R14)

The pathway for impact is climate change causing reduced rainfall and runoff, changed timing of rainfall and increased evapotranspiration that contribute to reducing recharge and groundwater availability.

Recharge to the NSW MDB Porous Rock occurs primarily through infiltration from rainfall, runoff and surface water within the outcropping areas. However, inflow can also occur from downward percolation of groundwater from overlying permeable strata that coincides with layers of the sedimentary sequences that have sufficient permeability for groundwater exchange to occur. The exception is the Oaklands Basin for which the aquifers do not outcrop and hence there is no direct recharge from rainfall or interaction with surface water features. Reduced rainfall, changed timing of rainfall and increased evapotranspiration can reduce both runoff to rivers and streams, and direct infiltration into the alluvium. Lower infiltration and groundwater recharge caused by climate change may reduce groundwater availability for environment. This impact pathway is shown in Figure 6-8.

Likelihood can be conceptualised as the predicted potential for climate change to cause sufficiently reduced rainfall, changed timing of rainfall, and increased evapotranspiration, which can reduce recharge to the groundwater systems.

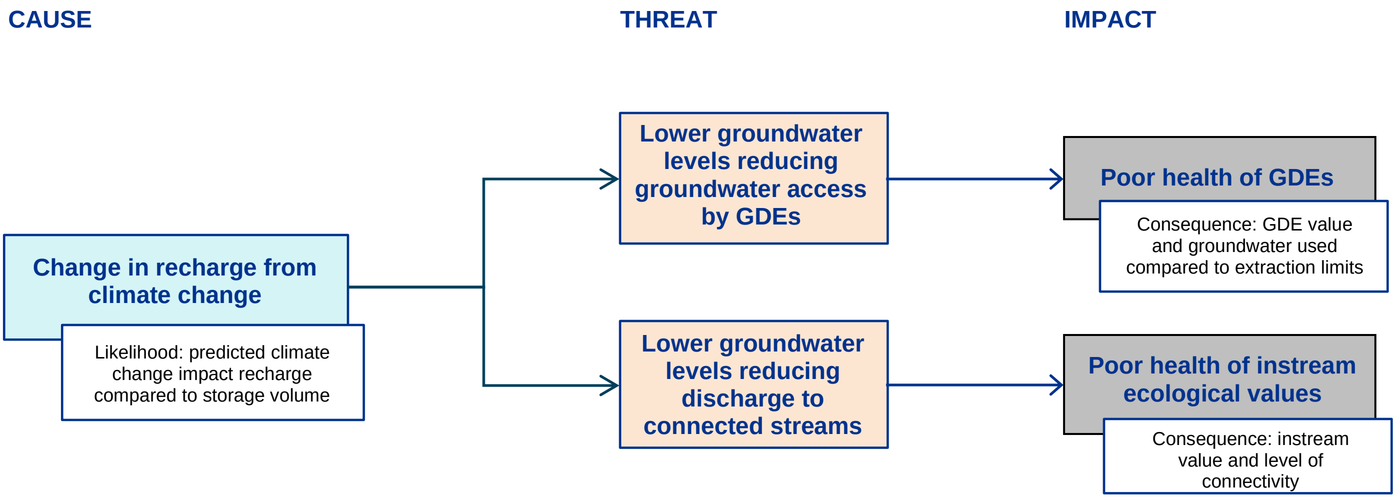


Figure 6-8 Impact pathway for risk of climate change reducing recharge and groundwater availability impacting the environment

6.5.1. Determining the likelihood of the impact occurring

The likelihood metrics are discussed in more detail in section 5.3. The likelihood metrics and rankings are provided below (Table 6-15; Table 6-16). Likelihood rankings are low in all resource units.

Table 6-15 Likelihood metrics and results for the NSW MDB Porous Rock (climate change impacting the productive base of a groundwater system)

Likelihood metric[1]	Metric category	Category definition[1]	SDL resource unit results [1]
Productive base of aquifer measured by Storage/Recharge ratio (S/R)	Low	High S/R value (i.e. greater than 40)	Sydney Basin MDB Western Porous Rock MDB Gunnedah-Oxley Basin MDB Oaklands Basin (does not receive recharge directly from rainfall or surface water features)
	Medium	Medium S/R value (i.e. between 20 and 40)	
	High	Low S/R value (i.e. less than 20)	

Data source: [1]CSIRO and SKM 2010

Table 6-16 Likelihood matrix and rankings for the NSW MDB Porous Rock (climate change impacting the productive base of a groundwater system)

Predicted change in storage/recharge ratio		
	S:R >40	Low All
	S:R 20 - 40	Medium
	S:R <20	High

SDL resource unit	Likelihood ranking
Oaklands Basin	Low
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Low

6.5.2. Confidence in data

This assessment has been undertaken with consideration to the best available information on storage volumes and current average annual recharge. A limitation of the data and information used is the moderate confidence in the storage and recharge data according to the criteria in Table 2-5, as estimating these metrics at an SDL resource unit scale incurs some uncertainty. The metrics are an approximation of the productive base of the groundwater system, and as such, their applicability is moderate. As discussed in 5.3.1, no recharge data is available for the Oaklands Basin and a conservative medium ranking has been applied. Confidence in this ranking is low.

6.5.3. Existing water management actions and mechanisms

The WSPs for NSW MDB groundwater systems were developed in consultation with community stakeholders, and are applicable for 10 year periods. The WSPs recognise the effects of climate variability on groundwater levels by including provisions that manage the sharing of water within the limits of water availability on a long term average annual basis. Part 4 of Chapter 7 of the Basin Plan allows SDLs for groundwater SDL resource units to be adjusted by up to 5% to reflect new or improved information about the groundwater resources, including improved information on climate change impacts. For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

6.5.4. Risk outcomes

6.5.4.1. Groundwater–dependent ecosystems

Combining the likelihood (Table 6-16) and consequence (Table 6-4) rankings provides the overall risk outcomes for climate change reducing recharge and impacting groundwater access by GDEs as shown in Table 6-17. Risk outcomes are as follows:

- nil in the Oaklands Basin
- low in the Western Porous Rock, Sydney Basin MDB and Gunnedah-Oxley Basin MDB.

Table 6-17 Overall risk outcomes for impacts on groundwater–dependent ecosystems associated with climate change in the NSW MDB Porous Rock

		Likelihood		
		Low	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil
	Low	Low Sydney Basin MDB, Western Porous Rock	Low	Medium
	Medium	Low Gunnedah-Oxley Basin MDB	Medium	High
	High	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Low

6.5.4.2. Instream ecological values

Combining the likelihood (Table 6-16) and consequence (Table 6-6) rankings provides the overall risk outcomes for climate change reducing recharge and impacting instream ecological values as shown in Table 6-18. Risk outcomes are as follows:

- nil in the Oaklands Basin
- low in the Western Porous Rock, Sydney Basin MDB and Gunnedah-Oxley Basin MDB.

Table 6-18 Overall risk outcomes for impacts on instream ecological values associated with climate change in the NSW MDB Porous Rock

		Likelihood		
		Low	**Medium**	**High**
Consequence	**Nil**	Nil Oaklands Basin	Nil	Nil
	Low	Low Western Porous Rock, Sydney Basin MDB, Gunnedah-Oxley Basin MDB	Low	Medium
	Medium	Low	Medium	High
	High	Medium	High	High

SDL resource unit	Risk Outcome
Oaklands Basin	Nil
Western Porous Rock	Low
Sydney Basin MDB	Low
Gunnedah-Oxley Basin MDB	Low

6.6. Risk of poor water quality to the environment (QL5)

Deterioration in water quality can impact the health of GDEs and instream ecological values. The pathway for impacts associated with poor health of groundwater dependent ecosystems and instream ecological values is shown in in Figure 6-9. Exposure to lower quality groundwater (the threat) may be caused by contaminants entering groundwater systems, or induced movement of poor quality water within groundwater systems where the water table is utilised by groundwater–dependent ecosystems.

Risk of groundwater extraction inducing connection with poor quality groundwater and impacting groundwater users is assessed in section 4.4. There, the likelihood metric assessed the decline in recovered groundwater levels using saturated thickness for the resource unit. It is not appropriate to use this metric here as depth to water table determines groundwater use for both GDEs and instream ecological values. Full assessment of the consequence metrics is restricted by a lack of relevant GDE condition assessment data and fundamental information regarding GDE sensitivity to groundwater contaminants and the detection of resultant changes to asset condition.

Terrestrial vegetation GDEs are known to have various tolerances for water quality, particularly salinity. In the Murray–Darling Basin, vegetation communities tend to be dominated by river red gums, black box, river cooba, coolabah and lignum. Each of these species tends to have varying tolerances to salinity. This is also dependent on location in the landscape such as riparian or floodplain and also their flooding frequency requirements. River red gums have been recorded to have a maximum salinity tolerance of 20,000 mg/L (30,000 µS/cm) with a requirement of a flooding event every 1.5 years and are generally located within riparian areas. Black box and river cooba have a higher salinity tolerance. Although not conducive with good plant health, they have been found in areas with salinity of approximately 27,000 mg/L (40,000 µS/cm). They require a flooding event every 3 to 5 years and are generally located in flood plains (Doody and Overton 2009).

GDEs including terrestrial (vegetation), aquatic (wetlands, springs and baseflows) and subterranean (aquifer and karsts) are highly diverse. As a result, assessing risk from poor water quality for all GDEs is problematic. Previous studies have reported that aquatic biota would be adversely affected when salinity exceeds 1,000 mg/L (1,500 µS/cm) (Hancock and Boulton 2008; Nielsen et al. 2003). Groundwater dependent biota are found most commonly in fresh to brackish water, less than 3,350 mg/L or 5,000 µS/cm (Hose et al. 2015), but have also been found in very high electrical conductivities, approaching that of seawater, between 36,300 and 54,800 µS/cm. There may be a range of environmental attributes that influence the distribution of aquatic biota, including habitat, site, water quality (organic carbon, dissolved oxygen, nitrate and ammonia) and climate variables (Korbel 2012).

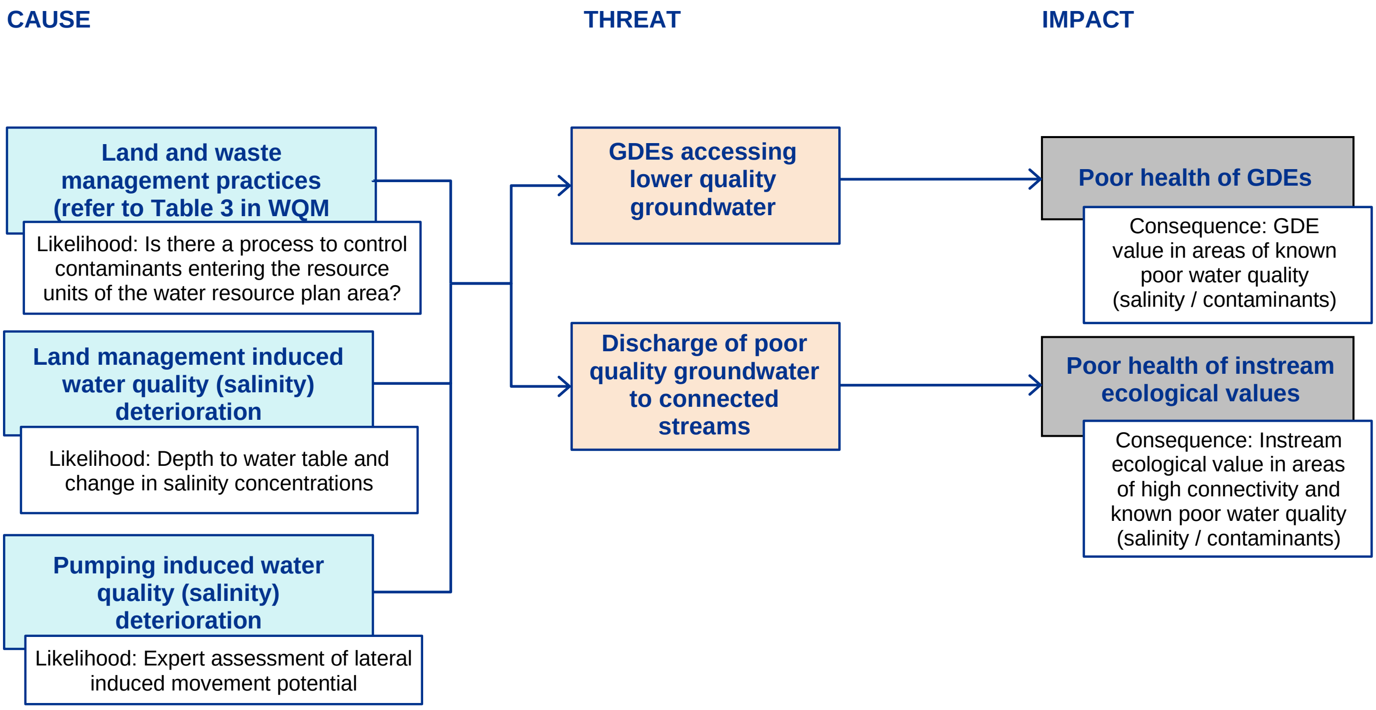


Figure 6-9 Impact pathway for risk of poor water quality impacting the environment

6.6.1. Confidence in data

This is a qualitative assessment based on NSW Department of Planning and Environment groundwater quality specialist expert opinion. As such the risk outcomes have low data confidence according to the criteria in Table 2-5.

6.6.2. Existing water management actions and mechanisms

The WMA 2000 requires that the water quality and water-dependent ecosystems of all water sources should be protected. The Basin Salinity Management Strategy 2030 recognises and addresses the inter-related issues of riverine salinity, water table and land management.

Limiting the total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels ensures a share of the water remains for the environment to protect groundwater quality and hydraulic relationships. Limiting the construction and use of bores within specified distances of high priority GDEs and near rivers reduces the likelihood of induced changes in water quality. For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

See section 4.8.1 for a description of process based controls regarding the entry of contaminants into groundwater systems.

Note for the risk 'land management induced water quality (salinity) deterioration' dryland salinity is a land management issue that cannot be mitigated under a water resource plan. Refer to the Water quality management plan—GW11 NSW Murray Darling Basin Porous Rock Water Resource Plan area tables 6, 8 and 11 for further information.

6.6.3. Risk outcomes

Quantitative assessment of these risks has not been possible due to lack of likelihood and consequence data. These knowledge gaps do not have identified knowledge strategies (see Table 8-6). Salinity targets and other considerations of these risks are discussed in the WQM Plan section 5.

6.6.3.3. Risk outcomes related to the cause 'land and waste management practices'

As discussed in section 4.8.1 a likelihood of low has been assigned for the metric 'Is there a process to control contaminants entering the resource units of the water resource plan area?' to all resource units within the WRP area for both GDEs and instream ecological values. A conservative medium has been applied to the consequence metric GDEs and instream ecological values for all resource units with the exception of the Oaklands Basin for both receptors. This resource unit is considered disconnected as indicated in Table 6-6 and nil has been applied. Although HEVAE metrics have been examined with respect to extraction demand in other sections of this report, an assessment has not been made for these risk receptors in areas where contamination is known to occur and a conservative middle ground as described in section 2-4 has been used.

It is noted the ideal consequence metric would be an assessment of the change in condition of GDEs or instream ecological values where this is associated with salinity or a particular contaminant.

The combination of consequence and likelihood metrics has provided the risk outcomes shown in Table 6-19. Risk outcomes are as follows:

- nil – QAL in the Oaklands Basin for GDEs and instream ecological values
- low – QAL in the Western Porous Rock, Sydney Basin MDB and Gunnedah-Oxley Basin MDB for GDEs and instream ecological values.

6.6.3.4. Risk outcomes related to the cause 'land management induced water quality (salinity) deterioration'

For the NSW MDB Porous Rock, an increase in groundwater salinity in the unconfined (i.e. water table) portion of the groundwater system on which terrestrial vegetation is dependent could conceptually occur from evaporation direct from the water table, lateral groundwater flow from adjacent areas of higher salinity groundwater or from an increase in the vertical flux from underlying aquifers of higher salinity.

An increase in recharge to the groundwater system that is not matched by an increase in discharge can result in the water table rising to be within the depth that salinity may increase due to evaporative processes. Higher recharge rates can also result in higher potentiometric head in the deeper aquifers.

As discussed in section 6.6.3.3 a conservative medium has been applied to the consequence metric for both GDEs and instream ecological values in all resource units with the exception of the Oaklands Basin where nil has been applied. The nil ranking is appropriate due to the disconnected nature of the resource unit.

A likelihood of medium has been applied to the Gunnedah-Oxley Basin MDB and Sydney Basin MDB for GDEs and instream ecological values units as these areas have a history of land management induced water quality (salinity) deterioration (dryland salinity). A likelihood of low has been applied for both GDEs and instream ecological values in the Western Porous Rock. A likelihood of nil has been applied for both GDEs and instream ecological values in the Oaklands Basin.

The combination of consequence and likelihood metrics has provided the risk outcomes shown in Table 6-19. Risk outcomes are as follows:

- nil – QAL in the Oaklands Basin for GDEs and instream ecological values
- low – QAL in the Western Porous Rock for GDEs and instream ecological values
- medium – QAL in the Gunnedah-Oxley Basin MDB and Sydney Basin MDB for GDEs and instream ecological values.

6.6.3.5. Risk outcomes related to the cause 'pumping induced water quality (salinity) deterioration'

The risk of increase in salinity of the unconfined aquifer from pumping is low. Being unconfined, pumping drawdown impacts are significantly smaller in the water table aquifer compared to the confined or semi-confined portion of these groundwater systems. The limited available pumping drawdown of a shallow water table aquifer also limits the volume that is able to be pumped. Consequently the potential to change salinity of the water table aquifer from inducing groundwater flow laterally is limited due to the limited pumping influence in an unconfined aquifer. Low permeability of the resource units also limits pumping influence.

As discussed in section 6.6.3.3 a conservative medium has been applied to the consequence metric for both GDEs and instream ecological values in all resource units with the exception of the Oaklands Basin where nil has been applied. The nil ranking is appropriate due to the disconnected nature of the resource unit. A likelihood of low has been applied to all resource units and both GDEs and instream ecological values within the WRP area. The combination of consequence and likelihood metrics has provided the risk outcomes shown in Table 6-19. Risk outcomes are as follows:

- nil – QAL in the Oaklands Basin for GDEs and instream ecological values
- low – QAL in the Western Porous Rock, Gunnedah-Oxley Basin MDB and Sydney Basin MDB for GDEs and instream ecological values

Table 6-19 Overall risk outcomes for impact on the environment from poor quality groundwater in the NSW MDB Porous Rock

		Likelihood (QAL)			
		Nil	**Low**	**Medium**	**High**
Consequence	**Nil**	Nil – QAL **Land management induced water quality (salinity) deterioration** Oaklands Basin (GDEs and IEV)	Nil – QA **Land and waste management practices** Oaklands Basin (GDEs and IEV) **Pumping induced water quality (salinity) deterioration** Oaklands Basin (GDEs and IEV)	Nil – QAL	Nil – QAL
	Low	Nil – QAL	Low – QAL	Low – QAL	Medium – QAL
	Medium (conservative)	Nil – QAL	Low – QAL **Land and waste management practices** Sydney Basin MDB (GDEs and IEV) Western Porous Rock (GDE and IEV) Gunnedah-Oxley Basin MDB (GDE and IEV) **Pumping induced water quality (salinity) deterioration** Sydney Basin MDB (GDEs and IEV) Western Porous Rock (GDE and IEV) Gunnedah-Oxley Basin MDB (GDE and IEV) **Land management induced water quality (salinity) deterioration** Western Porous Rock (GDE and IEV)	Medium – QAL **Land management induced water quality (salinity) deterioration** Sydney Basin MDB (GDEs and IEV) Gunnedah-Oxley Basin MDB (GDE and IEV)	High – QAL
	High	Nil – QAL	Medium – QAL	High – QAL	High – QAL

SDL resource unit	**Risk outcomes**					
	Land and waste management practices		**Land management induced water quality (salinity) deterioration**		**Pumping induced water quality (salinity) deterioration**	
	GDEs	Instream Ecological Values (IEV)	GDEs	Instream Ecological Values (IEV)	GDEs	Instream Ecological Values (IEV)
Western Porous Rock	Low – QAL	Low – QAL	Low – QAL	Low – QAL	Low – QAL	Low – QAL
Oaklands Basin	Nil – QAL	Nil – QAL	Nil – QAL	Nil – QAL	Nil – QAL	Nil – QAL
Sydney Basin MDB	Low – QAL	Low – QAL	Medium – QAL	Medium – QAL	Low – QAL	Low – QAL
Gunnedah-Oxley Basin MDB	Low – QAL	Low – QAL	Medium – QAL	Medium – QAL	Low – QAL	Low – QAL

6.7. Risk of growth in basic landholder rights and local water utilities to the environment (QL6)

This section considers the potential for impacts on GDEs and instream ecological values from a growth in groundwater extraction for basic landholder rights and local water utilities. The approach taken in this document is to assess the risk with groundwater management in place. While a conceptual pathway for potential impacts to occur can be identified (Figure 6-10), in practice the NSW approach to management of all extraction within LTAAEL and SDL precludes the occurrence of impacts with the result there is no pathway for the risk to occur. To reflect this, a risk outcome of nil has been applied to all resource units. For assessment of the potential risk to AALs from growth in BLR and LWU extraction refer to sections 5.4 and 5.5.

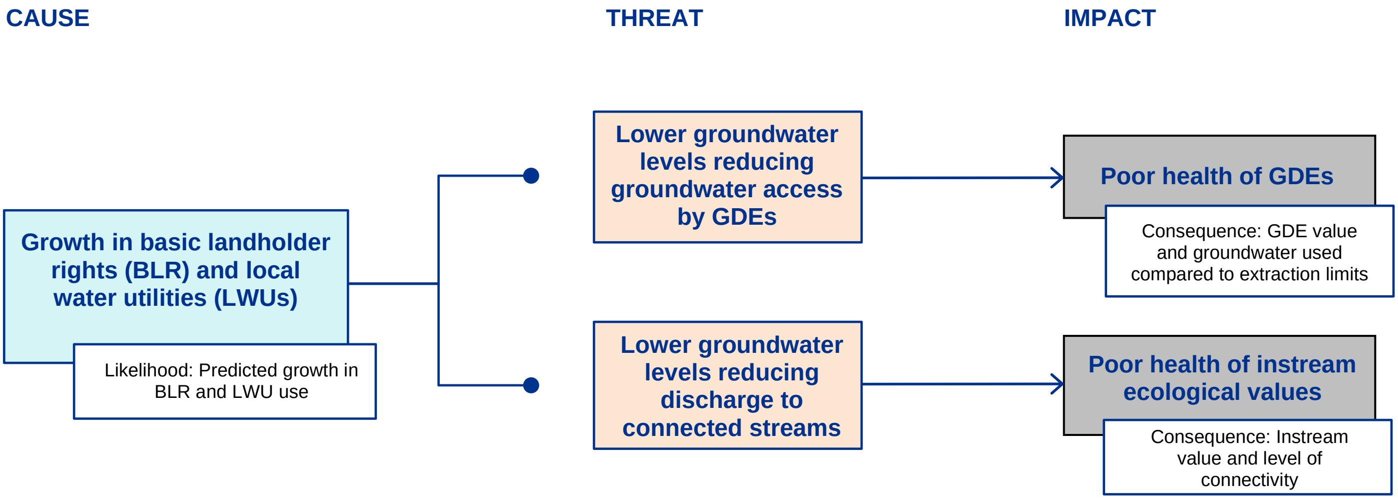


Figure 6-10 Impact pathway for risk of growth in basic landholder rights and local water utilities impacting the environment

6.7.1. Confidence in data

This is a qualitative assessment based on NSW Department of Planning and Environment – Water groundwater specialist expert opinion. As such the risk outcomes have low data according to the criteria in Table 2-5.

6.7.2. Existing water management actions and mechanisms

Existing water management actions and mechanisms are described in sections 5.4.3 and 5.5.3.

6.7.3. Risk outcomes

All resource units have been assigned an outcome of nil – QAL as there is no pathway for environmental impact to occur (Table 6-20). Growth in BLR or LWU extraction is accounted for within the SDL and the AWD mechanism ensures the average annual extraction is managed to the water sharing plan extraction limit.

Table 6-20 Overall risk outcomes for impact on the environment associated with growth in basic landholder rights and local water utilities in the NSW MDB Porous Rock

SDL resource unit	Risk Outcome
Western Porous Rock	Nil – QAL
Oaklands Basin	Nil – QAL
Sydney Basin MDB	Nil – QAL
Gunnedah-Oxley Basin MDB	Nil – QAL

6.8. Risk of growth in mining reducing groundwater availability (groundwater–dependent ecosystems and instream ecological values) (QL7)

This section considers the potential for impacts from growth in mining reducing groundwater availability and reducing the availability of groundwater for GDEs and instream ecological values. Current mining activities are described in section 5.8.

Aquifer interference activities such as mining may take water from the water source in which they exist as well as connected groundwater and surface water sources. Even where there is no take of water, mining can still affect the functioning of aquifers which can impact water users and dependent ecosystems.

The approach taken in this document is to assess risk at a resource unit scale with groundwater management in place. While a conceptual pathway for potential impacts to occur can be identified (Figure 6-11), in practice the NSW approach is to require all volumetric impacts to be accounted for by licence under the extraction limit of the relevant water sources. Any increase in take or reduction in recharge through growth in mining related activities would require an access licence to be held by the proponent to account for this volume.

With regard to current risks from licensed take associated with mining activities impacting GDEs or instream ecological values this is incorporated into all risks associated with groundwater take (i.e. risks R9 and R10 (section 6.3).However it is recognised this approach does not identify the potential for growth in mining related interception.

The Australian Government's Bioregional Assessments are independent, scientific assessments of the potential cumulative impacts of coal and unconventional gas developments on the environment, including water-dependent ecosystem and social and economic impacts. The assessments target regions with significant coal deposits and focus on those regions that are subject to significant existing or anticipated mining activity and on those areas identified by governments through the National Partnership Agreement on Coal Seam Gas and Large Coal Mining Development.

The Sydney Basin and the Northern Inland Catchments bioregions have undergone assessment by the Bioregional Assessments program. The Sydney Basin MDB resource unit is within the western coalfields of the Sydney Basin bioregion and the Gunnedah-Oxley Basin MDB is within the Northern Inland Catchments bioregion. These regions contains substantial coal and coal seam gas-bearing geological sequences. The Namoi subregion of the Northern Inlands Catchments bioregion and the Sydney Basin have active coal mines. Detailed regional modelling was not completed for the Sydney Basin bioregion. The coal seam gas potential of the Western Coalfields is low.

The Oaklands Basin is not within a bioregion identified in the Bioregional Assessments Program but does contain substantial coal reserves. Given the resource unit lies below the Murray Alluvium and Murrumbidgee

Alluvium shallow and deep resource units there is no foreseeable development within the terms of the relevant alluvial WSPs. The Western Porous Rock resource unit is not within a bioregion identified in the Bioregional Assessments Program but does contains mineral sand mines in operation near Pooncarie (Senior 2019).

See section 5.8 for further consideration of Bioregional Assessments in relation to the NSW MDB Porous Rock WRP area.

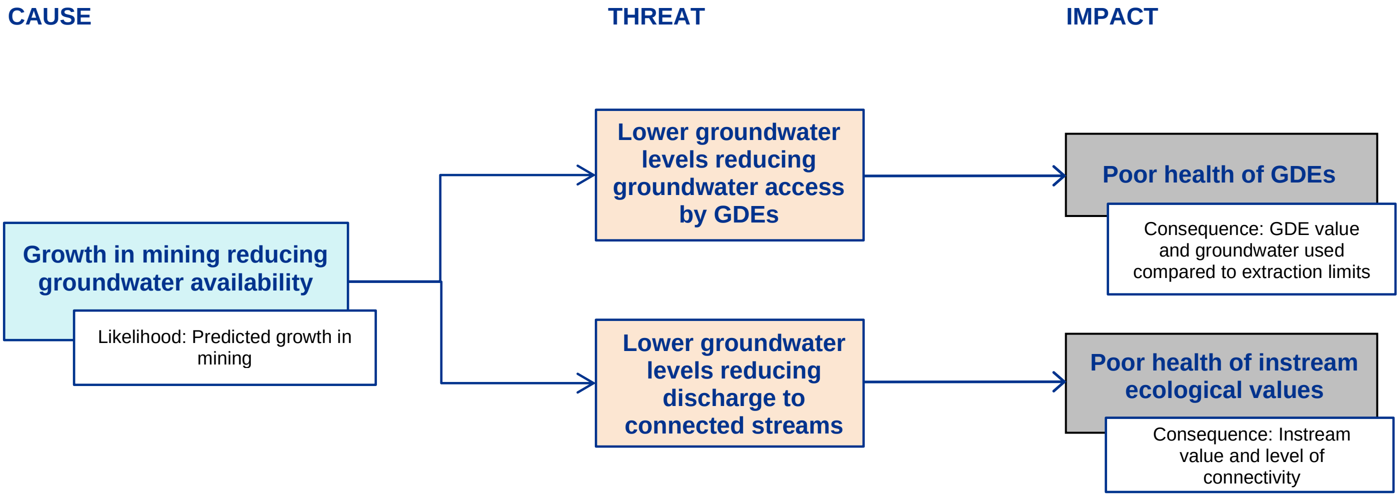


Figure 6-11 Impact pathway for risk of growth in mining reducing groundwater availability impacting the environment

6.8.1. Confidence in data

This assessment does not calculate risk, but relies on the findings of an independent assessment of the potential for growth in coal seam gas and coal to provide a risk outcome. As such the potential for growth in all mining activities is not addressed and therefore the risk outcomes have moderate data confidence according to the criteria in Table 2-5

6.8.2. Existing water management actions and mechanisms

Refer to section 5.8.2 for discussion of relevant mechanisms related to the management of mining and coal seam gas activities in NSW. Additional GDE and instream ecological value mechanisms can be found in section 6.3.3 inclusive of sections. . For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

6.8.3. Risk outcomes

The Namoi, Gwydir, Border Rivers and Macquarie Castlereagh valleys have been included in the three NSW subregions of the Northern Inland Catchments bioregion that have undergone assessment by the Bioregional Assessments program. Within the Gwydir (incorporating the NSW Border Rivers) and Central West subregions there is limited potential for additional coal resource development and resultant impacts on the environment. For subsurface groundwater features, the Gunnedah-Oxley Basin MDB was identified in a group of 20 water dependent assets within the zone of potential hydrological change in the Namoi subregion. Across this subregion 102 groundwater–dependent ecosystems identified in the National Atlas of Groundwater Dependent Ecosystems (Bureau of Meteorology, 2012) were identified as within the zone of potential hydrologic change with some of these assets located within the WRP area.

Regarding instream ecological values in the Namoi subregion, regional scale modelling estimated changes in the streamflow of the Namoi River would be minimal (<1% reduction). Modelling of unregulated streams using three hydrological variables (zero-flow, high-flow and annual flow characteristics) within areas of likely impact showed increases in the number of zero-flow days however it is predicted that any effects would be localised as affected catchments are small (<100 km2) (Commonwealth of Australia, 2018b). The findings suggest changes in streamflow may lead to potential impacts on water-dependent floodplain or lowland riverine landscapes including those dependent on groundwater. (Commonwealth of Australia, 2018a).

Risk outcomes are shown in Table 6-21 and are as follows:

- nil in the Oaklands Basin for instream ecological values
- low in the Oaklands Basin for GDEs
- low in the Western Porous Rock, Sydney Basin MDB and Gunnedah-Oxley Basin MDB for GDEs and instream ecological values

Risk outcomes are based on the outcomes of the Bioregional Assessments Program for the growth in mining reducing groundwater availability within the term of the water sharing plan (i.e. the next 10 years). The nil risk outcome for the Oaklands Basin for instream ecological values reflects the disconnected nature of the resource.

These outcomes should be considered in conjunction with the existing water management actions and mechanisms described in section 5.8.2 and section 6.8.2 and in the NSW MDB Porous Rock WRP section 5.6. Refer to section 5.8.3 for explanatory text.

With regard to current risks from licensed take associated with mining activities, this is incorporated into all risks associated with groundwater take (i.e. risks R1 (section 4.3), R2 (section 4.4), R3 (section 4.6), QL1 (section 4.6), QL2 (section 4.7), R9, R10 (section 6.3).

Table 6-21 Overall risk outcomes for impact on the environment associated with growth in mining in the NSW MDB Porous Rock

SDL resource unit	Risk Outcome GDEs	Risk Outcome Instream Ecological Value
Western Porous Rock	Low	Low
Oaklands Basin	Low	Nil
Sydney Basin MDB	Low	Low
Gunnedah-Oxley Basin MDB	Low	Low

7. Risks to other groundwater–dependent values

7.1. Public benefit values

Risks to the availability and suitability of groundwater for public benefit values (i.e. Indigenous social, cultural) as required under 10.41(3)(a) in relation to 4.02(2)(b) of the Basin Plan have not been formally assessed in this document, however regard has been had in the following way:

Groundwater availability and quality is linked to a number of public benefit values. The benefits and values associated with improved ecosystem health, and groundwater as an alternative water source when there is a water shortage, provide for various social, cultural and other public benefit values.

Consideration within the development of the WRP is limited on the basis that current methodologies to assess broader benefits are still under development, and the relationships between groundwater and these values are generally indirect.

Future risk assessments could include an assessment of these risks as further data becomes available. As there is a related requirement in 10.53(1)(f) of the Basin Plan, refer to sections 1.3.1, 1.7 and 4.4 of the NSW MDB Porous Rock WRP for further information relevant to risks to Indigenous values and uses of groundwater.

8. Risk treatment overview

Section 10.43(1) of the Basin Plan requires WRPs to describe water resource management strategies to address medium or high levels of risk or explain why the risk cannot be addressed by the WRP in a manner commensurate with the level of risk. As strategies are not required for risk outcomes that are low, they have not been further considered in the risk treatment overview.

Medium and high risk outcomes were reviewed to determine whether they are adequately addressed by existing strategies, or whether modifications or new strategies may be required. Risk treatment options were developed following a systematic approach outlined in Figure 8-1 and Table 8-1. Defining tolerable risk outcomes (those high or medium results NSW considers are acceptable or adequately managed by existing water resource management strategies) were also part of this approach. Explanations for risk outcomes that the WRP cannot address in a manner commensurate with the level of risk are provided in the consolidated risk table at the start of this document.

As this risk assessment examines risks to water quality, it is relevant to note the relevant WQM Plans include measures to address water quality risks as previously required under section 10.31 of the Basin Plan. Where the WQM Plans identify measures that are contained within the WRP or WSPs, these strategies are also shown in this section. Note this material is included to show linkages between the two documents and the WQM Plans should be referred to in the first instance.

The risk treatment options reflect the complex nature of risk based water resource management and allow for a range of strategies to be identified for inclusion in the water resource plan and applied irrespective of their legislative base or approach. In this way the risk assessment has informed both the review of water sharing plan rules and the development of the water resource plan.

Option A is used when other risk options have been assessed and no further strategies are available, or by default when a risk is defined as tolerable.

Options B and C are used when mitigation is not immediately possible and guide the development of strategies that aim to improve knowledge about the risk or the resource. They allow for instances where there has not been adequate information available to fully assess a risk or to develop or modify an existing mitigation strategy. Although associated strategies cannot directly mitigate risk, they aim to provide sufficient information to enable mitigation strategies to be reassessed or developed under options D to G. Options B and C may be linked to adaptive management strategies that are responsive to information improvements during the term of the WRP or related plan. Additional information on strategies related to these options can be found in the EMER Plan.

Options D to G are used when mitigation is possible and guide the modification or improved implementation of existing, or development of new strategies that mitigate risk through activity control mechanisms. Strategies related to these options may need consideration of impact on other risk outcomes or third parties. This element has been included to reflect Basin Plan and NSW principles for WRP development. These recognise the competing economic, social, cultural, and environmental demands on water resources. Identifying where strategy trade-offs have been applied is particularly important where mitigation strategies may not result in the full mitigation of an identified risk. The pathway allows the likely effects of adjusted or new strategies on risk outcomes to be considered as residual risks. It also enables the acceptance of a high or medium risk outcome as tolerable if predefined criteria are met or following the application of a risk treatment option. The difference between these tolerable risks is discussed in section 8.2.

For detailed information on the application of the options and strategies applied to individual risk outcomes see the consolidated risk table. Note risk outcomes that are low or have been assigned a tolerable status based on predefined criteria are assumed to have adequate strategies in place and have not been further reviewed in this risk assessment.

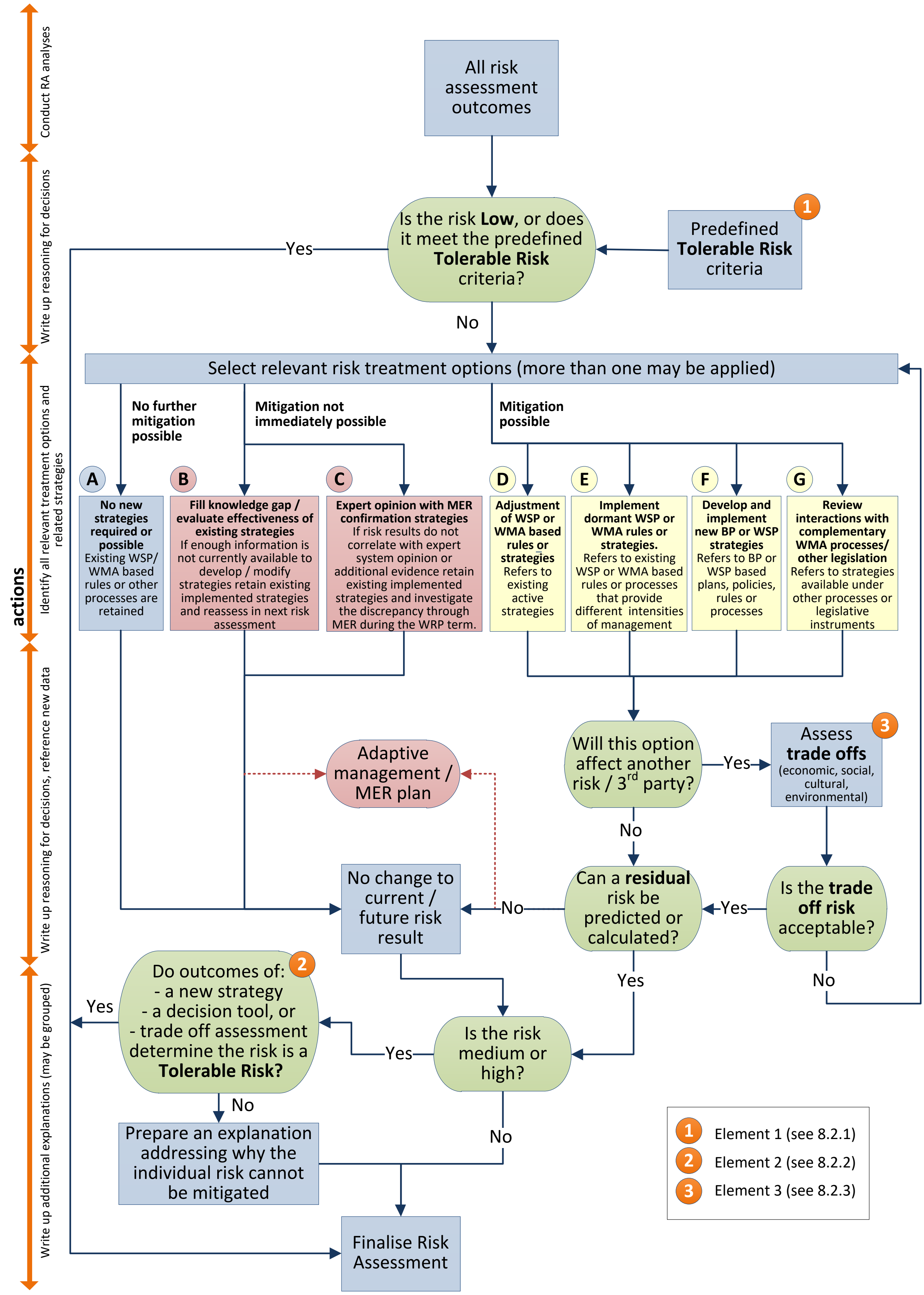


Figure 8-1 Risk treatment pathway

Table 8-1 Risk treatment options explained

Element	Description
A No new strategies required or possible	No further mitigation is possible and no new strategies are proposed. This may be relevant where the risk is adequately managed via existing strategies or where a risk cannot be fully mitigated and trade-offs limit other options. Note: existing strategies are retained and the risk outcome does not change.
B Fill knowledge gap / evaluate effectiveness of existing strategies	Mitigation is not immediately possible and knowledge improvement is proposed. Where there is not enough information available regarding the resource and/or the effectiveness of existing or alternative strategies this option can be used. The EMER Plan will address the knowledge gaps to enable the existing strategies to be reviewed in the future. Note: existing strategies are retained and the risk outcome does not change
C Expert opinion with monitoring, evaluation and reporting confirmation strategies	Mitigation is not immediately possible and knowledge improvement via the EMER Plan is proposed. This option may be used where there is a discrepancy between risk assessment results and expert opinion or alternative evidence. Differences may be due to conservative estimations of consequence or likelihood in risk assessment calculations, knowledge from complementary WRP activities such as LTWP development (including identification of asset watering requirements), type of data available for risk calculation, or other factors that affect results such as data confidence. Note: existing strategies are retained and the risk outcome does not change. Alternative information sources may enable decisions around the tolerability of a risk outcome to be made.
D Adjustment of WSP or WMA 2000 based rules or strategies	Mitigation is possible through adjustment of an existing active (i.e. implemented) water sharing strategy. These strategies are generally those currently implemented via WSPs, the WMA 2000 or related policies. Note: existing strategies that are not modified by this risk treatment option are retained. Other risk outcomes may change as a result of strategy modification. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
E Implement dormant WSP or WMA 2000 strategies	Mitigation is possible through the implementation of an existing dormant or partially implemented water sharing strategy (i.e. currently available for use via WSP or WMA 2000). These strategies often describe alternative levels of management intensity than the implemented active strategy. Examples include IDELs/TDELs and time bound local area management in groundwater systems where these strategies are not already active, or incorporating substantial amounts of mapping information on high priority groundwater–dependent ecosystems into WSPs. Note: unaffected existing strategies are retained, risk outcomes may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
F (i) Develop and implement new water sharing strategies	Mitigation is possible through the development and implementation of new WSP or WMA 2000 based sharing strategies such as rules, policies or other processes. Note: unaffected existing strategies are retained, risk outcomes may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
F (ii) Develop / implement new strategies (WRP/WQM Plan/IRG/LTWP/ Basin Plan)	Mitigation is possible through the development and implementation of new strategies that are not covered by F(i) and are related to the introduction of the Basin Plan and appear in associated instruments. Note: unaffected existing strategies are retained, risk outcomes may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
G (i) Review interaction with complementary WMA 2000 processes	The WMA 2000 covers a broad range of activities of which water sharing is one. This option focuses on reviewing linkages to WMA 2000 based strategies that are complementary to water sharing such as floodplain harvesting and floodplain management. Note: unaffected existing strategies are retained, risk outcomes may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.
G (ii) Review interaction with strategies available under other legislation	Other legislative instruments that contain strategies that may mitigate risk to groundwater sources (e.g. the *Environmental Planning and Assessment Act 1979* and *Contaminated Land Management Act 1997*. Multi agency strategies such those covering land management should also be included where relevant. This strategy type aims to review interaction with and improve linkages to complementary non WMA 2000 or Basin Plan processes and controls. Note: unaffected existing strategies are retained, risk outcomes may change. As use of this option may affect risks or a third party, care should be taken to assess the proposed changes through secondary lenses as indicated by the flow chart.

For information regarding the process of applying actions and mechanisms refer to Schedule I of NSW Murray-Darling Basin Porous Rock WRP.

8.1. Existing water resource management strategies, actions and mechanisms

This risk assessment has assessed risks with existing WSP or WMA 2000 based rules in place. It builds on the knowledge and experience of earlier risk based approaches to water planning and management in NSW (NoW, 2011). A range of strategies under the WMA 2000 and associated WSPs address risk for the WRP area, these are consistent with strategies applied elsewhere in the NSW portion of the Basin and other areas of the State. These strategies have been identified for each risk as water management actions and mechanisms in previous sections of this report. They are also shown later in this section in the strategy summary table (Table 8-7) and the consolidated risk table. Further information on existing strategies and the way in which they address risk can also be found in the documents listed in Table 8-2 available from the Department of Planning and Environment - Water website. For information regarding the process of applying actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

Table 8-2 Further information regarding existing strategies, actions and mechanisms

Document
Water Sharing Plan for the Murray-Darling Basin Porous Rock Groundwater Sources – Background document, NSW Department of Primary Industries (NSW Office of Water) 2011
Macro water sharing plans – the approach for groundwater. A report to assist community consultation (DPI Water 2015)
NSW Aquifer Interference Policy: NSW Government policy for the licensing and assessment of aquifer interference activities, State of New South Wales through Department of Trade and Investment, Regional Infrastructure and Services, September 2012.

8.2. Tolerable risk outcomes

A medium or high risk outcome does not necessarily imply existing water management strategies require change or are inadequate. In many circumstances these risks will already have an appropriate level of management in place under the WMA 2000 that is commensurate with the risk outcome (i.e. via the relevant water sharing or other water management plans, water management policies etc.). In these situations NSW has made an informed decision to accept the risk outcome as an acceptable or tolerable risk in line with the *Basin Plan Water Resource Plan Requirements Position Statement 9B Strategies for addressing risks.* Where a risk outcome is considered tolerable, the Basin Plan does not require further strategies to be implemented. These results are not further considered in this document.

8.2.1. Predefined tolerable risk criteria

This section refers to element 1 on the risk treatment pathway. Risk outcomes that meet the predefined tolerable risk criteria are automatically assigned risk treatment option A as no new strategies required or possible. There are a variety of reasons why medium or high risk outcomes may be tolerable including the balancing of environmental, social, cultural and economic demands on water resources. No predefined tolerable risk criteria have been identified for this WRP area.

8.2.2. Risks assessed as tolerable following application of a risk treatment option

This section refers to element 2 on the risk treatment pathway. Although risk outcomes may arrive at this element following the application of any risk treatment option, only those where a tolerable risk has been determined are discussed. Table 8-3 lists the explanations for determining risk outcomes are tolerable. If a risk does not appear, there are no medium or high risk outcomes for the risk and tolerable rationales are not required. The consolidated risk table identifies for each location the tolerable status and relevant rationale for each risk result. As noted earlier, strategies relating to risks to water quality are not discussed in this section; refer to the WQM Plan Tables 6 and 11 for this material.

Table 8-3 Tolerable risk outcome rationale

Risk		RTO	Tolerable rationale
R2	Risk of groundwater extraction inducing connection with poor quality groundwater	F, A, A	The risk outcomes for induced connection with poor water quality (salinity) in the NSW MDB Porous Rock are tolerable because strategies and mechanisms established in the relevant WSP are in place to manage local drawdown impacts that could lead to elevated salinity levels. With reference to other types of groundwater degradation NSW considers the NSW Environment Protection Authority's risk based licensing and approval system adequately manages the threat of water quality degradation from major contaminants entering the groundwater SDL source units from point sources and hence adequately mitigates risk. Mechanisms (i.e. measures) are also in place to reduce the mobilisation of nutrients within the SDL unit from known contamination sites and plumes induced from pumping. Refer to the WQM Plan (Tables 6 and 11) for further details.
R3	Risk of local drawdown reducing groundwater access by consumptive users		These risk outcomes are tolerable because strategies and mechanisms are in place to manage local drawdown impacts. The WSP establishes minimum distances between groundwater extraction points (water supply works) to minimise interference and impacts. The Minister may also to apply restrictions on extraction from these works to minimise interference between users, to maintain or protect water levels in an aquifer, or to maintain pressure, or to ensure pressure recovery, in an aquifer. Risk calculations are based on extraction density mapping using a five kilometre radius. This is a conservative approach to identifying the cumulative impacts of bores.
R9	Risk of groundwater extraction causing local drawdown impacting GDEs	E	Risk is tolerable as a substantial amount of new GDE mapping information has been used to identify high priority GDEs within the WRP area as discussed in section 6.2, significantly improving the implementation of this existing mechanism. The WSP establishes minimum distances between new or amended water supply works and GDEs. The Minister may also apply restrictions on extraction from water supply works to protect GDEs.
R10	Risk of groundwater extraction causing local drawdown impacting instream ecological values	A	Risk is tolerable as there are strategies in place to manage extraction based on degree of surface to groundwater connectivity. Risks are tolerable because the contribution of groundwater to support instream ecological values is less than surface water as these systems are less highly connected to surface waters. As also applies for R9, the WSP establishes minimum distances between new or amended water supply works and streams. The Minister may also apply restrictions on extraction from water supply works to protect GDEs – which include instream ecological values.
QL5	Risk of poor water quality to the environment (land management induced water quality (salinity) deterioration)	G	Risk is tolerable because there are no water management strategies or mechanisms available to address the risk. Dryland salinity is a land management issue that cannot be mitigated under a water resource plan. Refer to the Water quality management plan—GW11 NSW Murray Darling Basin Porous Rock Water Resource Plan area tables 6, 8 and 11 for further information regarding complementary land management strategies.

8.2.3. Trade-off assessments.

This section refers to element 3 on the risk treatment pathway. Risk outcomes may arrive at this element of the pathway following the application of options D to G where a new or modified strategy affects another risk outcome or may result in a third party impact. No assessments have been identified for this section of the risk assessment.

8.3. New or modified water resource management strategies, actions and mechanisms.

This section refers to strategies that have been developed, modified, or had their implementation improved as a result of applying options D to G on the risk treatment pathway. The WRP describes the consultation that has been undertaken to determine which strategies will be implemented.

A number of overarching principles guide the development of WRPs in NSW. These acknowledge the legislative framework and water resource management strategies in place in NSW prior to the introduction of the Basin Plan. These principles have been considered during the preparation of new actions and mechanisms and are summarised in Table 8-4.

Table 8-4 Principles guiding development of strategies in NSW

Instrument or source	Principles
Water Act 2007 (Cth)	There will be no net reduction in the protection of planned environmental water
	The Commonwealth is responsible for funding the gap between existing limits and the Sustainable Diversion Limits (SDL).
	WRPs will meet the requirements set out in the Basin Plan
Basin Plan 2012	Nothing in the Basin Plan requires a change in the reliability of water allocations of a kind that would trigger Subdivision B of Division 4 of Part 2 of the *Water Act 2007* (s. 6.14 of the Basin Plan)
Water Management Act 2000 (NSW)	WSPs are required to balance social, cultural, economic and environmental needs of the community and catchments (this is a fundamental objective of water management in NSW and is described in the objects of the Act).
Delivering WRP Plans for NSW Roadmap 2016-2019	WRPs are cost neutral for NSW licence holders
	Development of WRPs minimises change to NSW WSPs within their initial ten year terms

The strategies outlined in this section were developed with consideration to their implementation. As this is primarily through the rules and conditions within the WRP and the WSP, strategies have been limited to water management actions and mechanisms as these are within the scope of Basin Plan strategies and controls. As previously mentioned strategies outside this scope that relate to the management of water quality risks are outlined in the WQM Plan. Table 8-5 provides information on the new strategies and explains how risk is addressed.

Table 8-5 New or modified water management actions and mechanisms

Mechanism	Description
N1 Sustainable Diversion Limits for each groundwater SDL resource unit.	This new mechanism is a Basin Plan requirement that is implemented through existing WSP mechanisms.
E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale	A substantial amount of new GDE mapping information has been used to identify high priority GDEs within the WRP area significantly improving the implementation of this existing mechanism.

8.4. Knowledge strategies

This section refers to strategies developed as a result of applying options B and C on the risk treatment pathway. Although knowledge improvement strategies cannot directly mitigate risk outcomes, these strategies aim to provide information on which to base future calculations of risk and to inform planning decisions regarding strategy or mechanism application. A summary of these strategies is provided in Table 8-6, further information on can be found in the EMER Plan.

Table 8-6 Knowledge strategies

Strategy	Mechanism and description
I1 Improve knowledge used to assess risk	K1 Projects resulting from application of risk treatment option C Expert opinion with monitoring, evaluation and reporting confirmation strategies **Risk and potential impacts of sediment compaction on overlying surface water resources** NSW Department of Planning and Environment will be assessing the suitability of satellite data analysis to identify areas of land subsidence associated with groundwater pumping. A project will be undertaken in 2019 that quantifies land subsidence in the Lower Namoi groundwater source through field survey of installed subsidence benchmarks and compares this to InSAR analysis of satellite data. The aim of the project is to evaluate this remote sensing technique for detecting areas of land subsidence associated groundwater pumping. If successful this type of analysis could be used in other areas that also have high levels of groundwater pumping that do not have established benchmarks as is the case in the Lower Namoi.
I2 Improve knowledge of effectiveness of existing strategies	K2 Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies No programs identified at time of writing
I3 Monitor groundwater resources and dependent ecosystems	K3 Existing groundwater level and take monitoring programs NSW has existing, ongoing groundwater resource monitoring programs that focus on groundwater levels and groundwater take across all NSW resource units. Monitoring is not restricted to areas where medium and high risks have been identified and is responsive to monitoring actions identified in Schedule I. Existing monitoring programs are described in the WRP (sections 5.6, 7.1, 7.2). Further detail is provided in the WRP (Schedule I), the EMER Plan (Schedule H Table 3 for summary information, Appendices A-J for mapped monitoring location information) and the WQM Plan including information on prior programs (Schedule F sections 2 and 3).
	K4 Proposed water quality and environmental monitoring **Groundwater dependent vegetation extent and condition** A proposed vegetation condition and extent monitoring program has been identified in the EMER Plan (Schedule H Table 4 for summary information, Appendices A-J for mapped monitoring location information). It is anticipated the full extent of this program will correspond to areas with medium and high risk outcomes identified in this report. **Groundwater quality** A proposed groundwater quality monitoring program has been identified in the NSW MDB Porous Rock WRP (section 7-2), the EMER Plan (WRP Schedule H section 3) and the WQM Plan (WRP Schedule F sections 4.3, Table 11). It is anticipated the full extent of this program will correspond to areas with medium and high risk outcomes identified in this report.
	K5 Complementary water quality and environmental monitoring programs

Strategy	Mechanism and description
	Groundwater quality The WQM Plan (section 4.2) has identified a range of measures that contribute to achieving water quality objectives within the water resource plan area. Many of these measures have associated monitoring programs that contribute to understanding and management of the groundwater resources of the WRP area. **Instream ecological and water quality monitoring** Programs identified in the EMER Plan for adjacent surface waters (refer to Table 3-1) may also be relevant to areas where medium or high risk outcomes have been determined for instream ecological values dependent on groundwater in this document.

8.5. Summary of strategies to address risk

A summary of strategies is shown in Table 8-7 to complement the consolidated risk table. The listed strategies align with those used in the WRP, WSP, and WQM Plans. For information regarding LTWP objectives refer to Table 6-2. Here, strategies are described with associated actions and mechanisms for each risk and the relevant WRP and water quality objectives. The applicable risk treatment option (RTO) is included, and links to relevant sections of the Basin Plan in order to streamline strategy assessment. For more information refer to the document map. Table 8-8 contains a list of abbreviations used in Table 8-7. Grey shading indicates mechanisms are not active but are available for use. For information regarding the process of applying strategies, actions and mechanisms refer to Schedule I of the NSW MDB Porous Rock WRP.

Table 8-7 Summary of strategies to address risk

1 Strategies	2 Water management actions and mechanisms / supporting activities	3 RTO	4 Associated management plan or instrument	5 Relevant risks	6 Relevant Basin Plan clauses	7 Relevant objectives
1 Limit total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels. This strategy reserves water for the environment in order to protect: * all GDEs * baseflows in connected surface waters that are reliant on groundwater connectivity * water quality including salinity * hydraulic relationships between groundwater and surface water, between groundwater systems and within groundwater systems * groundwater quality, including salinity	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale).	D	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 4 and 6	R1, R2, R3, R4, R5, R6, R7, R9, R10, R13 R14, QL1, QL2, QL3, QL4, QL5, QL6, QL7	**4.03(3) (a)(iii) (a)(iv) (c) (f)** **Ch. 10 Part 3, Part 8 Part 10**	**WSP** Part 2 All objectives **WQM Plan** 1
	E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits.	A	NSW Murray-Darling Basin Porous Rock Water Resource Plan 2022 section 5			
	N1 Sustainable Diversion Limits for each groundwater SDL resource unit.	F				
	E3 Require all take to be licensed except for basic landholder rights or where a policy indicates otherwise.	A	*Water Management Act 2000 Division 1 Part 2*			
	E4 Extraction limits for individual works to manage extraction at the extraction point.	A				

1 Strategies	2 Water management actions and mechanisms / supporting activities	3 RTO	4 Associated management plan or instrument	5 Relevant risks	6 Relevant Basin Plan clauses	7 Relevant objectives
* structural integrity of aquifers and pressure.	E5 Compliance with individual extraction limits.	D	NSW Murray-Darling Basin Porous Rock Water Resource Plan 2022 section 5 *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 9 and 11 NSW Aquifer Interference Policy 2012 *Water Management Amendment Act 2018* and Water Metering Regulation (in prep)			
	E6 Prohibit trade between surface water and groundwater sources.	A	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Part 10			
	E7 Trade limits or prohibitions between groundwater sources and management zones. *Note: Refer to section 4.5.3 for details*	A	All relevant regulated and unregulated waters sharing plans. Part 10			
	E7a Limits to trade of LWU WALs.	A	*Access Licence Dealing Principles Order 2004*			

1 Strategies	2 Water management actions and mechanisms / supporting activities	3 RTO	4 Associated management plan or instrument	5 Relevant risks	6 Relevant Basin Plan clauses	7 Relevant objectives
2 Manage the location and rate of groundwater extraction at a local scale within water sources and SDL management units to prevent or manage localised drawdown related impacts. This strategy allows consumptive groundwater extraction to be limited on a smaller scale than a water source or SDL unit to : * Limit seasonal drawdown * Protect water levels and aquifer structural integrity * Protect GDE connectivity to groundwater * Prevent declines in salinity, groundwater beneficial use category, and such water quality declines impacting dependent GDE vegetation. * Limit impacts on other groundwater extractors	E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. *Note: this mechanism is available for use if required in the NSW MDB Porous Rock WRP area*	A	*Water Management Act 2000* s.324, and 331	R1, R2, R3, R5, R6, R9, R10, R13, R14, QL1, QL2, QL3, QL4, QL5, QL6, QL7	**4.03(3) (a)(iii) (a)(iv) (c) (f)** **Ch. 10 Part 3, Part 4 Part 8 Part 10**	**WSP** Part 2 All objectives **WQM Plan** 1
	E9 Trade limits or prohibitions between local management areas within a groundwater source. *Note: this mechanism is applied via management zones in the NSW MDB Porous Rock WRP area (identified in Table 2-4). Also refer to trade impact assessments, see Figure I-3 and Figure I-4 in Schedule I of the NSW MDB Porous Rock WRP for further information.*	A	*Access Licence Dealing Principles Order 2004* *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Part 9			
3 Limit the location and rate of extraction in the vicinity of high priority groundwater–dependent ecosystems. This strategy aims to limit extraction induced declines in water levels that may significantly impact GDE connectivity to groundwater and the condition of high priority GDEs within the WRP area.	E10 Setback distances for new bores from high priority GDE boundaries and rivers allow management of extraction related impacts at an asset scale.	E D	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 9 and 11 *Water Management Act 2000* s.100, 100A, and 102	R9, R13, QL5, QL6, QL7	**4.03(3) (a)(iii) (a)(iv) (c) (f)** **Ch. 10 Part 3, Part 4 Part 8 Part 10**	**WSP** Part 2 Environmental objectives
	E4 Extraction limits for individual works to manage extraction at the extraction point.	D				

1 Strategies	2 Water management actions and mechanisms / supporting activities	3 RTO	4 Associated management plan or instrument	5 Relevant risks	6 Relevant Basin Plan clauses	7 Relevant objectives
4 Limit impacts of groundwater extraction on surface water flows and surface / groundwater hydraulic relationships. This strategy aims to manage alluvial groundwater sources according to level of surface water connectivity to limit declines in surface water levels that may significantly impact the condition of: * Instream GDEs * surface water low flow refugial habitats in unregulated rivers * regulated rivers	E1 Reserve all water above the long-term average annual extraction limit (LTAAEL) for the environment as planned environmental water (defined and managed by the listed WSP at the water source scale).	**D**	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 4 and 6	R10, R14, QL1, QL2, QL5, QL6, QL7	**4.03(3) (a)(iii) (a)(iv) (c) (f)** **Ch. 10 Part 3, Part 4 Part 8 Part 10**	**WSP** Part 2 Environmental objectives
	E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits.	**A**	NSW Murray-Darling Basin Porous Rock Water Resource Plan 2022 section 4			
	N1 Sustainable Diversion Limits for each groundwater SDL resource unit.	**F**				
	E6 Prohibit trade between surface water and groundwater sources.	**A**	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Part 10 All relevant regulated and unregulated waters sharing plans. Part 10 *Access Licence Dealing Principles Order 2004*			
	E4 Extraction limits for individual works to manage extraction at the extraction point.	**A**	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 9 and 11			

1 Strategies	2 Water management actions and mechanisms / supporting activities	3 RTO	4 Associated management plan or instrument	5 Relevant risks	6 Relevant Basin Plan clauses	7 Relevant objectives
5 Limit interference between bores. This strategy aims to limit new production bores impacting established bores used for a set list of purposes.	E14 Setback distances for new bores from bores on neighbouring properties, bores used to supply local water or major utilities and NSW Department of Planning and Environment monitoring bores.	A	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Part 9 *Water Management Act 2000* s.100, 100A, and 102	R2, QL3	**4.03(3)** **(a)(ii)** **(a)(iv)** **(c)** **(f)** **Ch. 10 Part 4 Part 7**	**WSP** Part 2 Social and cultural objectives **WQM Plan** 3, 4
6 Limit extraction near contamination sources. This strategy aims to protect overlying ground and surface water sources and public health and safety by limiting exposure to and mobilisation of contamination sources.	E15 Setback distances from known contamination sites and plumes. E4 Extraction limits for individual works to manage extraction at the extraction point. E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. *Note: this mechanism is available for use if required in the NSW MDB Porous Rock WRP area*	A	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 9, 10 and 11 *Water Management Act 2000* s.324 and 331 *Water Management Act 2000* s.100, 100A, and 102	R2, QL3	**4.03(3)** **(a)(ii)** **(a)(iv)** **(c)** **(f)** **Ch. 10 Part 4 Part 7**	**WSP** Part 2 Social and cultural objectives **WQM Plan** 3, 4
7 Limit pumping induced flow of saline groundwater into low salinity aquifers This strategy aims to reduce the likelihood of a change in the groundwater beneficial use category, and reduce the likelihood of poor	E16 Bore construction standards. E17 Work approval conditions may place conditions on the bore such as screen depth conditions.	A	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 9 and 11	R2, QL3, QL5	**4.03(3)** **(a)(iii)** **(a)(iv)** **(c)** **(f)**	**WSP** Part 2 Environmental objectives

1 Strategies	2 Water management actions and mechanisms / supporting activities	3 RTO	4 Associated management plan or instrument	5 Relevant risks	6 Relevant Basin Plan clauses	7 Relevant objectives
water quality affecting dependent GDE vegetation.	E4 Extraction limits for individual works to manage extraction at the extraction point.		*Water Management Act 2000* s.100, 100A, and 102		**Ch. 10 Part 4 Part 7**	**WQM Plan** 1
7B Manage potential impacts of salinity and rising water tables	E22 Allow licences to be issued and used to manage potential impacts of salinity and rising water tables.	A	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 7, 9 and 11	R2, R9, R10	**4.03(3) (a)(iii) (a)(iv) (c) (f)** **Ch. 10 Part 4 Part 7**	**WSP** Part 2 Environ-mental **WQM Plan** 1
8 Access to or extraction of basic landholder rights (BLR) This strategy aims to limit groundwater resource impacts attributable to BLR extraction and growth in use, and in some circumstances other users. *Note: BLR are established and controlled through the* WMA 2000 *and are recognised in WSPs. Control mechanisms are only applied when required.*	E18 Minister may restrict BLR access. *Note: this mechanism is available for use if required in the NSW MDB Porous Rock WRP area*	A	*Water Management Act 2000* s.331, and 336B	R5, QL6	**4.03(3) (a)(i) (c) (f)** **Ch. 10 Part 3 Part 4**	**WSP** Part 2 all objectives
	E8 Minister may temporarily restrict groundwater access where it is in the public interest to do so, or to: (a) maintain water levels in an aquifer, or (b) maintain, protect or improve the quality of water in an aquifer, or (c) prevent land subsidence or compaction in an aquifer, or (d) protect groundwater–dependent ecosystems or (e) maintain pressure or to ensure pressure recovery in an aquifer. *Note: this mechanism is available for use if required in the NSW MDB Porous Rock WRP area*	A	*Water Management Act 2000* s.324, and 331			
	E19 Minister may limit growth in BLR when a land holding is subdivided and there is high hydrological stress on the river or aquifer. *Note: this mechanism is available for use if required in the NSW MDB Porous Rock WRP area*	A	*Water Management Act 2000* s.52(2)			

1 Strategies	2 Water management actions and mechanisms / supporting activities	3 RTO	4 Associated management plan or instrument	5 Relevant risks	6 Relevant Basin Plan clauses	7 Relevant objectives
	E20 Minister may direct landholder accessing BLR to not waste or improperly use water. *Note: this mechanism is available for use if required in the NSW MDB Porous Rock WRP area*	A	*Water Management Act 2000* s.325			
9 Implement the WQM Plan for the WRP area.	*Refer to the WQM Plan for detailed listing.* *Note: actions and mechanisms are relevant to the WRP are listed in previous strategies.*	F	Water Quality Management Plan for the NSW Murray-Darling Basin Porous Rock WRP area Basin Salinity Management Strategy	R2, QL3, QL5	**4.03(3) (a)(ii) (a)(iv)** **Ch. 10 Part 4 Part 7**	**WSP** Part 2 All objectives **WQM Plan** all
10 Protect the environment and water users from changes in water availability attributable to climate change and irrigation efficiency. This strategy aims to reduce long term impacts on the health of groundwater resources and on consumptive water users.	E1 Limit total water extraction (basic rights and groundwater take) within each groundwater source/SDL resource unit to predetermined sustainable levels.	D	*Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* Parts 4 and 6 NSW Murray-Darling Basin Porous Rock Water Resource Plan 2022	R4 R7, R13, R14	**4.03(3) (a)(iv) (c) (g)(iii) (h)(iii)** **Ch. 10 Part 3**	**WSP** Part 2 Environment al objectives
	E2 Available water determinations ensure average annual extraction is managed to the water sharing plan extraction limits.	A				
	N1 Sustainable Diversion Limits for each groundwater SDL resource unit.	F				
11 Improve knowledge used to assess risk for the WRP area.	K1 Projects resulting from application of risk treatment option C Expert opinion with monitoring, evaluation and reporting confirmation strategies.	C	NSW Groundwater Environmental Monitoring, Evaluation and Reporting Plan	QL1	**4.03(3) (c) (g) (h)**	**WSP** Part 2 Environment al objectives

1 Strategies	2 Water management actions and mechanisms / supporting activities	3 RTO	4 Associated management plan or instrument	5 Relevant risks	6 Relevant Basin Plan clauses	7 Relevant objectives
12 Improve knowledge of effectiveness of existing strategies.	K2 Reviews resulting from application of risk treatment option B Fill knowledge gap / evaluate effectiveness of existing strategies.	B	NSW Groundwater Environmental Monitoring, Evaluation and Reporting Plan	Not applied	**4.03(3)** **(b)** **(c)** **(e)** **(g)**	**N/A**
13 Monitor groundwater resources and dependent ecosystems This strategy aims to monitor groundwater levels, extraction and the health of the resource and dependent ecosystems to inform adaptive resource management in the short and long term.	K3 Existing groundwater level and take monitoring programs K4 Proposed water quality and environmental monitoring programs K5 Complementary water quality and environmental monitoring programs	F B	NSW Groundwater Environmental Monitoring, Evaluation and Reporting Plan refer to summary information in tables 3, 4 and appendices Water Quality Management Plan for the NSW MDB Porous Rock WRP area table 11	All risks	**4.03(3)** **(b)** **(c)** **(e)** **(g)** **(h)** **(i)**	**WSP** Part 2 All objectives

[1] Refer to the Water Resource Plan for the accreditation status of trade rules and listed sections of the WMA 2000.
[2] Grey shaded boxes indicate inactive mechanisms and have been included to show mechanisms are available for use if required.

Table 8-8 Abbreviations used in Table 8-7

Abbreviation	Explanation
RTO	Risk treatment option refer to Figure 8-1
E	Existing action / mechanism / supporting activity
N	New or modified action / mechanism / supporting activity
K	Knowledge based action / mechanism / supporting activity
R1	Risks to structural integrity of the groundwater systems
R2	Risk of groundwater extraction inducing connection with poor quality groundwater
R3	Risk of local drawdown in bores reducing groundwater access by consumptive users
QL1	Risk of sediment compaction impacting surface water users
QL2	Risk of groundwater extraction impacting water users in adjacent groundwater systems
QL3	Risk of poor water quality to water users
R4	Risk of climate change reducing recharge and groundwater availability
R5	Risk of growth in basic landholder rights reducing groundwater availability
R6	Risk of growth in local water utilities reducing groundwater availability
R7	Risk of increases in irrigation efficiency and improved water delivery reducing recharge
R8	Risk of growth in plantation forestry intercepting recharge
QL4	Risk of growth in mining reducing groundwater availability
R9	Risk of groundwater extraction causing local drawdown (GDEs)
R10	Risk of groundwater extraction causing local drawdown (Instream ecological value)
R11	Risk of growth in plantation forestry intercepting recharge (GDEs)
R12	Risk of growth in plantation forestry intercepting recharge (Instream ecological value)
R13	Risk of climate change reducing recharge and groundwater availability (GDEs)
R14	Risk of climate change reducing recharge and groundwater availability (Instream ecological value)
QL5	Risk of poor water quality to the environment (GDEs and instream ecological values)
QL6	Risk of growth in basic landholder rights and local water utilities to the environment (GDEs and instream ecological values)
QL7	Risk of growth in mining reducing groundwater availability (GDEs and instream ecological values)

Definitions

Access	The means or opportunity to use (water).
Access licence	(1) An access licence entitles its holder (a) to specified shares in the available water within a specified water management area or from a specified water source (the share component), and (b) to take water (i) at specified times, at specified rates or in specified circumstances, or in any combination of these, and (ii) in specified areas or from specified locations, (the extraction component). An access licence may also be referred to as a water access licence or a WAL.
Alluvial aquifer	A groundwater system whose geological matrix is composed of unconsolidated sediments consisting of gravel, sand, silt and clay transported and deposited by rivers and streams.
Alluvium	Unconsolidated sediments deposited by rivers or streams consisting of gravel, sand, silt and clay, and found in terraces, valleys, alluvial fans and floodplains.
Aquatic ecosystems	Ecosystems dependent on flows, or periodic or sustained inundation/waterlogging for their ecological integrity e.g. wetlands, rivers, karst and other groundwater–dependent ecosystems, saltmarshes, estuaries and areas of marine water the depth of which at low tide does not exceed 6 metres.
Aquifer	Under the *Water Management Act 2000* an aquifer is a geological structure or formation, or an artificial landfill that is permeated with water or is capable of being permeated with water. More generally, the term aquifer is commonly understood to mean a groundwater system that can yield useful volumes of groundwater. For the purposes of groundwater management in NSW the term ‘aquifer’ has the same meaning as ‘groundwater system’ and includes low yielding and saline systems.
Aquitard	A confining low permeability layer that retards but does not completely stop the flow of water to or from an adjacent aquifer, and that can store groundwater but does not readily release it.
Artesian	Groundwater which rises above the surface of the ground under its own pressure by way of a spring or when accessed by a bore.
Australian Height Datum (AHD)	Elevation in metres above mean sea level.
Available water determination	A determination referred to in section 59 of the *Water Management Act 2000* that defines a volume of water or the proportion of the share component (also known as an ‘allocation) that will be credited to respective water accounts under specified categories of water access licence. Initial allocations are made on 1 July each year and, if not already fully allocated, may be incremented during the water year.
Baseflow	Discharge of groundwater into a surface water system.
Basement (rock)	See Bedrock
Basic landholder rights (BLR)	Domestic and stock rights, harvestable rights or native title rights.
Bedding	Discrete sedimentary layers that were deposited one on top of another.
Bedrock	A general term used for solid rock that underlies aquifers, soils or other unconsolidated material. .
Beneficial use (category)	[1]A general categorisation of groundwater uses based on water quality and the presence or absence of contaminants. Beneficial use is the equivalent to the ‘environmental value’ of water.
Bore (or well)	A hole or shaft drilled or dug into the ground.
Brackish water	Water with a salinity between 3,000 and 7,000 mg/L total dissolved solids.

[1] As defined in *Macro water sharing plans – the approach for groundwater. A report to assist community consultation* (DPI Water 2015)

Confidence	Generally described as a state of being certain either that a hypothesis or prediction is correct or that a chosen course of action is the best or most effective.
Confined aquifer	An aquifer which is bounded above and below by impermeable layers causing it to be under pressure so that when the aquifer is penetrated by a bore, the groundwater will rise above the top of the aquifer.
Connected water sources	Water sources that have some level of hydraulic connection.
Consequence	The loss of value for an impacted receptor.
Dependency	The state of being determined, influenced or controlled by something else.
Development (of a groundwater resource)	The commencement of extraction of significant volumes of water from a water source.
Discharge	Flow of groundwater from a groundwater source.
Drawdown	The difference between groundwater level/pressure before take and that during take.
Ecological value	The intrinsic or core attributes associated with naturalness, diversity, rarity and special features, but excluding representativeness used to classify water sources for apportioning water management rules. The perceived importance of an ecosystem which is underpinned by the biotic and/or abiotic components and processes that characterise that ecosystem.
Ecosystem	A specific composition of animals and plants that interact with one another and their environment.
Ecosystem functions	The processes that occur between organisms and within and between populations and communities. They include interactions with the nonliving environment that result in existing ecosystems and bring about dynamism through changes in ecosystems over time.
Electrical conductivity (EC)	Ability of a substance to conduct an electrical current. Used as a measure of the concentration of dissolved ions (salts) in water (i.e. water salinity). Measured in micro-Siemens per centimetre (µS/cm) or deci-Siemens per metre (dS/m) at 25o C. 1 dS/m = 1000 µS/cm
Environmental Value	[2]Particular values or uses of the environment which are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of contamination, waste discharges and deposits.
Extraction management unit (EMU)	A group of water sources; defined for the purpose of managing long-term average annual extractions.
Fractured rock	Rocks with fractures, joints, bedding planes and cavities in the rock mass.
Geological formation	A fundamental lithostratigraphic unit used in the local classification of strata and classified by the distinctive physical and chemical features of the rocks that distinguish it from other formations.
Geological sequence	A sequence of rocks or sediments occurring in chronological order.
Groundwater	Water that occurs beneath the ground surface in the saturated zone.
Groundwater Data System (GDS)	NSW Department of Planning and Environment database which includes data on water level records and information on aquifer thickness
Groundwater–dependent Ecosystem (GDE)	[3]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 equilibrium	A state where the forces driving groundwater flow have reached a balance in a groundwater system, for example where groundwater inflow equals groundwater outflow.

[2] As defined in *Guidelines for Groundwater Quality Protection in Australia 2013* published by the National Water Quality Management Strategy (Australian Government 2014).

[3] Kuginis L, Dabovic, J, Byrne, G, Raine, A, and Hemakumara, H. 2016, *Methods for the identification of high probability groundwater dependent vegetation ecosystems.* DPI Water, Sydney, NSW.

Groundwater system	Any type of saturated sequence of rocks or sediments that is in hydraulic connection. The characteristics can range from low yielding and high salinity water to high yielding and low salinity water.
Hydraulic conductivity	The capacity of a porous medium to transmit water. Measured in metres/day.
Hydraulic connection	A path or conduit allowing fluids to be connected. The degree to which a groundwater system can respond hydraulically to changes in hydraulic head.
Hydraulic head	The height of a water column above a defined point, usually expressed in metres.
Hydrogeology	The branch of geology that relates to the occurrence, distribution and processes of groundwater.
Hydrograph	A plot of water data over time.
Igneous rock	Rocks which have solidified from a molten mass.
Indices	Metrics are combined as indicators and indicators are combined as indices.
Indigenous Cultural Site	An area of particular significance to Aboriginal people because of either or both Aboriginal tradition, the history, including contemporary history, of any Aboriginal party for the area.
Infiltration	The movement of water from the land surface into the ground.
Interception	Occurs when flows or surface or groundwater are stopped, reduced or redirected.
Irrigation Water	The artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall.
Key Environmental Asset	Environmental assets identified across the Murray-Darling Basin with significant and representative high-flow requirements.
Licensed Water Users	Water users licensed to take a defined allocation of water.
Likelihood	The probability that a cause will result in a threat. It is not an indication of the size of the threat, but rather conveys the probability that the threat will be significant.
Long term average annual extraction limit (LTAAEL)	The long-term average volume of water (expressed in megalitres per year) in a water source available to be lawfully extracted or otherwise taken.
Make good provisions (in reference to a water supply work)	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.
Management zone	A defined area within a water source where a particular set of water sharing rules applies.
Metric	A numerical comparison of an observed variable and its value expected under reference condition. A metric is a specification for how an attribute will be measured. It may be binary (‘yes’ or ‘no’, ‘present’ or ‘absent’), a ranking (high, medium, low), or a number.
Minimal impact considerations	Factors that need to be assessed to determine the potential effect of aquifer interference activities on groundwater and its dependent assets.
Monitoring bore	A specially constructed bore used to measure groundwater level or pressure and groundwater quality at a specific depth. Not intended to supply water.
Ongoing take	The take of groundwater that occurs after part or all of the principal activity has ceased. For example extraction of groundwater (active take) entering completed structures, groundwater filling abandoned underground workings (passive take) or the evaporation of water (passive take) from an abandoned excavation that has filled with groundwater.
Perched water table	A local water table of very limited extent which is separated from the underlying groundwater by an unsaturated zone.
Permeability	The capacity of earth materials to transmit a fluid.
Porous rock	Consolidated sedimentary rock containing voids, pores or other openings in the rock (such as joints, cleats and/or fractures.

Potable	Drinking water safe enough to be consumed by humans or used with low risk of immediate or long-term harm.
Pre-development	Prior to development of a groundwater resource.
Productive base	S/R Ratio Aquifer storage (S) to Aquifer Recharge (R) ratio. The ratio provides an indication of the intrinsic inertia (inertia of the aquifer storage to change in recharge condition, whether brought about by human activity or climate change) of the aquifer.
QAL	This suffix on a risk outcome indicates a qualitative assessment
Recharge	The addition of water into a groundwater system by infiltration, flow or injection from sources such as rainfall, overland flow, adjacent groundwater sources, irrigation, or surface water sources
Recovery	The rise of groundwater levels or pressures after groundwater take has ceased. Where water is being added, recovery will be a fall.
Recovery decline	Where groundwater levels or pressures do not fully return to the previous level after a period of groundwater removal or addition.
Reference condition	The benchmark against which the health of the ecosystem metric is assessed. Reference condition describes the patterns and processes that would be expected to prevail without substantial human intervention. A reference condition is not a target or an implied objective for management but is merely representing the river ecosystem in a definitive state of good health.
Reliable water supply	[4]Rainfall of 350 mm 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 (i.e. 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.
Reliance	Dependency on water availability for a range of purposes.
Salinity	The concentration of dissolved minerals in water, usually expressed in EC units or milligrams of total dissolved solids per litre.
Saturated (aquifer) thickness	The vertical thickness of the hydro-geologically defined aquifer in which the pore spaces are filled (saturated) with water.
Saturated zone	Area below the water table where all soil spaces, pores, fractures and voids are filled with water.
Seasonal Fluctuations	Refers to a lowering of the surface that represents the level to which water will rise in cased bores. Natural drawdown may occur due to seasonal climatic changes. Groundwater pumping may also result in seasonal and long-term drawdown.
Sedimentary rock	A rock formed by consolidation of sediments deposited in layers, for example sandstone, siltstone and limestone.
Share component	An entitlement to water specified on an access licence, expressed as a unit share or for specific purpose licences a volume in megalitres (e.g. local water utility, major water utility and domestic and stock).
Stock watering	The watering of stock animals being raised on the land but does not include water in connection with the raising of stock animals on an intensive commercial basis that are housed or kept in feedlots or buildings for all (or a substantial part) of the period during which the stock animals are being raised.
Sustainable Diversion Limits	The volume of water that can be taken from a Sustainable Diversion Limit resource unit as defined under the Murray-Darling Basin Plan 2012.
Unassigned water	Exists where current water requirements (including licensed volumes and water to meet basic landholder rights) are less than the extraction limit for a water source.

[4] As defined by Strategic Regional Land Use Plans

Unconfined aquifer	A groundwater system usually near the ground surface, which is in connection with atmospheric pressure and whose upper level is represented by the water table.
Unconsolidated sediment	Particles of gravel, sand, silt or clay that are not bound or hardened by mineral cement, pressure, or thermal alteration of the grains.
Unsaturated zone	Area above the water table where soil spaces, pores, fractures and voids are not completely filled with water.
Water access entitlement	A water product issued under the *Water Management Act 2000*.
Water Access Licence (WAL)	Refer to 'access licence' above.
Water balance	A calculation of all water entering and leaving a system.
Water Licensing System (WLS)	Systems in place that allow the right to take a water allocation from a specified waterway or location.
Water Quality	Refers to the chemical, physical, biological, and radiological characteristics of water.
Water resource plan	[5]A plan made under the Commonwealth *Water Act 2007* that outlines how a particular area of the Murray–Darling Basin's water resources will be managed to be consistent with the Murray–Darling Basin Plan. These plans set out the water sharing rules and arrangements relating to issues such as annual limits on water take, environmental water, managing water during extreme events and strategies to achieve water quality standards and manage risks.
Water sharing plan	[6]A plan made under the *Water Management Act 2000* which 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.
Water source	Defined under the *Water Management Act 2000* as '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 of the ground and includes the coastal waters of the State. Individual water sources are more specifically defined in water sharing plans.
Water table	Upper surface of groundwater at atmospheric pressure, below which the ground is saturated.
Yield	The amount of water that can be supplied over a specific period.

[5] https://www.mdba.gov.au/basin-plan-roll-out/water-resource-plans 21/03/17

[6] As defined in *Macro water sharing plans – the approach for groundwater. A report to assist community consultation* (DPI Water 2015)

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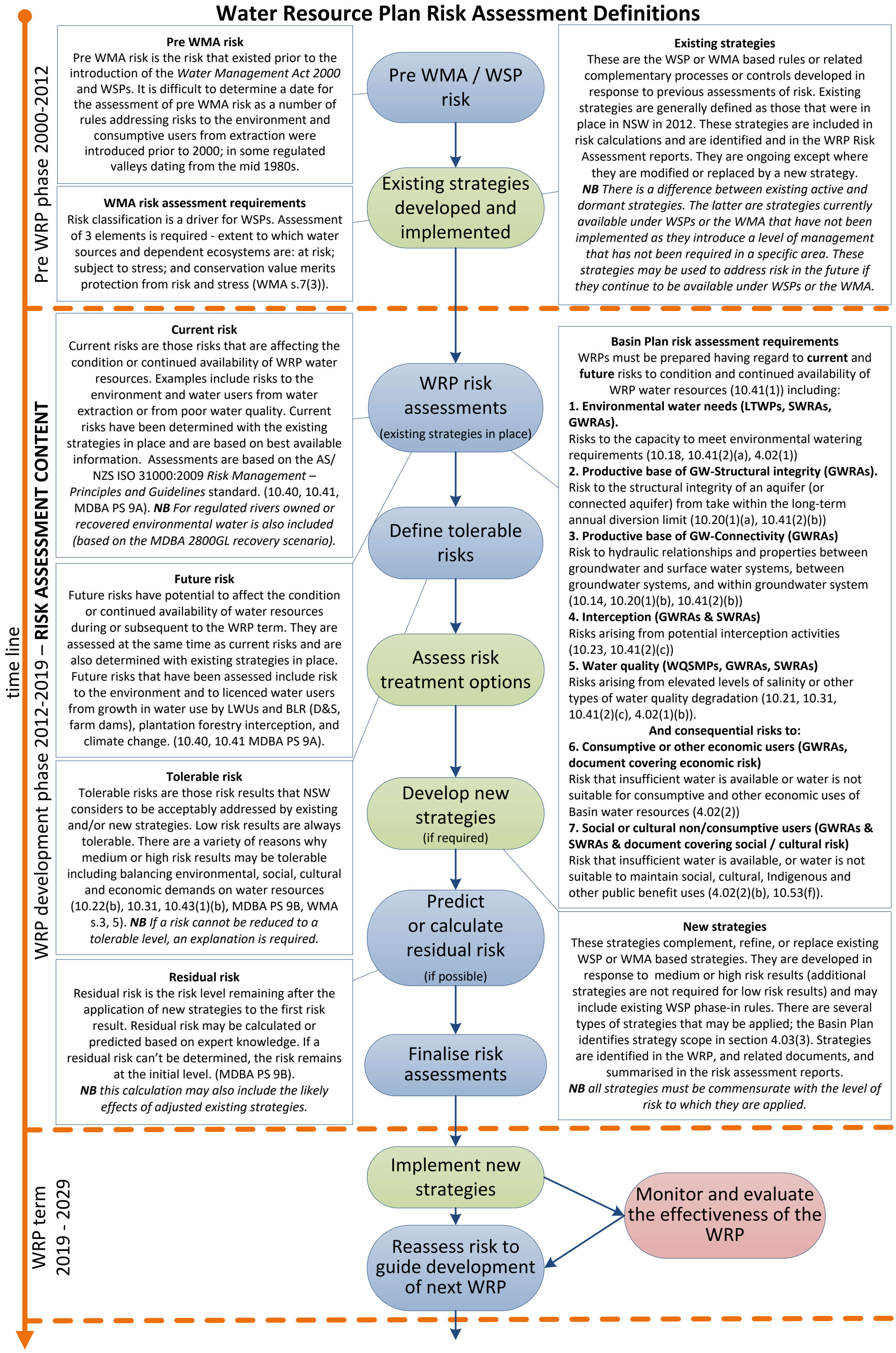
Appendix A Risk assessment definitions



Appendix B Data summary table

Table B-1 Summary of data used for the NSW Murray-Darling Basin Porous Rock Water Resource Plan area risk assessment

#	Metric	Data Description	Report Reference	Data source/Reference	Confidence level	Reasoning
1	Risk to consumptive users - Consequence	Number of users	4.2	Risk of growth in plantation forestry intercepting recharge – (R8) Likelihood	High	Data is measured and applicable to the specific groundwater sources and the scale of assessment. The greatest uncertainty is whether the metrics of 'number of access licences' and 'extraction volume' accurately reflect the level of dependence, sensitivity and value of the groundwater sources to describe the consequence.
		Average annual extraction volume by access licences (averaged over 10 years) (metered)	4.2	Risk of growth in mining reducing groundwater availability (QL4)	High	Data is measured and applicable to the specific groundwater sources and the scale of assessment. The greatest uncertainty is whether the metrics 'extraction volume' accurately reflect the level of dependence and sensitivity.
2	Risk to structural integrity of the aquifer system (R1) - Likelihood	Percentage of compressible sediments	4.3.1	No data - medium assumed	Low	No data available. There is no direct measurement and monitoring of subsidence. The assessment does not attempt to accurately predict potential compaction under aquifer system and groundwater pumping scenarios. Rather, the assessment draws upon the known factors and processes associated with compaction, and uses reliable data on both groundwater drawdown and compressible sediment thickness from the NSW government databases to provide a practical categorisation of relative compaction risk.
		Long term decline in seasonally recovered groundwater levels	4.3.1	NSW Department of Planning, Industry and Environment Groundwater Data System, 2017	Moderate	
3	Risk of groundwater extraction inducing connection with poor quality aquifers (R2) - Likelihood	Decline in seasonally recovered groundwater levels	4.4.1	NSW Department of Planning, Industry and Environment Groundwater Data System, 2017	Moderate	Reliable data from the NSW government databases is used on seasonally recovered groundwater levels (as an indicator of long-term drawdown) to provide a practical categorisation of groundwater drawdown and quality variation.
		Water quality (salinity)	4.4.1	NSW Department of Planning, Industry and Environment 2019a, *Risk assessment for the Murrumbidgee Water Resource Plan area (SW9)*, NSW Department of Planning, Industry and Environment, Sydney, NSW. NSW Department of Planning, Industry and Environment 2019b, R*isk assessment for the Namoi Water Resource Plan area (SW14)*, NSW	Moderate	The NSW government monitoring bores were sampled for salinity at the time of their construction; however, groundwater quality data collection from the NSW Murray-Darling Basin Porous Rock Groundwater Source has subsequently been sporadic. The assessment uses reliable data from the NSW government databases on groundwater quality within the main and linked aquifer systems, to provide a practical categorisation of groundwater drawdown and quality variation.

#	Metric	Data Description	Report Reference	Data source/Reference	Confidence level	Reasoning
				Department of Planning, Industry and Environment, Sydney, NSW. NSW Department of Planning, Industry and Environment 2019c, *Risk assessment for the NSW Murray and Lower Darling Water Resource Plan area (SW8)*, NSW Department of Planning, Industry and Environment, Sydney, NSW. DPI Water 2011a, *Western Murray Porous Rock and Lower Darling Alluvium Groundwater Sources, Groundwater Status Report,* NSW Department of Primary Industries, Office of Water, Sydney, NSW. Parsons Brinkerhoff 2011. Characterisation of hydrogeochemistry and risks to groundwater quality. Impact of groundwater pumping on groundwater quality. National Water Commission – Raising National Water Standards Programme. December 2011.		
4	Risk of local drawdown in bores reducing groundwater access by consumptive users (R3) - Likelihood	Density of groundwater extraction	4.5.1	NSW Department of Planning, Industry and Environment, Water Licensing System (2017)	High	This assessment has been undertaken based on metered groundwater extraction data based on AAL data held by WaterNSW (formerly by DPI Water). Production bore locations are identified throughout NSW, and licensed groundwater extraction is metered throughout the NSW Murray-Darling Basin Porous Rock.
5	Risk of sediment compaction impacting surface water users (QL1)	Number of AAL's	5.2	NSW Department of Planning, Industry and Environment, Water Licensing System (2017)	High	Data based on metered groundwater extraction data collected by WaterNSW (formerly by DPI Water).
		Level of allocation	5.2	NSW Department of Planning, Industry and Environment, Water Licensing System (2017)	High	Data based on metered groundwater extraction data collected by WaterNSW (formerly by DPI Water).

#	Metric	Data Description	Report Reference	Data source/Reference	Confidence level	Reasoning
6	Risk of groundwater extraction impacting water users in adjacent groundwater systems (QL2)	Aquifer S/R ratio	5.3.1	Storage and Recharge ratios: CSIRO and SKM 2010, Sustainable Extraction Limits Derived from the Recharge Risk Assessment Method - New South Wales (part 1, 2 and 3), CSIRO Canberra.	Moderate	The metrics are an approximation of the productive base of the groundwater system, and as such, their applicability is moderate.
7	Risk of poor water quality to water users (QL3)	Entitlement and extraction volumes	5.4.1	WaterNSW Water Accounting System 2017	High Moderate (BLR extraction)	This assessment has been undertaken with reference to data produced by NSW Department of Planning, Industry and Environment, metered groundwater extraction by licence holders, unassigned water volumes and LTAAELs as determined for Water Sharing Plans.
		Ratio of existing BLR use to unassigned water	5.4.1	NSW Department of Planning, Industry and Environment, Water Licensing System 2017	Moderate	BLR extraction is based on assumed extraction from bores.
		Extraction as a proportion of the LTAAEL	5.4.1	NSW Department of Planning, Industry and Environment, Water Licensing System 2017	High	LTAAELs as determined for Water Sharing Plans.
8	Risks to aquifer Access Licence Holders – Consequence	Ratio of LWU use to total LWU entitlement volume	5.5.1	NSW Department of Planning, Industry and Environment, Water Licensing System 2017	High	This assessment has been undertaken with reference to data produced by NSW Department of Planning, Industry and Environment on metered groundwater extraction by LWU licence holders, metered groundwater extraction by other licence holders, and LTAAELs as determined for Water Sharing Plans.
		Ratio of use to LTAAEL	5.5.1	NSW Department of Planning, Industry and Environment Groundwater Data System, 2017	High	LTAAELs as determined for Water Sharing Plans.
9	Risk of poor water quality to water users (QL3)	Percentage of overall WRP area under irrigation	5.6.1	NSW Department of Planning, Industry and Environment 2018, *NSW Landuse 2013* Australian Landuse and Management dataset (ALUM) at https://data.nsw.gov.au/data/dataset/b91b6975-462c-4d3f-b933-109ca7bdadbd) and groundwater source shapefile	Low	With irrigation intensity being nil to low across the area, there is high confidence in the data used to inform this component of the risk assessment.
10	Risk of growth in basic landholder rights reducing groundwater	Growth in plantation forestry area	5.7.1	CSIRO 2008, *Water availability in the Barwon-Darling. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia.	Low	Specific reference listed.

#	Metric	Data Description	Report Reference	Data source/Reference	Confidence level	Reasoning
	availability (R5) - Likelihood			CSIRO 2008a, *Water availability in the Gwydir. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia. CSIRO 2008b, *Water availability in the Macquarie-Castlereagh. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia. CSIRO 2008c, *Water availability in the Murray. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia. CSIRO 2008d, *Water availability in the Murrumbidgee. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia. CSIRO 2008e, *Water availability in the Namoi. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia.		
11	Risk of growth in local water utilities reducing groundwater availability (R6) - Likelihood	HEVAE consequence score (GDE)	6.3.1.5	Dabovic J, Dobbs L, Byrne G and Raine A 2019, *A new approach to prioritising groundwater dependent vegetation communities to inform groundwater management in New South Wales, Australia*, Australian Journal of Botany, 67, 397–413 Healey M, Raine A, Lewis A, Hossain B, Hancock F and Sayers J 2018, Applying the High Ecological Value Aquatic Ecosystem (HEVAE) Framework to Water Management Needs in NSW, NSW DPI Water, Sydney, NSW.	N/A	The HEVAE Framework has been considered a best practice approach to identifying environmental assets (Murray-Darling Basin Authority 2014). The criteria used in the HEVAE framework aligns to criteria listed in Schedules 8 and 9 of the Basin Plan for identifying ecological assets and ecosystem functions.
		Extraction compared to LTAAEL	6.3.1.5	NSW Department of Planning Environment, Water Licensing System	High	LTAAELs as determined for Water Sharing Plans.

#	Metric	Data Description	Report Reference	Data source/Reference	Confidence level	Reasoning
12	Risk of increases in irrigation efficiency and improved water delivery reducing recharge (R7) - Likelihood	HEVAE consequence score for instream values	6.3.2.8	Healey M, Raine A, Lewis A, Hossain B, Hancock F and Sayers J 2018, Applying the High Ecological Value Aquatic Ecosystem (HEVAE) Framework to Water Management Needs in NSW, NSW DPI Water, Sydney, NSW.	N/A	The HEVAE Framework has been considered a best practice approach to identifying environmental assets (Murray-Darling Basin Authority 2014). The criteria used in the HEVAE framework aligns to criteria listed in Schedules 8 and 9 of the Basin Plan for identifying ecological assets and ecosystem functions.
		Level of surface water-groundwater connection	6.3.2.8	DPI Water 2015, *Macro water sharing plans – the approach for groundwater. A report to assist community consultation*, NSW Department of Primary Industries, Office of Water, 2nd edition, updated November 2015.	N/A	
13	Risk of growth in plantation forestry intercepting recharge – (R8) Likelihood	Density of groundwater extraction (see #5 above)	6.4.1	NSW Department of Planning and Environment, Groundwater Data System	Moderate / High	This assessment has been undertaken with reference to data produced by NSW Department of Planning and Environment on metered groundwater extraction by licence holders. Production bore locations are identified throughout NSW, and licensed groundwater extraction is metered throughout the NSW Murray-Darling Basin Porous Rock.
14	Risk of growth in mining reducing groundwater availability (QL4)	Growth in coal and coal seam gas area	5.8	Bioregional Assessments Program https://www.bioregionalassessments.gov.au/bioregional-assessment-program	Moderate	This assessment does not calculate risk, but relies on the findings of an independent assessment of the potential for growth in coal seam gas and coal to provide a risk outcome. As such the potential for growth in all mining activities is not addressed and therefore the risk outcomes have moderate data confidence
15	Risk to water available for the Environment GDEs - Consequence	HEVAE consequence score (GDE)	6.2.1.2	Dabovic J, Dobbs L, Byrne G and Raine A 2019, *A new approach to prioritising groundwater dependent vegetation communities to inform groundwater management in New South Wales, Australia*, Australian Journal of Botany, 67, 397–413. Healey M, Raine A, Lewis A, Hossain B, Hancock F, Sayers J and Dabovic J draft, 'Applying the High Ecological Value Aquatic Ecosystem (HEVAE) Framework to Water Management Needs in NSW', NSW DPI Water, Sydney, NSW.	High	The HEVAE Framework has been considered a best practice approach to identifying environmental assets (Murray-Darling Basin Authority 2014). The criteria used in the HEVAE framework aligns to criteria listed in Schedules 8 and 9 of the Basin Plan for identifying ecological assets and ecosystem functions.

#	Metric	Data Description	Report Reference	Data source/Reference	Confidence level	Reasoning
		Extraction compared to LTAAEL	6.2.1.2	NSW Department of Planning, Industry and Environment Groundwater Data System, (2017) and NSW Water Licensing System (2017)	High	LTAAELs as determined for water sharing plans.
16	Risk to water available for the environment: Instream ecological values - Consequence	HEVAE consequence score for instream values	6.2.2.2	Healey M, Raine A, Lewis A, Hossain B, Hancock F, Sayers J and Dabovic J draft, 'Applying the High Ecological Value Aquatic Ecosystem (HEVAE) Framework to Water Management Needs in NSW', NSW DPI Water, Sydney, NSW.	High	The HEVAE Framework has been considered a best practice approach to identifying environmental assets (Murray-Darling Basin Authority 2014). The criteria used in the HEVAE framework aligns to criteria listed in Schedules 8 and 9 of the Basin Plan for identifying ecological assets and ecosystem functions.
		Level of surface water-groundwater connection	6.2.2.2	DPI Water 2015, Macro water sharing plans – the approach for groundwater. A report to assist community consultation, NSW Department of Primary Industries, Office of Water, 2nd edition, updated November 2015.	High	
17	Risk of groundwater causing local drawdown (R9, R10) - Likelihood	Density of groundwater extraction (see #5 above)	6.3.1	NSW Water Accounting System (2017)	Moderate / High	This assessment has been undertaken with reference to data produced by NSW Department of Planning, Industry and Environment on metered groundwater extraction by licence holders. Production bore locations are identified throughout NSW, and licensed groundwater extraction is metered throughout the Darling Alluvium
18	Risk of growth in plantation forestry intercepting recharge (R11, R12) - Likelihood	Growth in plantation forestry area (see #11 above)	6.4.1	CSIRO 2008, *Water availability in the Barwon-Darling. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia. CSIRO 2008a, *Water availability in the Gwydir. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia. CSIRO 2008b, *Water availability in the Macquarie-Castlereagh. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia. CSIRO 2008c, *Water availability in the Murray. A report to the Australian*	Low	Specific reference listed (modelled predictions have high uncertainty).

#	Metric	Data Description	Report Reference	Data source/Reference	Confidence level	Reasoning
				Government from the CSIRO Murray-darling Basin Sustainable Yields Project, CSIRO, Australia. CSIRO 2008d, *Water availability in the Murrumbidgee. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia. CSIRO 2008e, *Water availability in the Namoi. A report to the Australian Government from the CSIRO Murray-darling Basin Sustainable Yields Project,* CSIRO, Australia.		
19	Risk of climate change reducing recharge and groundwater availability (R13, R14) - Likelihood	Aquifer S/R ratio (see #6 above)	6.5.1	Storage and Recharge ratios: CSIRO and SKM 2010, Sustainable Extraction Limits Derived from the Recharge Risk Assessment Method - New South Wales (part 1, 2 and 3), CSIRO Canberra.	Moderate	The metrics are an approximation of the productive base of the groundwater system, and as such, their applicability is moderate.
20	Risk of poor water quality to the environment (QL5)	Qualitative assessment of risk	6.6	Expert opinion	Low	This is a qualitative assessment based on NSW Department of Planning and Environment groundwater specialist expert opinion.
21	Risk of growth in BLR and LWU to the environment (QL6)	Qualitative assessment of risk	0	Expert opinion	Low	This is a qualitative assessment based on NSW Department of Planning and Environment groundwater specialist expert opinion.
22	Risk of growth in mining reducing groundwater availability (GDEs and instream ecological values) (QL7)	Growth in coal and coal seam gas area	6.8	Bioregional Assessments Program https://www.bioregionalassessments.gov.au/bioregional-assessment-program	Moderate	This assessment does not calculate risk, but relies on the findings of an independent assessment of the potential for growth in coal seam gas and coal to provide a risk outcome. As such the potential for growth in all mining activities is not addressed and therefore the risk outcomes have moderate data confidence

Appendix C HEVAE alignment with Schedules 8 and 9 of the Basin Plan for groundwater–dependent ecosystems

Table C-1 Alignment of Schedule 8 Key environmental asset criteria with GDE HEVAE criteria

KEA Criteria (Schedule 8)	HEVAE Criteria/associated attributes
Criterion 1: The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of supporting species listed in those agreements Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it is: (a) A declared Ramsar wetland; or (b) With environmental watering, capable of supporting a species listed in or under the JAMBA, CAMBA, ROKAMBA or the Bonn Convention.	Vital Habitat: An aquatic ecosystem provides vital habitat for flora and fauna species if it supports: i) Unusually large numbers of a particular native or migratory species; and/or ii) Maintenance of populations of specific species at critical life cycle stages; and/or iii) key/significant refugia for aquatic species that are dependent on the habitat, particularly at times of stress.
Criterion 2: The water-dependent ecosystem is natural or near-natural, rare or unique Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Represents a natural or near-natural example of a particular type of water-dependent ecosystem as evidenced by a relative lack of post-1788 human induced hydrologic disturbance or adverse impacts on ecological character; or (b) Represents the only example of a particular type of water-dependent ecosystem in the Murray-Darling Basin; or (c) Represents a rare example of a particular type of water-dependent ecosystem in the Murray-Darling Basin.	Naturalness: The ecological character of the aquatic ecosystem is not adversely affected by modern human activity. - Percentage of native vegetation verses non-native vegetation; - Edge to area ration of patches; - Catchment Disturbance Index (infrastructure density, land use index and land cover change); and - National parks.
Criterion 3: The water-dependent ecosystem provides vital habitat Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Provides vital habitat, including: (i) A refugium for native water-dependent biota during dry spells and drought; or (ii) Pathways for the dispersal, migration and movements of native water-dependent biota; or (iii) Important feeding, breeding and nursery sites for native water-dependent biota; or (b) Is essential for maintaining, and preventing declines of, native water-dependent biota.	Vital Habitat: An aquatic ecosystem provides vital habitat for flora and fauna species if it supports: i) Unusually large numbers of a particular native or migratory species; and/or ii) Maintenance of populations of specific species at critical life cycle stages; and/or iii) key/significant refugia for aquatic species that are dependent on the habitat, particularly at times of stress. - Vital wetlands (Ramsar/DIWA/SEPP14 (coastal) listed wetlands) and springs; and - vegetation condition (condition of native vegetation can be used to provide an indication of the ability of the community to support species diversity).
Criterion 4: Water-dependent ecosystems that support Commonwealth, State or Territory listed threatened species or communities Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Supports a listed threatened ecological community or listed threatened species; or	Distinctiveness: The aquatic ecosystem is rare/threatened or unusual; and/or The aquatic ecosystem supports rare/threatened/ endemic species/communities/genetically unique populations; and/or The aquatic ecosystem exhibits rare or unusual geomorphological features/processes and/or environmental conditions, and is likely to support unusual assemblages of

KEA Criteria (Schedule 8)	HEVAE Criteria/associated attributes
Note: See the definitions of listed threatened ecological community and listed threatened species in section 1.07. (b) Supports water-dependent ecosystems treated as threatened or endangered (however described) under State or Territory law; or (c) Supports one or more native water-dependent species treated as threatened or endangered (however described) under State or Territory law.	species adapted to these conditions, and/or are important in demonstrating key features of the evolution of Australia's landscape, riverscape or biota. - State and/or Commonwealth listed threatened species, endangered populations and endangered ecological communities.
Criterion 5: The water-dependent ecosystem supports, or with environmental watering is capable of supporting, significant biodiversity Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it supports, or with environmental watering is capable of supporting, significant biological diversity. This includes a water-dependent ecosystem that: (a) Supports, or with environmental watering is capable of supporting, significant numbers of individuals of native water-dependent species; or (b) Supports, or with environmental watering is capable of supporting, significant levels of native biodiversity at the genus or family taxonomic level, or at the ecological community level.	Diversity: The aquatic ecosystem exhibits exceptional diversity of species (native/migratory), habitats, and/or geomorphological features/processes. - habitat types associated with characteristics of patch size and isolation (i.e. distance between patches).

Table C-2 Alignment of Schedule 9 Key ecosystem function criteria with GDE HEVAE criteria

Key ecosystem function criteria (Schedule 9)	HEVAE or risk assessment criteria/associated attributes
Criterion 1: The ecosystem function supports the creation and maintenance of vital habitats and populations Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides vital habitat, including: (a) a refugium for native water-dependent biota during dry periods and drought; or (b) pathways for the dispersal, migration and movement of native water-dependent biota; or (c) a diversity of important feeding, breeding and nursery sites for native water-dependent biota; or (d) a diversity of aquatic environments including pools, riffle and run environments; or (e) a vital habitat that is essential for preventing the decline of native water-dependent biota.	**HEVAE** The HEVAE method identifies a diverse range of vegetation GDE areas in very poor through to very high ecological value. Highest ecological value areas are assumed to provide a diverse range of habitats for native water-dependent flora and fauna. Vital habitat is a key criteria assessed in the HEVAE method. **Vital Habitat:** An aquatic ecosystem provides vital habitat for flora and fauna species if it supports: i) Unusually large numbers of a particular native or migratory species; and/or ii) Maintenance of populations of specific species at critical life cycle stages; and/or iii) key/significant refugia for aquatic species that are dependent on the habitat, particularly at times of stress. - Vital wetlands (Ramsar/DIWA/SEPP14 (coastal) listed wetlands) and springs; and - vegetation condition (condition of native vegetation can be used to provide an indication of the ability of the community to support species diversity). **Diversity:** The aquatic ecosystem exhibits exceptional diversity of species (native/migratory), habitats, and/or geomorphological features/processes. habitat types associated with characteristics of patch size and isolation (i.e. distance between patches). **Risk Assessment**

Key ecosystem function criteria (Schedule 9)	HEVAE or risk assessment criteria/associated attributes
	The surface water risk assessment process identified key features of flow regimes which have impacts on key ecosystem functions identified by the Murray-Darling Basin Authority (2010; 2012) and Alluvium (2010). Within the risk assessment method, impacts on ecosystem function are considered through assessment of altered stream flow in regulated and unregulated rivers. Flow regimes influence the hydrologic connectivity, longitudinal and lateral pathways for ecological dispersal, nutrient and organic and inorganic material delivery in river systems.
Criterion 2: The ecosystem function supports the transportation and dilution of nutrients, organic matter and sediment Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides for the transportation and dilution of nutrients, organic matter and sediment, including: (a) pathways for the dispersal and movement of organic and inorganic sediment, delivery to downstream reaches and to the ocean, and to and from the floodplain; or (b) the dilution of carbon and nutrients from the floodplain to the river systems.	N/A
Criterion 3: The ecosystem function provides connections along a watercourse (longitudinal connections) Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides connections along a watercourse or to the ocean, including longitudinal connections: (a) for dispersal and re-colonisation of native water-dependent communities; or (b) for migration to fulfil requirements of life-history stages; or (c) for in-stream primary production.	N/A
Criterion 4: The ecosystem function provides connections across floodplains, adjacent wetlands and billabongs (lateral connections) Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides connections across floodplains, adjacent wetlands and billabongs, including: (a) lateral connections for foraging, migration and re-colonisation of native water-dependent species and communities; or (b) lateral connections for off-stream primary production.	**Vital Habitat:** An aquatic ecosystem provides vital habitat for flora and fauna species if it supports: - Vital wetlands (Ramsar/DIWA/SEPP14 (coastal) listed wetlands) and springs; and - vegetation condition (condition of native vegetation can be used to provide an indication of the ability of the community to support species diversity). **Diversity:** The aquatic ecosystem exhibits exceptional diversity of species (native/migratory), habitats, and/or geomorphological features/processes. - habitat types associated with characteristics of patch size and isolation (i.e. distance between patches).

References

Alluvium, (2010), *Key ecosystem functions and their environmental water requirements*. Report by Alluvium for Murray-Darling Basin Authority, Canberra, ACT.

Murray-Darling Basin Authority, (2010), *Guide to the proposed Basin Plan: Technical Background, Murray-Darling Basin Authority, Volume 2, Part 1*, Canberra, ACT.

Murray-Darling Basin Authority, (2012), *Hydrologic modelling to inform the proposed Basin Plan - methods and results*. Murray-Darling Basin Authority, Canberra, ACT.

Appendix D HEVAE alignment with Schedules 8 and 9 for instream ecological values

Table D-1 Alignment of Schedule 8 Key environmental asset criteria with HEVAE criteria for instream ecological values

Key environmental asset criteria (Schedule 8)	HEVAE criteria/associated attributes
Criterion 1: The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of supporting species listed in those agreements Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it is: (a) A declared Ramsar wetland; or (b) With environmental watering, capable of supporting a species listed in or under the JAMBA, CAMBA, ROKAMBA or the Bonn Convention.	Vital Habitat: An aquatic ecosystem provides vital habitat for flora and fauna species if it supports (see details below)
Criterion 2: The water-dependent ecosystem is natural or near-natural, rare or unique Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Represents a natural or near-natural example of a particular type of water-dependent ecosystem as evidenced by a relative lack of post-1788 human induced hydrologic disturbance or adverse impacts on ecological character; or (b) Represents the only example of a particular type of water-dependent ecosystem in the Murray-Darling Basin; or (c) Represents a rare example of a particular type of water-dependent ecosystem in the Murray-Darling Basin.	Naturalness: The ecological character of the aquatic ecosystem is not adversely affected by modern human activity. • Geomorphic recovery (conservation or rapid) potential of River Styles® • Hydrologic stress (demand versus low flow percentile) • Catchment Disturbance Index (infrastructure density, land use index and land cover change) • Macroinvertebrate (AUSRIVAS) O/E bands (i.e. deviation from reference) • River reaches in National Park Estate
Criterion 3: The water-dependent ecosystem provides vital habitat Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Provides vital habitat, including: (i) A refugium for native water-dependent biota during dry spells and drought; or (ii) Pathways for the dispersal, migration and movements of native water-dependent biota; or (iii) Important feeding, breeding and nursery sites for native water-dependent biota; or (b) Is essential for maintaining, and preventing declines of, native water-dependent biota.	Vital Habitat: An aquatic ecosystem provides vital habitat for flora and fauna species if it supports: i. unusually large numbers of a particular native or migratory species; and/or ii. maintenance of populations of specific species at critical life cycle stages; and/or iii) key/significant refugia for aquatic species that are dependent on the habitat, particularly at times of stress. • Vital wetlands (Ramsar and DIWA listed wetlands) • Dissolved Organic Carbon (DOC) input (surrogate measure = river reaches of 60% woody riparian vegetation cover and measure of unconfined or partially confined River Style) • Large Woody Debris (LWB) (surrogate measure = river reaches of 60% woody riparian vegetation cover and specific River Styles®)

Key environmental asset criteria (Schedule 8)	HEVAE criteria/associated attributes
Criterion 4: Water-dependent ecosystems that support Commonwealth, State or Territory listed threatened species or communities Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) Supports a listed threatened ecological community or listed threatened species; or Note: See the definitions of listed threatened ecological community and listed threatened species in section 1.07. (b) Supports water-dependent ecosystems treated as threatened or endangered (however described) under State or Territory law; or (c) Supports one or more native water-dependent species treated as threatened or endangered (however described) under State or Territory law.	Distinctiveness: The aquatic ecosystem is rare/threatened or unusual; and/or The aquatic ecosystem supports rare/threatened/ endemic species/communities/genetically unique populations; and/or The aquatic ecosystem exhibits rare or unusual geomorphological features/processes and/or environmental conditions, and is likely to support unusual assemblages of species adapted to these conditions, and/or are important in demonstrating key features of the evolution of Australia's landscape, riverscape or biota. • State and/or Commonwealth listed threatened species, endangered populations and endangered ecological communities • Rare River Styles®
Criterion 5: The water-dependent ecosystem supports, or with environmental watering is capable of supporting, significant biodiversity Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it supports, or with environmental watering is capable of supporting, significant biological diversity. This includes a water-dependent ecosystem that: (a) Supports, or with environmental watering is capable of supporting, significant numbers of individuals of native water-dependent species; or (b) Supports, or with environmental watering is capable of supporting, significant levels of native biodiversity at the genus or family taxonomic level, or at the ecological community level.	Diversity: The aquatic ecosystem exhibits exceptional diversity of species (native/migratory), habitats, and/or geomorphological features/processes. • Macroinvertebrate Diversity (No. of AUSRIVAS Families) • Fish Diversity (Fish biodiversity hot spots assigned to specific River Styles® reach)
Reference: Healey M, Raine A, Lewis A, Hossain B, Hancock F and Sayers J (2018) *Applying the High Ecological Value Aquatic Ecosystem (HEVAE) Framework to Water Management Needs in NSW*, NSW DPI Water, Sydney, NSW.	

Table D-2 Alignment of Schedule 9 Key ecosystem function criteria with HEVAE criteria for instream ecological values

Key ecosystem function criteria (Schedule 9)	HEVAE or risk assessment criteria/associated attributes
Criterion 1: The ecosystem function supports the creation and maintenance of vital habitats and populations Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides vital habitat, including: (a) a refugium for native water-dependent biota during dry periods and drought; or	**HEVAE** The HEVAE method identifies a diverse range of instream and riparian riverine areas in very poor through to very high ecological value. Highest ecological value areas are assumed to provide a diverse range of aquatic habitats for native water-dependent flora and fauna. Vital habitat is a key criteria assessed in the HEVAE method.

Key ecosystem function criteria (Schedule 9)	HEVAE or risk assessment criteria/associated attributes
(b) pathways for the dispersal, migration and movement of native water-dependent biota; or (c) a diversity of important feeding, breeding and nursery sites for native water-dependent biota; or (d) a diversity of aquatic environments including pools, riffle and run environments; or (e) a vital habitat that is essential for preventing the decline of native water-dependent biota.	Vital Habitat: An aquatic ecosystem provides vital habitat for flora and fauna species if it supports: i. unusually large numbers of a particular native or migratory species; and/or ii. maintenance of populations of specific species at critical life cycle stages; and/or iii) key/significant refugia for aquatic species that are dependent on the habitat, particularly at times of stress. • Vital wetlands (Ramsar and DIWA listed wetlands) • Dissolved Organic Carbon (DOC) input (surrogate measure = river reaches of 60% woody riparian vegetation cover and measure of unconfined or partially confined River Style) • Large Woody Debris (LWB) (surrogate measure = river reaches of 60% woody riparian vegetation cover and specific River Styles®) **Risk Assessment** The risk assessment process has identified key features of flow regimes which have impacts on key ecosystem functions identified by the Murray-Darling Basin Authority (2010; 2012) and Alluvium (2010). Within the risk assessment method, impacts on ecosystem function are considered through assessment of altered stream flow in regulated and unregulated rivers. Flow regimes influence the hydrologic connectivity, longitudinal and lateral pathways for ecological dispersal, nutrient and organic and inorganic material delivery in river systems.
Criterion 2: The ecosystem function supports the transportation and dilution of nutrients, organic matter and sediment Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides for the transportation and dilution of nutrients, organic matter and sediment, including: (a) pathways for the dispersal and movement of organic and inorganic sediment, delivery to downstream reaches and to the ocean, and to and from the floodplain; or (b) the dilution of carbon and nutrients from the floodplain to the river systems.	
Criterion 3: The ecosystem function provides connections along a watercourse (longitudinal connections) Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides connections along a watercourse or to the ocean, including longitudinal connections: (a) for dispersal and re-colonisation of native water-dependent communities; or (b) for migration to fulfil requirements of life-history stages; or (c) for in-stream primary production.	
Criterion 4: The ecosystem function provides connections across floodplains, adjacent wetlands and billabongs (lateral connections) Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides connections across floodplains, adjacent wetlands and billabongs, including: (a) lateral connections for foraging, migration and re-colonisation of native water-dependent species and communities; or (b) lateral connections for off-stream primary production.	

References

Alluvium, (2010), *Key ecosystem functions and their environmental water requirements*. Report by Alluvium for Murray-Darling Basin Authority, Canberra, ACT.

Murray-Darling Basin Authority, (2010), *Guide to the proposed Basin Plan: Technical Background, Murray-Darling Basin Authority, Volume 2, Part 1*, Canberra, ACT.

Murray-Darling Basin Authority, (2012), *Hydrologic modelling to inform the proposed Basin Plan - methods and results*. Murray-Darling Basin Authority, Canberra, ACT.

Appendix E Consequence decision trees

Decision trees (E-1; E-2) and their annotation tables (E-1; E2) for HEVAE scoring for GDEs and instream ecological values are provided below.

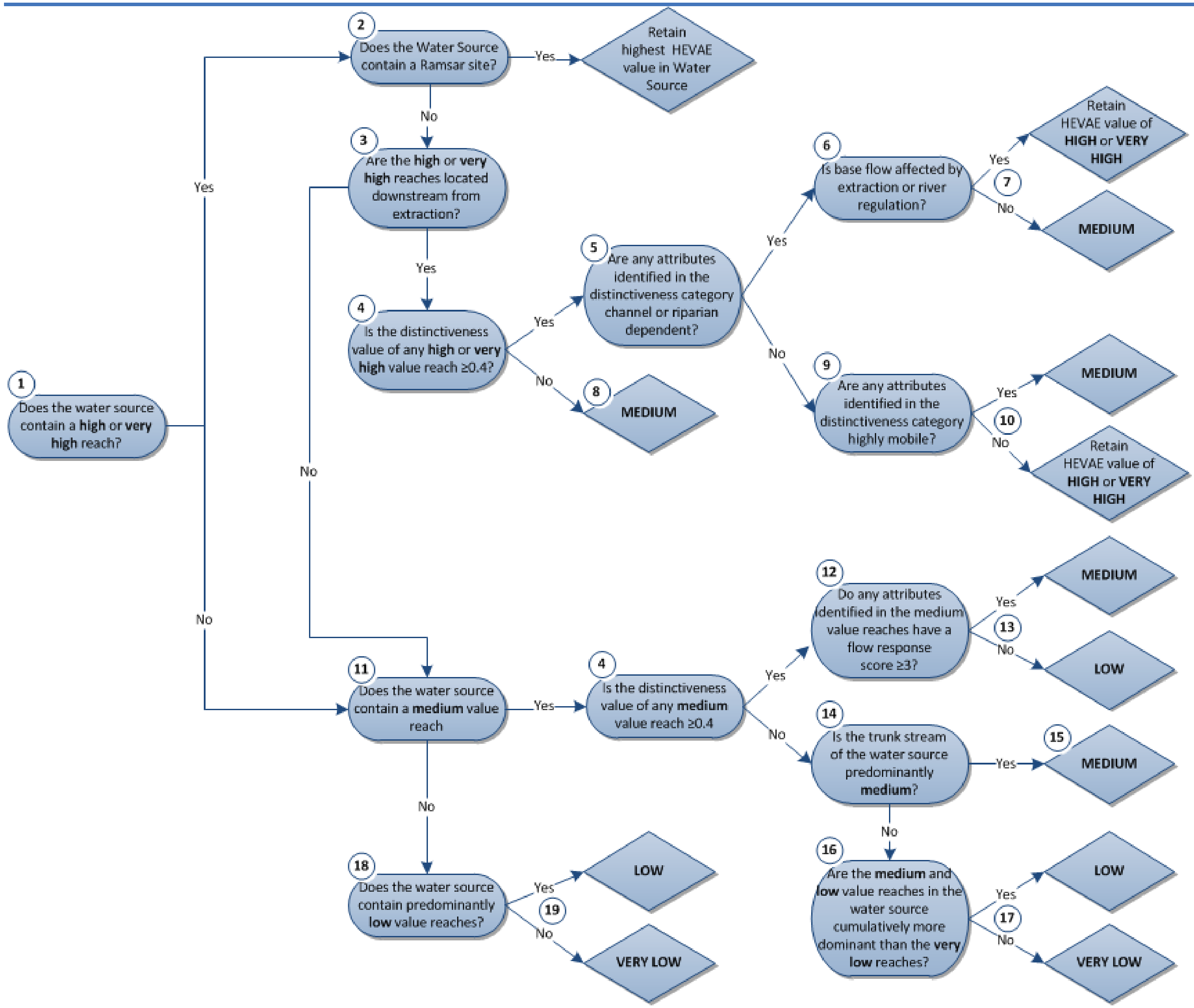


Figure E- 1 Consequence decision tree for instream HEVAE

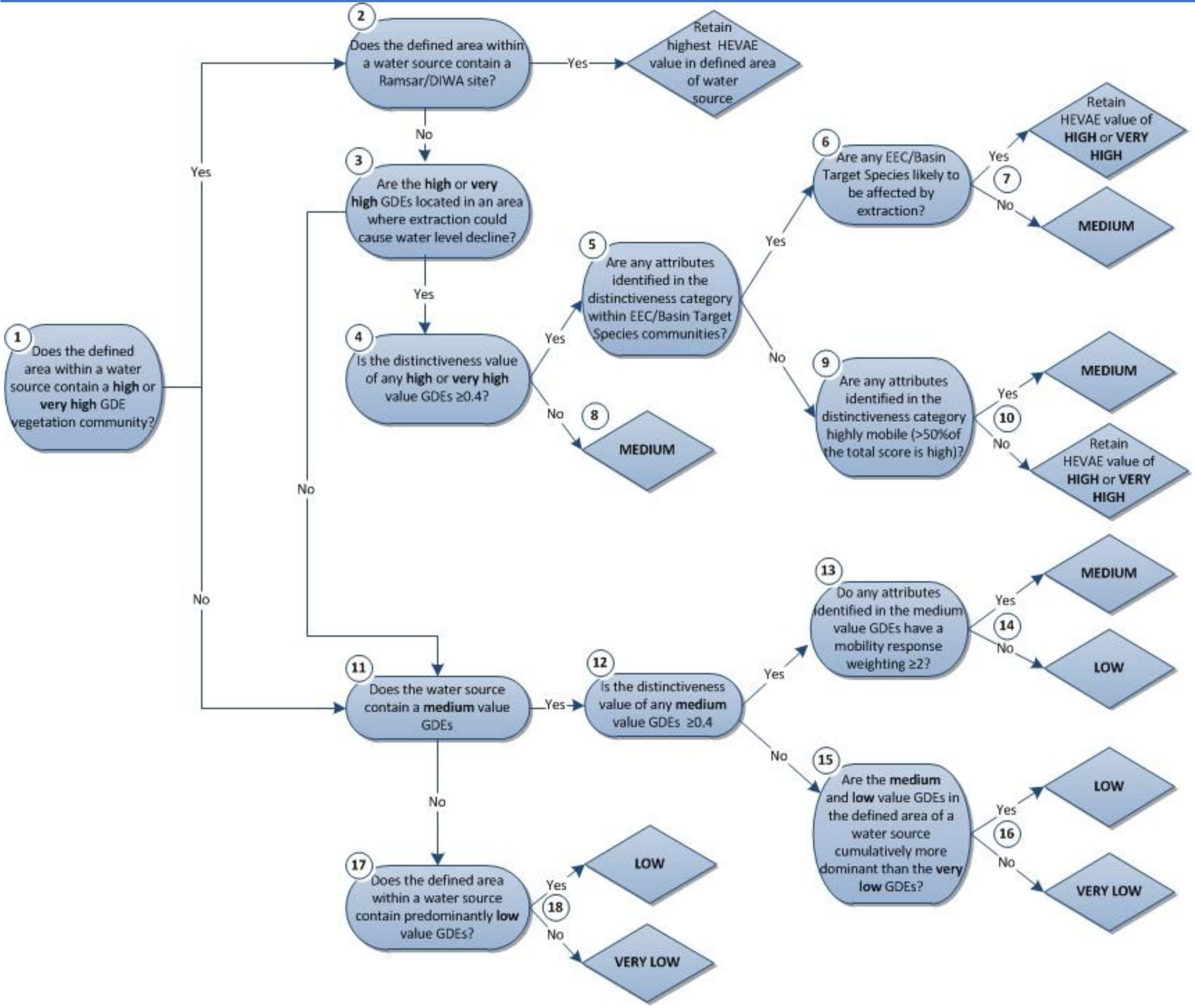


Figure E- 2 Consequence decision tree for GDE HEVAE

Table E-1 Rationale for each bifurcation in the decision tree used for converting instream HEVAE ranks to ‘consequence of extraction pressure on aquatic ecosystem condition’ score

ANNOTATION	RATIONALE
1	Management for retention of conservation values is a higher priority in high and very high value reaches Limiting extraction is easier to justify in high and very high value reaches, than it is in medium reaches
2	Ramsar sites are valued for their contribution to international conservation efforts for migratory species. Australia is a signatory country and has an obligation to maintain these sites. This includes maintenance of flows.
3	The attributes of high or very high value sites are influenced by extraction pressure. Sites that are upstream of extraction points are assumed to be unaffected by extraction pressure, so the assessment focus shifts to whether there are medium value reaches in the water source. If a high or very high value site is likely to be affected by extraction pressure the focus shift to whether any threatened species, populations, communities or rare River Styles® could be affected.
4	The attributes of high or very high value sites are influenced by extraction pressure. The most ‘at risk’ HEVAE criteria from extraction pressure (in the short-term) is distinctiveness. Distinctiveness includes consideration of biotic and abiotic characteristics and function of the reach (i.e. threatened species, populations, communities and rare River Styles®). A distinctiveness score of ≥ 0.4 in the HEVAE means the reach has a medium, high or very high value as habitat for threatened species, populations, or communities, or a rare River Style®. Habitat for threatened species, populations and communities is protected under State and Commonwealth legislation.
5	Distinguishes between species, populations, communities and/or rare River Styles® that occur on the floodplain versus the channel and riparian zone because (it was assumed) extraction pressure is more likely to affect attributes that occur in the channel and riparian zone, rather than the floodplain. *This is a decision that relies on expert understanding of the attribute’s ecology and biology.*
6	Given the attribute is identified as relying on channel and riparian habitat (from 5), this step assumes the least possible habitat available to the attribute occurs under low flow conditions, and asks whether the lowest flows in the system are affected by extraction.
7	Any attributes that are channel and/or riparian dependent, and are considered vulnerable to extraction of low flows retain their original high or very high value category. Any attributes that are channel and/or riparian dependent and are considered resilient to extraction of low flows are allocated a ‘medium’ consequence category.
8	High or very high value reaches that have low distinctiveness are assumed to have attributes that are more resilient to extraction pressure (at least in the short-term), and are assigned a ‘medium’ consequence category.
9	Establishes that attributes are floodplain dependent, and asks whether they are able to move (i.e. birds, bats) or not (i.e. plant). The assumption is that more mobile species/population/community can move to avoid changes in habitat owing to extraction pressure.
10	If the species can move they are assigned a risk category of ‘medium’.

ANNOTATION	RATIONALE
	If the species/population/community is sessile, it is assumed to be at greater risk of harm from extraction pressure (because it can't move to avoid the pressure), and retains its original categorisation of 'high' or 'very high'.
11	Establishes that the water source either doesn't have 'high' or 'very high' reaches, OR there are 'high' or 'very high' reaches but they are above extraction points (and therefore assumed unaffected by extraction pressure), and asks whether there are 'medium' value reaches in the water source. This allows the risk of extraction pressure on medium value aquatic ecosystems to be assessed independently of the 'low' and 'very low' value aquatic ecosystems.
12	Asks whether species/populations/communities in the reach are moderately to highly sensitive to extraction, primarily because they specific flow requirements and limited ability to move if those flow requirements are not met (e.g. fish, frogs, turtles, macrophytes). This information is in the MS Excel Distinctiveness file for each catchment, in the column labelled 'Flow Sensitivity Weighting'
13	If a species/population/community has a flow response score ≥3 (i.e. it is sensitive to extraction), it is assigned a risk category of 'medium'. If a species/population/community has a flow response score <3 (i.e. it is less sensitive to extraction), it is assigned a risk category of 'low'.
14	Deals with 'medium' value reaches that don't have high Distinctiveness (i.e. ≥0.4). Asks whether the main river in the water source has a predominantly 'medium' value. This question weights the value of the main river higher than any tributaries, because it is assumed the main river is likely more affected by extraction pressure than tributaries.
15	If the main river in a water source has a predominantly medium HEVAE condition, the consequence score is also medium.
16	Asks whether the combined length of medium and low HEVAE reaches in a main river in an assessment area is less than the length of reaches in the same main river with a very low HEVAE rank. The rationale is if the main river is comprised of mostly low with some medium HEVAE reaches, then a conservative approach should be adopted and the low consequence score prevails.
17	If the reach has a mainly very low HEVAE rank, and there is little apparent reliance on the reach by freshwater-dependent flora and fauna, the consequence awarded is 'very low'.
18	There are no very high, high or medium HEVAE ranked reaches in the assessment area – only low and very low. It is assumed there is little reliance on habitats in these reaches by freshwater-dependent flora and fauna.
19	The assessment area is awarded the same consequence score as the predominant HEVAE rank for the area. It is assumed there is little reliance on habitats in these reaches by freshwater-dependent flora and fauna.

Table E-2 Rationale for each bifurcation in the decision tree used for converting HEVAE ranks to 'consequence of extraction pressure on GDE condition' score

ANNOTATION	RATIONALE
1	Management for retention of conservation values is a higher priority in high and very high value GDEs Limiting extraction is easier to justify in high and very high value GDEs, than it is in medium GDEs Some Groundwater alluvial water sources are large and applying an overall consequence score is not feasible for management purposes especially when some areas have very low or no extraction. These large water sources are divided into smaller areas using a comparison of recovered water levels between pre-development (1974 to 1978) and 2015/16 which was based upon the maximum recovered water level and the water year. The contour which was zero change was used to divide the water source into defined areas for determining consequence, likelihood and overall risk.
2	Ramsar/DIWA sites are valued for their contribution to international conservation efforts for migratory species. Australia is a signatory country and has an obligation to maintain these sites.
3	Water level decline is either associated with observed negative change in recovered water levels (pre-development and 2015/16 water levels). The attributes of high or very high value sites are influenced by extraction pressure. Sites that are located in areas where there is no observed decline in water levels or located in areas with low or no extraction points are assumed to be unaffected by extraction pressure, so the assessment focus shifts to whether there are medium value reaches in the water source. If a high or very high value site is likely to be affected by extraction pressure the focus shift to whether any threatened species, populations, communities or rare river styles could be affected.
4	The attributes of high or very high value sites are influenced by extraction pressure. The most 'at risk' HEVAE criteria from extraction pressure (in the short-term) is distinctiveness. Distinctiveness includes consideration of biotic and abiotic characteristics and function of the GDE (i.e. threatened species, populations and communities). A distinctiveness score of ≥ 0.4 in the HEVAE means the GDE has a medium, high or very high value as habitat for threatened species, populations, or communities. Habitat for threatened species, populations and communities is protected under State and Commonwealth legislation.
5	Distinguishes between species, populations, communities that are Endangered Ecological Communities (EEC) or a Basin Target Species (BTS). These communities are identified as being important under the Basin Watering strategy and have targets for improving health and distribution over the term of the WRPs.
6	Given the attribute is identified as being an EEC or BTS (from 5), this step assumes that the habitat is at risk from extraction which causes altered groundwater availability.
7	Any attributes that are considered vulnerable to extraction of groundwater retain their original high or very high value category. Any attributes that are considered resilient to extraction of low flows are allocated a 'medium' consequence category.
8	High or very high value GDEs that have low distinctiveness are assumed to have attributes that are more resilient to extraction pressure (at least in the short-term), and are assigned a 'medium' consequence category.

ANNOTATION	RATIONALE
9	Establishes if attributes highly mobile (i.e. birds, bats) or not (i.e. plant, frogs). The assumption is that more mobile species/population/community can move to avoid changes in habitat owing to extraction pressure.
10	Due to all threatened species being used in Distinctiveness, a threshold of 50% highly mobile was used to assign a score. If the species can move they are assigned a risk category of 'medium'. If the species/population/community is sessile, it is assumed to be at greater risk of harm from extraction pressure (because it can't move to avoid the pressure), and retains its original categorisation of 'high' or 'very high'.
11	Establishes that the water source either doesn't have 'high' or 'very high' GDEs, OR there are 'high' or 'very high' GDEs but they are in areas of low or no extraction (and therefore assumed unaffected by extraction pressure), and asks whether there are 'medium' value GDEs in the water source. This allows the risk of extraction pressure on medium value GDEs to be assessed independently of the 'low' and 'very low' value aquatic ecosystems.
12	The attributes of high or very high value sites are influenced by extraction pressure. The most 'at risk' HEVAE criteria from extraction pressure (in the short-term) is distinctiveness. Distinctiveness includes consideration of biotic and abiotic characteristics and function of the GDE (i.e. threatened species, populations and communities). A distinctiveness score of ≥ 0.4 in the HEVAE means the GDE has a medium, high or very high value as habitat for threatened species, populations, or communities. Habitat for threatened species, populations and communities is protected under State and Commonwealth legislation.
13	Asks whether species/populations/communities in the GDEs are moderately to highly sensitive to extraction, and limited ability to move if those flow requirements are not met (e.g. plants, frogs, turtles, small mammals, and small birds). *Flow ratings of 4 and 3 can be considered flow dependant for species. A species must be known to occur (i.e. a score of 1 = present in the distinctiveness attributes)* *Furthermore the presence of Murray cod alone is insufficient, other species, populations etc. must be present.*
14	If a species/population/community has a mobility response score ≥2 (i.e. its sensitive to extraction), it is assigned a risk category of 'medium'. If a species/population/community has a mobility response score <2 (i.e. it is less sensitive to extraction), it is assigned a risk category of 'low'.
15	Asks whether the combined area of medium and low HEVAE GDEs in a defined area in the water source is less than the area of GDEs in the defined area with a very low HEVAE rank. The rationale is if the defined area is comprised of mostly low with some medium HEVAE GDEs, then a conservative approach should be adopted and the low consequence score prevails.
16	If the GDE has a mainly very low HEVAE rank, and there is little apparent reliance on the reach by flora and fauna, the consequence awarded is 'very low'.
17	There are no very high, high or medium HEVAE ranked GDEs in the assessment area – only low and very low. It's assumed there is little reliance on habitats in these GDEs by freshwater-dependent flora and fauna.
18	The assessment area is awarded the same consequence score as the predominant HEVAE rank for the area. It's assumed there is little reliance on habitats in these GDEs by flora and fauna.