Groundwater Risk Assessment Tool and Management Framework

MAIN REPORT

Groundwater Assessment Project

Australian Government

National Water Grid®

Tasmanian Government

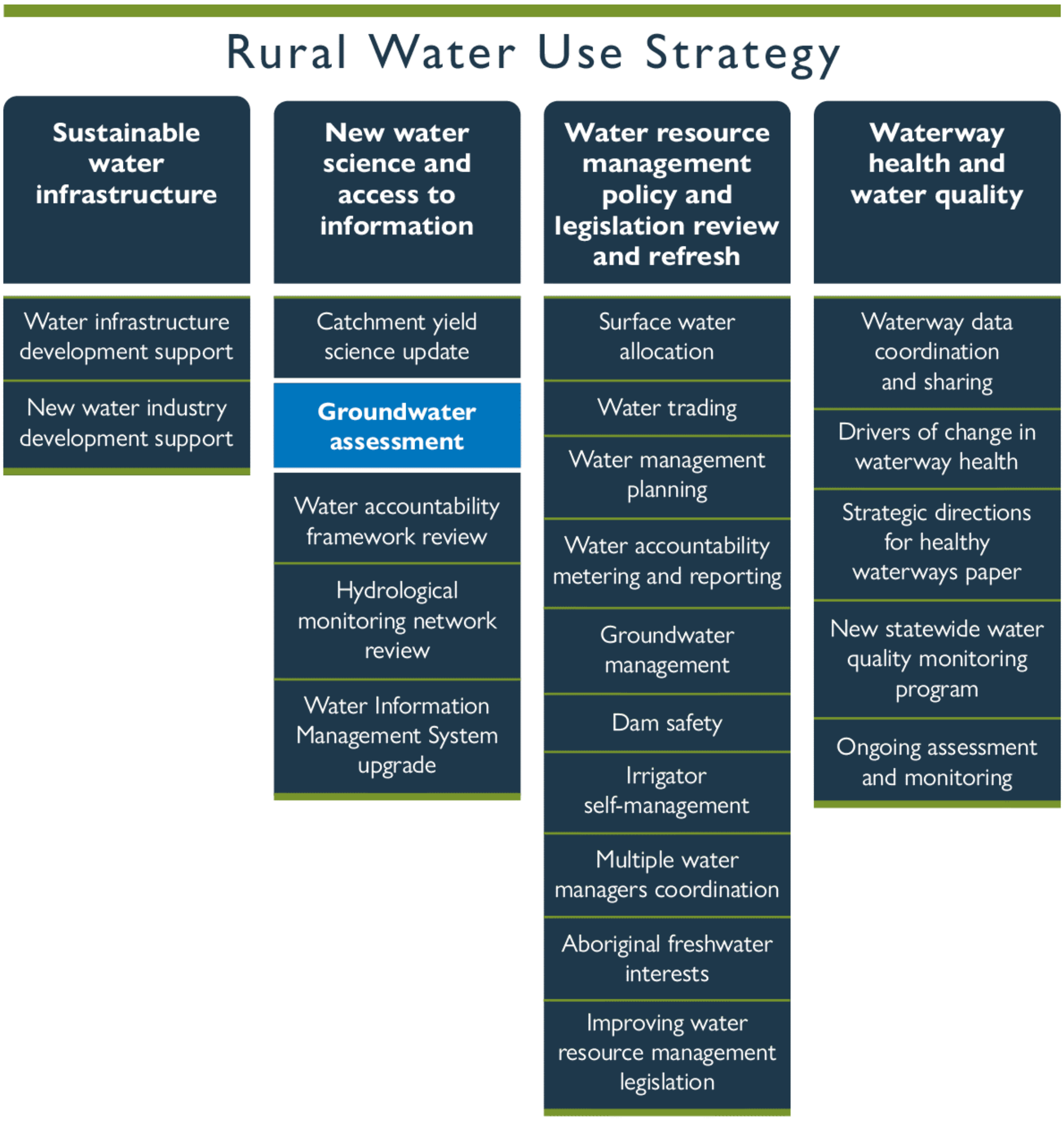
About this report

This document is part of a series of reports prepared for the Rural Water Use Strategy Program.

The Rural Water Use Strategy (RWUS) outlines actions to guide Tasmania's future water management arrangements to ensure water resource use and access is sustainable, supports the wide-range of water users that depend on them and protects and promotes freshwater environments.

The **Groundwater Assessment Project** (GAP) is one of several headline activities being implemented under the RWUS. These, together with a range of other activities, will ultimately lead to the review of water management policy and improvements in the functionality of Tasmania's water resource management legislation.

This project is being delivered in partnership between the Tasmanian Government and the Australian Government's National Water Grid Authority (NWGA).



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Appendices – available in separate report – see Groundwater Risk Assessment Tool and Management Framework - Appendices

Executive Summary

Tasmania's Rural Water Use Strategy (2021)[1] sets several goals and associated actions aimed at ensuring the availability of water resources to support the wide range of water uses and environments that depend on them. Action 1.2 of the Strategy is to consider any knowledge gaps identified through the Groundwater Assessment Project (GAP) and identify actions to improve our management of groundwater resources.

This report details the new Department of Natural Resources and Environment Tasmania (NRE Tas) Groundwater Risk Assessment Tool (GRAT) and Management Framework. The GRAT enables, for the very first time, a transparent and consistent statewide assessment of the relative risk of groundwater use and other factors that influence catchment and groundwater system water balances, water quality and values. The broader Management Framework, which incorporates the GRAT, provides a logical, transparent, and structured approach for identifying, analysing, and evaluating risks before determining the appropriate Risk Treatment. In other words, the GRAT is a tool that helps deliver the risk assessment component of the Framework.

Overview of the GRAT and Management Framework

The development of the GRAT and associated Management Framework focuses on providing a high-level (first pass) relative assessment of regional-scale risks across the State introducing a structured approach to assessing groundwater risk and supporting the identification of fit-for-purpose management actions in relation to those assessed risks. The GRAT and Management Framework are internal procedural tools designed to provide guidance to NRE Tas when identifying management provisions for groundwater that will protect existing and future users, as well as Groundwater Dependent Ecosystems (GDEs).

The GRAT and Management Framework provides a clear and transparent summary of the way NRE Tas assesses groundwater risk and management decisions supporting a consistent approach to the assessment and management of groundwater resources across the State.

It enables the assessment of cumulative impacts across key risk themes to support evaluation of environmental, social, and economic risks and outcomes. It is designed to be a risk screening tool that can be applied consistently to identify areas for further investigation or inform water resource management policy and water infrastructure investment planning.

The GRAT utilises multiple quantitative criteria, each with their own scoring and weighting schemes, to assess likelihood and consequence (the latter defined on the basis of value and vulnerability) of individual risk statements that are grouped into three main risk types:

1. Productive base of the aquifer
2. Groundwater quality and
3. Groundwater Dependent Ecosystems (GDEs).

The individual risk ratings are then aggregated to derive an overall risk for the assessed area.

The GRAT and Management Framework have undergone a peer review by Dr Ray Evans of Salient Solutions to ensure they are fit for purpose and in line with accepted national groundwater management and risk assessment practices.

Implementation of the GRAT and Management Framework

Preliminary implementation of the GRAT and Management Framework in 32 groundwater assessment units (GAUs) across the State has identified a number of high-risk areas requiring further investigations. This assessment required multiple statewide datasets to be identified, sourced, collated, and analysed. The value

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[2] https://nre.tas.gov.au/Documents/Rural%20Water%20Use%20Strategy.pdf

and limitations of existing information sources are described, and key knowledge and information gaps are identified.

Sassafras-Wesley Vale was assessed as having a high overall risk, which is consistent with it being the only area in Tasmania that is actively managed in the form of licensed groundwater allocations. Other high-risk GAUs that should be the primary focus for targeted field investigations include Smithton Syncline, Sheffield - Spreyton-Kimberley, Burnie Basalts, Flinders Island, Great-Forester-Brid, and Huon North.

The next stage of the GAP will involve implementation of targeted field studies, investigations, and activities to support the implementation of the Management Framework.

Report Structure

The report structure includes four core chapters:

1. Introduction.
2. Development of the GRAT and associated management framework, including the risk assessment framework, the GRAT and process of development.
3. Implementation and outcomes of the GRAT and associated management framework, including the identification of key risk areas in Tasmania and proposed management responses.
4. Key knowledge gaps and recommendations to guide future investment in monitoring, management, and investigation.

Acknowledgements

This report was authored in partnership between Dr Glenn Harrington (Innovative Groundwater Solutions) and Rebecca Sheldon (NRE Tasmania). We would also like to acknowledge Dr Ray Evans (Salient Solutions) for his peer review.

Abbreviations and Acronyms

CFEV	Conservation of Freshwater Ecosystem Values
DTW	Depth to Water table
EPA	Environment Protection Authority
GAP	Groundwater Assessment Project
GAU	Groundwater Assessment Unit
GDE	Groundwater Dependent Ecosystem
GIS	Geographic Information System
GMA	Groundwater Management Area
GRAT	Groundwater Risk Assessment Tool
GWIMS	Groundwater Information Management System
HGC	Hydrogeological Complex
ICT	Information and Communication Technology
ICV	Integrate Conservation Value
NRE Tas	Natural Resources and Environment Tasmania
NWGA	National Water Grid Authority
RWUS	Rural Water Use Strategy
TasSY Project	Tasmanian Sustainable Yield Project
TDS	Total Dissolved Solids

1. Introduction

This chapter provides background and context to the Groundwater Risk Assessment Tool (GRAT) and Management Framework. It describes the importance of the project in the Tasmanian groundwater context and how this project aligns with the Rural Water Use Strategy (RWUS) and associated programs.

1.1 Background

Estimates of groundwater use range from 10-30% of the total consumptive water use in the State. In several areas of the State, access to groundwater is commercially important, and in some cases, groundwater is the principal source of summer water for consumptive use. Interest in our groundwater resources is expected to increase over time in response to strong agricultural growth, greater utilisation of surface water resources and changes in the availability of water resulting from climate change.

Groundwater is critical for our freshwater environments. Groundwater inflows to creeks and rivers are the dominant contributor to summer river baseflows in a large portion of catchments across Tasmania (Harrington *et al*. 2009; Sheldon 2011).

Groundwater extraction can adversely impact water supply to water users and the environment including GDEs by causing drawdown of water levels, or indirectly by reducing groundwater flows to rivers and streams, impacting on catchment yields. Groundwater extraction has the potential to impact on the water quality of groundwater and surface water resources. Due to the interconnected nature of streams and rivers with groundwater systems in much of Tasmania, there is potential for groundwater extraction to cause increased transmission losses (loss of water from a system via groundwater or evaporation) in areas where water infrastructure relies on conveyance of irrigation rights via natural watercourses; and the potential to reduce the reliability and security of other surface water entitlements such as water licences issued under Part 6 of the Tasmanian *Water Management Act 1999*.

Sustainable groundwater yields and use, aquifer properties and recharge rates across Tasmania are not well understood due to the complexity of Tasmania's hydrogeological conditions. This is a knowledge gap that is relevant to water management decision-making and regulatory frameworks, infrastructure investment choices and optimising public investment in water security.

While there is a network of monitoring bores, and the locations and details of drilled bores is regulated and documented, NRE Tas has limited information on the success of, or on-going yield of the bores, the purpose for which the groundwater is used, or the amount of groundwater being taken on a seasonal and annual basis. This poses challenges to the sustainable management of the groundwater resource. Understanding where groundwater use may be impacting on other water users, or the environment, may highlight where more active management of groundwater extraction is required or areas where infrastructure investment through irrigation schemes may be desirable to provide alternative water supplies.

The GAP was developed in recognition that better understanding the potential for, or the extent of, groundwater use and impacts in Tasmania is important for meeting the objectives of the *Water Management Act 1999* and optimising water management outcomes for all water users including farmers, businesses, primary industries, and for the environment.

The project aims to develop the evidence-base to support review of groundwater management settings in Tasmania to sustainably manage our groundwater resources now and into the future.

1.2 Project Context

The GAP is one of three 'Water Science' projects funded by the Tasmanian Government and the Australian Government's National Water Grid Authority (NWGA). Together, these three projects underpin improvements to our knowledge base and support a range of actions under the Tasmanian Government's Rural Water Use Strategy (RWUS)[2] and associated Implementation Plan 2022-2025[3]. The GAP directly supports the delivery of Action 1.2 of the RWUS and specifically involves the following:

- Part A – the development of a Tasmanian Groundwater Risk Assessment Tool (GRAT) and management framework (i.e. the focus of this report); and
- Parts B & C – implementation of targeted field studies, investigations, and activities to support the GRAT and sustainable groundwater management in Tasmania.

The GAP has strong linkages to several other headline activities being implemented under the RWUS, as outlined in **Figure 1**. These, together with a range of other activities, will ultimately lead to the review of water management policy and improvements in the functionality of Tasmania's water resource management legislation.

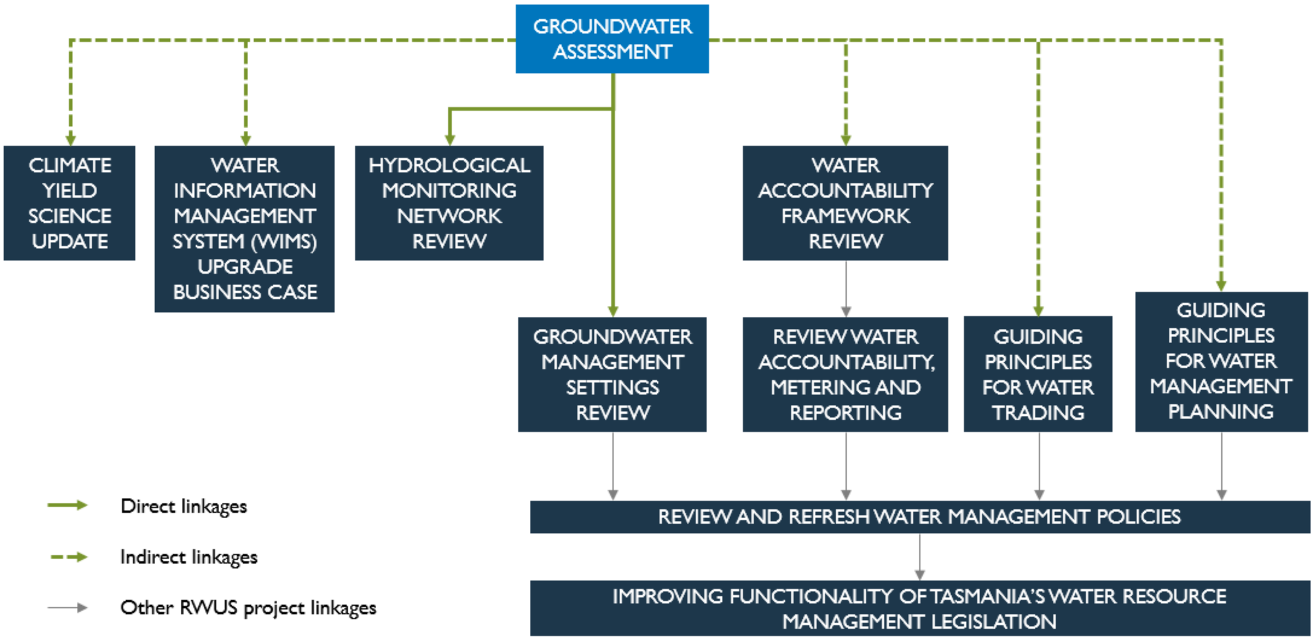

Figure 1: Linkages of the GAP to other relevant RWUS projects and initiatives.

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[2] https://nre.tas.gov.au/Documents/Rural%20Water%20Use%20Strategy.pdf

[3] https://nre.tas.gov.au/Documents/Rural%20Water%20Use%20Strategy%20Implementation%20Plan%202022.pdf

1.3 Scope

The development of the GRAT and associated groundwater management framework focuses on providing a high-level (first pass), relative assessment of regional risk at the statewide scale. It enables the assessment of cumulative impacts across key risk themes to support evaluation of environmental, social, and economic risks and outcomes. It is designed to be a risk screening tool that can be applied consistently to identify areas for further investigation or inform water resource management policy and water infrastructure investment planning.

The GRAT and Management Framework builds upon current NRE Tas work and previous groundwater assessment projects, most notably the former Department of Primary Industries and Water's 'Development of Models for Tasmanian Groundwater Resources' (REM 2008) and 'Tasmania Sustainable Yields (TasSY)' (Harrington *et al.* 2009). The latter focussed on selected regions of the State and specific risks to the water balance related to groundwater extraction and climate change. The GRAT therefore provides a more holistic approach to assessing groundwater-related risks across the entire State.

The GRAT enables, for the very first time, a transparent and consistent statewide assessment of the relative risk of groundwater use and other factors that influence catchment and groundwater system water balances, water quality and values. The broader Management Framework, which incorporates the GRAT, provides a logical, defensible, and structured approach for identifying, analysing, and evaluating risks before determining the appropriate Risk Treatment, which needs to consider both confidence levels and management response.

Primarily, the GRAT and management framework is an internal, procedural tool and document, which was designed to provide guidance to NRE Tas when identifying management provisions for groundwater – that is, provisions aimed at protecting existing and future users, as well as GDEs. Secondarily, the framework provides a clear and transparent summary of the way NRE Tas assesses groundwater risk and makes management decisions.

Review of the risk assessment component of the GRAT should be undertake on a medium to long-term basis to ensure it captures and draws on the best available information and remains consistent with accepted groundwater management practices nationally and overseas.

1.4 Objectives

The primary objective of the GAP is to deliver a transparent, systematic groundwater risk assessment tool and management framework that can be applied across the State to support existing and future sustainable management of the State's groundwater resources and meet our objectives under the *Water Management Act 1999* and National Water Initiative. The framework is underpinned by an appropriate information base, that can be consistently applied across the State and refined in priority groundwater use or future development areas. The GAP will improve our knowledge of risks and opportunities for groundwater use in Tasmania to inform water management policy and water infrastructure planning.

Specific objectives for Part A of the GAP are to:

- Collate knowledge and information that supports our current understanding of groundwater in key areas, including defining the groundwater resource (i.e. physical properties, storage, transmissivity, and recharge estimates), potential for impacts, estimating extraction, and identifying GDEs.
- Identify and outline options to address knowledge gaps (i.e. to inform Parts B & C of the GAP).
- Develop a contemporary statewide groundwater risk analysis tool that would utilise all available and future streams of groundwater information and apply this in a defendable risk management framework to assess risk.
- Identify management options for different levels of estimated groundwater risk and confidence in the risk assessment.

2. Groundwater Risk Assessment Tool and Management Framework Development

This chapter outlines the risk assessment framework that underpins the GRAT. It describes in detail the process undertaken to develop the GRAT and the associated management framework, including guiding principles, scale of assessment, through to proof of concept, limitations, and review requirements.

2.1 Risk Management Framework

The risk management framework and GRAT have been informed by several key references including: DEWNR (2012), DLWC (1998), RPS Aquaterra (2012), and Anderson *et al.* (2014). The framework is based on the Australian and New Zealand Standard for risk management (AS/NZS ISO 31000: 2018), which provides for the management of risk in a systematic, transparent, and credible manner. The risk management framework is summarised in **Figure 2**.

The GRAT is based on the standard approach to semi-quantitative risk assessment which can be influenced by the quality of information used, the assumptions and exclusions made, and any limitations of the techniques and how they are executed. Accordingly, the assumptions and exclusions have been clearly documented throughout this report so that decision makers can interpret the results of GRAT implementation with appropriate context.

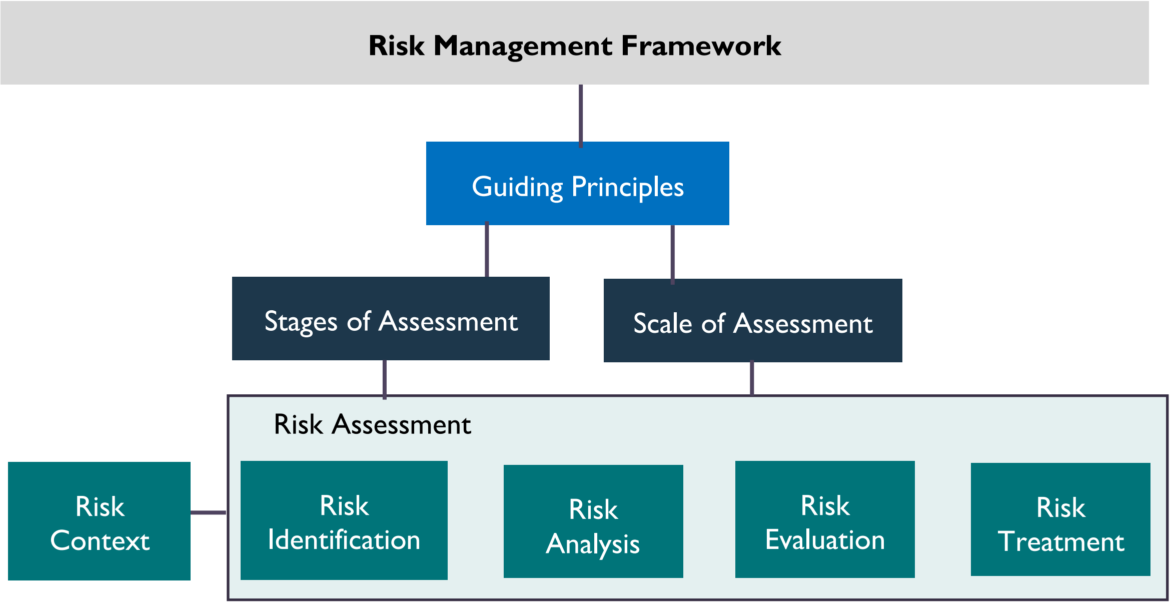


Figure 2: Risk management framework adopted for the GRAT.

2.1.1 Guiding Principles

A set of principles were developed to guide the development and implementation of the GRAT. These principles help to inform water resource managers but also end users and stakeholders. The principles respect the limitations of groundwater data and knowledge in Tasmania, the limited ability to collect new data, and as such identify preliminary, minimum datasets required to implement the GRAT.

Guiding principles include:

1. Given known data scarcity across the State, the GRAT has been developed for two stages of assessment: Stage 1 as a first pass evaluation of risk using preliminary, statewide datasets; and Stage 2 for evaluation of risk using secondary datasets if Stage 1 results in a High or Extreme risk being determined for a risk statement or GAU. This approach is required because some desirable criteria are unlikely to be assessable for many areas due to the absence of secondary datasets, particularly with statewide coverage (*see* **2.1.2 Stages of Assessment)**.
2. The GRAT is designed to be applied at the regional scale and thus may not identify local hotspots. There are other tools and means to identify risks at the local scale. The objective for the GRAT is to provide relative comparisons of risk between Groundwater Assessments Units (GAUs) at the regional scale (*see* **2.1.3 Scale of Assessment**).
3. For each Risk Statement, if the data required to assess any individual criterion is absent then that criterion is excluded from the consequence/likelihood assessment and the maximum possible overall score is adjusted accordingly (i.e. a non-assessable – N/A is assigned). The omission of such criteria will also be reflected in the confidence score (*see* **Confidence Level** section in **2.2.4 Risk Treatment**).
4. Each defined GAU must have the primary or target aquifer(s) identified prior to assessment.
5. The Precautionary Principle is applied throughout the tool and conservative options taken where applicable (Note - further details provided in **Appendix 1**).
6. The GRAT is a quantitative desktop assessment, however it could equally be used in future to incorporate qualitative knowledge (expert elicitation) where quantitative data is absent.
7. The GRAT can be easily linked to a GIS so risk may be visualised.

2.1.2 Stages of Assessment

Due to the paucity of desirable datasets and the incompleteness of many minimum datasets, the GRAT has been designed to be applied in two stages of assessment:

- **Stage 1**: a desktop, quantitative approach, which applies preliminary and statewide, readily available datasets. Stage 1 is typically a spatially driven exercise that results in the identification of relative risk across Tasmania and priority areas for further investigation and focus for management.
- **Stage 2**: aims to apply secondary, desirable datasets that either require outputs from further investigations (such as those proposed as Parts B & C of the GAP) and/or further assessment and compilation of location specific datasets. Stage 2 assessments should target priority areas, or areas of interest identified in Stage 1. The application of Stage 2 is designed to increase the confidence in risk assessment outputs and result in refined risk in key areas.

2.1.3 Scale of Assessment

To apply the GRAT and identify groundwater risks at a relevant scale, a regionalisation of groundwater areas across Tasmania was required. The regionalisation resulted in the development of GAUs, and these needed to be:

- Geologically and geographically appropriate.
- Administratively practical.
- Considerate of the degree of hydraulic connection with other groundwater sources and/or surface water systems.

- Defined based on recognised hydrogeological units, where similar hydrogeological units may be grouped together into one GAU.
- Contained within the four existing groundwater provinces of Tasmania (NLWRA 2001).

In adherence to the requirements outlined above, GAUs were developed based on several available and relevant spatial datasets such as:

- Connected water regions (Sheldon 2011).
- Hydrogeological complexes (HGCs; Latinovic *et al.* 2012).
- Groundwater modelling areas (REM 2008).
- Surface water catchments.

In the complex northwest region, GAUs were based largely on HGCs. In the geologically simpler northeast region GAUs were based largely on surface water catchments. In other areas GAU boundaries were based on a combination of HGCs and surface water catchments, often in consideration of connected water regions and previous groundwater modelling areas. The large southwest groundwater province was not disaggregated (i.e. it formed an entire GAU on its own) due to the limited development or likelihood of development of groundwater, and that much of this area resides in the Tasmanian Wilderness World Heritage Area. Additionally, groundwater development associated with mining enterprises on the west coast is regulated by the Environment Protection Agency Tasmania (EPA).

In total, 32 GAUs were delineated for Tasmania (**Figure 3**). Note the majority of the larger offshore islands were included in the mapping of GAUs, however all of these except King and Flinders islands were excluded from the GRAT analysis.

It must be noted that GAUs have been developed strictly for assessment purposes and identification of relative risk. GAUs are NOT designed to directly translate either current or future Groundwater Management Areas (GMAs) appointed under the *Water Management Act 1999*. GMA boundaries are established via consultative processes and may differ from those of GAUs (as was the case for Tasmania's only existing GMA in Sassafras-Wesley Vale).

Figure 3: Groundwater Assessment Units (GAUs) and Provinces of Tasmania.

2.2 Risk Assessment

2.2.1 Risk Identification

Risk identification is the process of finding, recognising, and describing risks including decisions regarding the important values and risks to those values.

The risk assessment framework adopts a cause/threat/impact model that describes the pathway for impacts to affect a receptor/value. 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.

Description of the cause/threat/impact model for risk identification:

Risk Statement: There is potential for [cause] to lead to [threat] which in turn could lead to [impact]

Where:

- A **cause** is an element which alone or in combination has intrinsic potential to give rise to risk.
- A **threat** is an occurrence or change of a particular set of circumstances.
- An **impact** is the outcome of an event affecting objectives and may be expressed quantitatively or qualitatively.

Preliminary identification of risks were generated by the NRE Tas Groundwater Working Group and a final list of 16 risks were translated into formal Risk Statements across three main risk types:

- Productive base (groundwater quantity)
- Groundwater quality
- GDEs.

Table 1 lists all 16 Risk Statements. The intent of the Risk Statements varies several relate to groundwater management approaches, some relate to land use planning, and some relate to climate change considerations. Accordingly, it is important to recognise that not all risks can be mitigated via groundwater management.

At least seven of the Risk Statements (i.e., 1.1, 1.2, 1.3, 1.4, 2.2, 2.4 and 3.1) are groundwater management focussed, five are core groundwater management risks (1.1, 1.2, 1.4, 2.4 and 3.1). Risk statements 1.3 and 2.2 are related to legacy bore construction issues that can only be addressed through intervention programs unrelated to standard groundwater management planning. It could be argued the elements of risk statement 1.3 dealing with nuisance flooding are not a high priority compared to the other Risk Statements. In any case, sound groundwater management based around an understanding of an aquifer scale water balance, a good knowledge of aquifer values and key users (both consumptive and environmental) and adequate monitoring, would mitigate these risks to a high degree.

The land use planning related Risk Statements (1.5, 2.3, 2.5, 3.3 and 3.5) would require coordination with other stakeholders (beyond groundwater users and water resource managers) to mitigate the risks. similarly, several stakeholders hold the key to mitigating the climate change Risk Statements. In some cases, these may not be able to be fully mitigated.

Importantly, implementation of Stage 1 of the GRAT has not considered any current or potential future risk control measures; hence all risks are unmitigated.

Table 1. Risk statements and criteria used for their assessment.

Criteria numbers refer to those listed in* **Table 2 *and are presented stacked in grouped order of value, vulnerability, and consequence.*

Risk Type	Risk Statement	Justification	Criteria*	Weighting
Production base of water resources	1.1 There is potential for groundwater extraction to cause water level declines, which in turn could lead to reduced water availability for existing groundwater users	Intensive groundwater pumping can lead to well interference with other groundwater users	1, 2, 3 5, 6 20, 21, 22, 23	2 + 3 + 3 = 8 max. 6 + 3 = 9 max. 3 + 3 + 3 + 3 = 12 max.
	1.2 There is potential for groundwater extraction to cause water level declines, which in turn could lead to reduced water availability to existing surface water entitlements	Intensive groundwater pumping close to rivers and streams can lead to either reduced groundwater discharge into gaining streams, or enhanced leakage out of losing streams, both of which reduce stream flow	1, 2, 3 7, 8, 9 20, 22, 23, 24	2 + 3 + 3 = 8 max. 9 + 3 + 6 = 18 max. 3 + 3 + 3 + 3 = 12 max.
	1.3 There is potential for bore construction and decommissioning practices to cause uncontrolled confined aquifer discharge, which in turn could lead to reduced groundwater availability (loss of pressure in aquifer) or land use impacts (nuisance flooding)	This need not be limited to leakage through faulty bores as there is potential for inter-aquifer leakage wherever a vertical head gradient exists between one or more aquifers	1, 2, 3 10, 11 25	2 + 3 + 3 = 8 max. 3 + 3 = 6 max. 3 = 3 max.
	1.4 There is potential for groundwater extraction to cause water level declines, which in turn could lead to declines in the structural integrity of the aquifer	Depressurisation of confined aquifers where they become partially unsaturated leads to irreversible aquifer compaction	1, 2, 3 12 20, 21, 23	2 + 3 + 3 = 8 max. 3 = 3 max. 3 + 3 + 3 = 9 max.
	1.5 There is potential for recharge interception and direct groundwater extraction by plantation forests to cause water level decline, which in turn could lead to reduced water availability for existing groundwater users	Plantation water use can have a marked impact on the water balance and thus water availability	1, 2, 3 5, 6, 13 23, 26	2 + 3 + 3 =8 max. 3 + 3 + 3 = 9 max. 6 + 3 = 9 max.

Risk Type	Risk Statement	Justification	Criteria*	Weighting
Water Quality	1.6 There is potential for climate change to cause a reduction in net groundwater recharge, which in turn could lead to reduced water availability for existing groundwater users	Climate change impacts include permanent shifts in daily rainfall intensity, seasonal and annual rainfall amounts, and evapotranspiration rates	1, 2, 3 5, 6 20, 27	2 + 3 + 3 = 8 max. 3 + 3 = 6 max. 3 + 3 = 6 max.
	2.1 There is potential for groundwater extraction to cause ingress from poorer quality aquifers, which in turn could lead to groundwater no longer being suitable for current purposes and/or users	Pumping from a productive aquifer can lead to drawdown propagation into, and therefore enhanced flow out of, adjacent formations of poorer quality	1 6, 14 20, 22	2 = 2 max. 3 + 3 = 6 max. 3 + 3 = 6 max.
	2.2 There is potential for bore construction and decommissioning practices to cause contamination from poorer quality aquifers, which in turn could lead to groundwater no longer being suitable for current purposes and/or users	This need not be limited to leakage through faulty bores and there is potential for inter-aquifer leakage wherever a vertical head gradient between one or more aquifers exists	1 6, 14 25	2 = 2 max. 3 + 3 = 6 max. 3 = 3 max.
	2.3 There is potential for point and diffuse sources to cause aquifer contamination, which in turn could lead to groundwater no longer being suitable for current purposes and/or users	This is a land management issue rather than a groundwater management risk; however, it needs to be considered given the potential impacts to existing users	1 6, 13, 15 28, 29	2 = 2 max. 3 + 3 + 3 = 9 max. 3 + 3 = 6 max.
	2.4 There is potential for groundwater extraction to cause sea water intrusion, which in turn could lead to groundwater no longer being suitable for current purposes and/or users	Reduced groundwater levels adjacent the coast lead to further inland migration of the saltwater interface	1 6, 16 20, 22, 23, 30	2 = 2 max. 3 + 3 = 6 max. 3 + 3 + 3 + 3 = 12 max.
	2.5 There is potential for irrigation to cause dryland salinity, which in turn could lead to groundwater no longer being suitable for current purposes and/or users	Irrigation can cause mobilisation of salts stored in the soil profile and rising water tables	1 6, 13 21, 31	2 = 2 max. 3 + 3 = 6 max. 3 + 6 = 9 max.

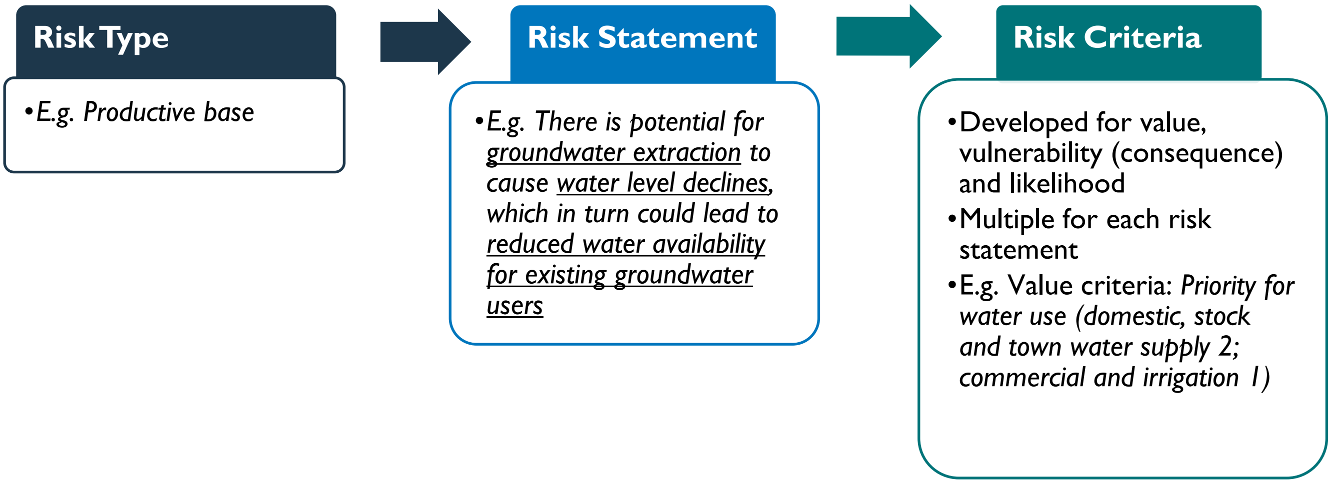
Risk Type	Risk Statement	Justification	Criteria*	Weighting
Groundwater Dependent Ecosystems	3.1 There is potential for groundwater extraction to cause water level decline, which in turn could lead to a decline in ecosystem values	Intensive groundwater pumping can lead to drawdown and thus reduced inundation, and reduced discharge flux at GDEs	4 17, 18 20, 22, 23, 32	4 = 4 max. 3 + 3 = 6 max. 3 + 3 + 3 + 3 = 12 max.
	3.2 There is potential for groundwater extraction to cause seawater intrusion, which in turn could lead to a decline in ecosystem values	Reduced groundwater levels adjacent the coast lead to further inland migration of the saltwater interface	4 16, 18, 19 22, 23, 30	4 = 4 max. 3 + 3 + 3 = 9 max. 3 + 3 + 3 = 9 max.
	3.3 There is potential for recharge interception and direct groundwater extraction by plantation forests to cause water level decline, which in turn could lead to a decline in ecosystem	Plantation water use can have a marked impact on the water balance and thus water availability	4 18 23, 33	4 = 4 max. 3 = 3 max. 3 + 3 = 6 max.
	3.4 There is potential for climate change to cause a reduction in net groundwater recharge, which in turn could lead to a decline in ecosystem values	Climate change impacts include permanent shifts in daily rainfall intensity, seasonal and annual rainfall amounts, and evapotranspiration rates	4 18 20, 27	4 = 4 max. 3 = 3 max. 3 + 3 = 6 max.
	3.5 There is potential for land use to cause groundwater quality decline, which in turn could lead to a decline in ecosystem values	This is a land management issue rather than a groundwater management risk; however, it needs to be considered given the potential impacts (e.g., of nutrient loads) to ecosystem health	4 18 34	4 = 4 max. 3 = 3 max. 3 = 3 max.

2.2.2 Risk Analysis

Risk analysis is the process to understand the nature of risk and to determine the magnitude or level of risk. The level of risk is a function of the consequence and likelihood of risk, which are expressed as scores and linked to a risk matrix to determine overall risk.

Criteria for the assessment of consequence and likelihood (**Table 2**) were developed as part of the Risk Analysis process for each of the Risk Statements identified in **Table 1**. The GRAT was purposely designed to be based primarily on statewide, readily available datasets, or those that require minimal analysis. Accordingly, most criteria were assessed in a quantitative manner, utilising metrics such as ratios, areas, and exceedance probabilities (e.g., 10% exceedance probability - P10) calculated directly from the datasets (**Table 2**). Each risk is assessed independently, although risk criteria are often repeated across multiple Risk Statements (**Table 1**) leading to identification of critical datasets and those required to meaningfully populate the GRAT. Several specific assessment criteria were developed for each value and vulnerability (and therefore consequence) and likelihood, for each of the Risk Statements outlined in the Risk Identification process (**Figure 4**).

In identifying risk criteria, consideration of the factors for which the resource is valued and factors that contribute to its vulnerability must be considered. Likewise, the factors that lead to the likelihood of an event occurring, or risk being realised. For most Risk Statements, several risk criteria culminate in individual value and vulnerability (which, when multiplied together yield consequence) and likelihood scores out of a maximum possible value (**Table 1**). Each risk criterion has a range of (typically between two and four) category options that vary in associated score from 0-9; typically scores are in the range 1-3 but zero is used occasionally, and higher scores are used for some criteria deemed worthy of additional weighting due to their relative importance (**Table 1**). During development of the GRAT, the sensitivity of the weighting scheme to criteria scores and overall risk levels was tested and adjusted before the final scheme was adopted – the purpose being to ensure that unwanted bias was not introduced in results.



- *E.g. Productive base*

- *E.g. There is potential for groundwater extraction to cause water level declines, which in turn could lead to reduced water availability for existing groundwater users*

- Developed for value, vulnerability (consequence) and likelihood
- Multiple for each risk statement
- E.g. Value criteria: *Priority for water use (domestic, stock and town water supply 2; commercial and irrigation 1)*

Figure 4: Overview of the development of risk criteria in the GRAT.

Table 2. Value, vulnerability, and likelihood criteria used to assess Risk Statements.

** Risk categories have both qualitative (VH – very high, H – high, M – moderate, L – low, VL – very low, Nil) and quantitative scores [ ].*

Criteria Type	Risk Criteria	Risk Categories and Scores*
Value	1. Priority for Water Use	Domestic, stock and town water supply (TWS) [2]
		Commercial & Irrigation [1]
	2. Accessibility of aquifer, bore yields and water quality	H – mean yield >5 L/s and mean Total Dissolved Solids (TDS) <500 mg/L [3]
		M – mean yield >5 L/s and mean 500<TDS<1000 mg/L OR mean yield <5 L/s and mean TDS <500 mg/L [2]
		L - mean yield <5 L/s and mean 500<TDS<1000 mg/L [1]
		VL - mean yield <5 L/s and mean TDS >1000 mg/L [0]
	3. Availability of alternative summer water sources	H - no other aquifers (<10% bores) suitable and summer surface water (SW) fully allocated [3]
		M - limited access to other aquifers (10-20% bores) and/or small/unreliable summer SW allocations [2]
		L - other aquifers (>20% bores) and/or summer SW available [1]
	4. GDE Value & Extent	VH - >25% GAU area has GDEs [4]
		H - 5-25% GAU area has GDEs and >50% of GDE area with Integrated Conservation Value (ICV) is H or VH [3]
		M – 5-25% GAU area has GDEs and <50% of GDE area with ICV is H or VH [2]
		L – <5% GAU area has GDEs [1]
Vulnerability	5. Aquifer robustness - ratio of aquifer storage to mean annual recharge	H – not robust <50 (recharge/storage volume – R/V >2%) [6]
		M - moderate robustness 50-100 (R/V 1-2%) [4]
		L - very robust >100 (R/V <1%) [2]
	6. Number of groundwater bores potentially affected	H - >500 existing bores distributed across GAU [3]
		M - 200-500 existing bores distributed across GAU [2]
		L - <200 existing bores in GAU [1]

Criteria Type	Risk Criteria	Risk Categories and Scores*
	7. Nature of connectivity to primary productive aquifer	H – gaining waterbodies [9]
		M - variably gaining and losing waterbodies [6]
		L - losing connected waterbodies [3]
		Nil - disconnected waterbodies or pumping from confined aquifer [0]
	8. Number of surface water allocations potentially affected	H – >400 allocations [3]
		M – 100-400 allocations [2]
		L – <100 allocations [1]
	9. Impacts to Transmission Losses: primary waterways used as irrigation conveyance channels	Yes [6]
		No [0]
	10. Aquifer type	H - confined >5 artesian bores main aquifer [3]
		M - confined 1-5 artesian bores main aquifer [2]
		L - no artesian bores but expert knowledge of confined conditions [1]
		Nil - unconfined no artesian bores [0]
	11. Area of land potentially affected by flooding	H - >1000 hectares (ha) low relief <1degree slope [3]
		M - 100-1000 ha low relief <1degree slope [2]
		L - <100 ha low relief <1degree slope [1]
		Not Applicable – unconfined aquifer
	12. Propensity for subsidence	H – significant (inelastic compaction) if pressures decline even without dewatering (confined sedimentary aquifers) [3]
		M – significant only if dewatered (karst aquifers) [2]
		L – minor only if dewatered (unconfined sedimentary aquifers) [1]
		Nil – aquifer incompressible (shallow fractured rock aquifer- FRA) [0]

Criteria Type	Risk Criteria	Risk Categories and Scores*
	13. Depth to water table	H – >50% GAU coverage >50% bores depth to water (DTW)<=10m [3]
		M - >50% GAU coverage 20-50% bores DTW<=10m [2]
		L - >50% GAU coverage <20% bores DTW<=10m [1]
		Non-assessable - insufficient data <50% GAU coverage
	14. Presence of poorer quality groundwater in adjacent aquifers	H - Average TDS other aquifers >1000 mg/L [3]
		M – Average TDS other aquifers 500-1000 mg/L [2]
		L - Average TDS other aquifers <500 mg/L [1]
	15. Presence of sandy soils	H - Average sand content >50% [3]
		M - Average sand content 25-50% [2]
		L - Average sand content <25% [1]
	16. Hydraulic gradient to coast	H – Average gradient 5km bores <0.005 [3]
		M - Average gradient 5km bores 0.005-0.010 [2]
		L - Average gradient 5km bores >0.010 [1]
		Not Applicable - Non-coastal GAU
	17. Nature of flow and connectivity to primary productive aquifer	H – Perennial connected wetlands (including confined aquifer spring-fed wetlands) and unregulated watercourses [3]
		M – Ephemeral connected wetlands and unregulated or regulated watercourses [2]
		L – Disconnected waterbodies or regulated watercourses with dam releases for sustained baseflow [1]
	18. GDE Sensitivity	High [3]
		Moderate [2]
		Low [1]

Criteria Type	Risk Criteria	Risk Categories and Scores*
	19. Proximity of GDEs to coast	H – 10% exceedance probability (P10) distance <1 km [3]
		M - P10 distance 1-2 km [2]
		L - P10 distance >2 km [1]
		Not Applicable - Non-coastal GAU
Likelihood	20. Ratio of existing groundwater use to long term average recharge	H - >20% [3]
		M - 10-20% [2]
		L - <10% [1]
	21. Density of existing groundwater use	H - some areas >2500 megalitres (ML) per 25 km^2 (> 1 ML/ha) [3]
		M - some areas 1250-2500 ML per 25 km^2 (0.5-1 ML/ha) [2]
		L - all areas <1250 ML per 25 km^2 (< 0.5 ML/ha) [1]
	22. Capacity for future increased extraction over next 10 years based on recent trends in bore development	H – >50 new permits granted or >50 new bores constructed over last 5 years [3]
		M – 20-50 new permits granted or 20-50 new bores constructed over last 5 years [2]
		L – <20 new permits granted or <20 new bores constructed over last 5 years [1]
	23. Trends in summer groundwater levels over last ten years	Widespread declines of any magnitude [3]
		Localised declines >10 cm/yr [2]
		Localised declines <10 cm/yr [1]
		Stable or rising GW levels [0]
		Non-assessable - insufficient data or not statistically significant [999]
	24. Proximity of groundwater pumping to waterways	H - P10 distance ALL bores <100m [3]
		M - P10 distance ALL bores 100-250m [2]
		L - P10 distance ALL bores >250m [1]
		Non-assessable - Total no. bores <100

Criteria Type	Risk Criteria	Risk Categories and Scores*
	25. Bore construction and age as proxy for casing/grout integrity	H – majority steel cased mean age >20 years old [3]
		M - majority steel cased mean age <20 years old [2]
		L - majority polyvinylchloride (PVC)/ fibreglass reinforced plastic (FRP) cased [1]
	26. Area of current plantation estate	H – >10000 ha [6]
		M - 3001 - 10000 ha [4]
		L - 100 - 3000 ha [2]
		Nil - <100 ha
	27. Predicted impacts of climate change on recharge	H - Average recharge scaling factor (RSF) for GAU <0.75 [3]
		M - Average RSF for GAU 0.75-0.90 [2]
		L - Average RSF for GAU >0.90 [1]
	28. Proximity of groundwater users to point source pollution	H - P10 distance ALL bores <250m [3]
		M - P10 distance ALL bores 250-500m [2]
		L - P10 distance ALL bores 500-1000m [1]
		Nil - P10 distance bores >1000m OR no known point sources [0]
		Non-assessable - Total No. bores <100
	29. Proximity of groundwater users to moderate-high risk land uses	H – 90% exceedance probability (P90) distance ALL bores <100m [3]
		M - P90 distance ALL bores 100-500m [2]
		L - P90 distance ALL bores >500m [1]
		Nil - no mod-high risk land use [0]
		Non-assessable - Total No. bores <100
	30. Proximity of groundwater pumping to coast	H – P10 distance ALL bores <500m [3]
		M - P10 distance ALL bores 500-1000m [2]

Criteria Type	Risk Criteria	Risk Categories and Scores*
		L - P10 distance ALL bores 1000-2000m [1]
		Nil - P10 distance >2000m or non-coastal GAU [0]
		Non-assessable - Total No. bores <100
	31. Salinity Hazard	H - >10% cells in GAU are High hazard [6]
		M - >20% cells in GAU are High or Moderate hazard [4]
		L - >10% cells in GAU are Moderate hazard [2]
		VL - >=90% cells in GAU are Low hazard [0]
	32. Proximity of groundwater pumping to GDEs	H – P10 distance ALL bores <100m [3]
		M - P10 distance ALL bores 100-250m [2]
		L - P10 distance ALL bores 250-500m [1]
		Nil - P10 distance >500m [0]
		Non-assessable - Total no. bores <100
	33. Proportion of GDE area coincident with plantation forests	H – >25% GDEs [3]
		M - 10-25% GDEs [2]
		L - <10% GDEs [1]
	34. Proportion of GDE area coincident with mod-high risk land uses	H – >25% GDEs [3]
		M - 10-25% GDEs [2]
		L - <10% GDEs [1]

For some criteria in the GRAT there are also “not applicable” or “non-assessable” scoring options (**Table 2**). Not Applicable is used where the risk is not relevant to a particular GAU (e.g., seawater intrusion in inland/non-coastal GAUs, or nuisance flooding from artesian bores where the main aquifer is unconfined). In these instances, the scoring of vulnerability or likelihood results in “N/A” as the risk is not applicable. Therefore, the overall risk is also recorded as N/A.

Non-assessable scoring is used in two different ways. Firstly, where certain thresholds are not met in the available data to enable a credible analysis (e.g. insufficient number of bores to compute statistical metrics), in which case the scoring of vulnerability or likelihood results in “N/A” as does the overall risk.

Secondly, non-assessable is an explicit option for scoring likelihood criterion number 23: trends in summer groundwater levels over the last ten years. In this specific case, non-assessable can be due to insufficient groundwater monitoring data (e.g., due to no monitoring bores within the GAU, or records spanning less than the last ten years) or no statistically significant trend in the available dataset. Regardless, the score is registered as “999” as a flag that effectively removes this criterion from the likelihood score and overall risk assessment. The reasons for this different treatment of groundwater level trend information are that the data is rarely going to be present at optimal spatial resolution, and trends can be misleading if not assessed in the context of sustainable yield/extraction limit estimates and the acceptable levels of impact that have been used to derive these estimates Therefore, it was deemed acceptable to continue calculating likelihood scores and overall risk in the absence of groundwater level trend data.

Consequence

In the GRAT, Consequence is a product of Value and Vulnerability. Scores for individual value criteria are summed, as are scores from individual vulnerability criteria. Consequence is then the product of these tallied scores. All consequence scores are then standardised by dividing the actual score by the highest collective possible score (identified as “max” scores in **Table 1**) and expressed over a base of 10.

$$\boldsymbol{Consequence} = \frac{\sum_{i=1}^{n} \boldsymbol{Value}(\boldsymbol{i}) \times \sum_{j=1}^{m} \boldsymbol{Vulnerability}(\boldsymbol{j})}{(\boldsymbol{Max.Value} + \boldsymbol{Max.Vulnerability}) \times \mathbf{10}}$$

Where:

- n is the number of value criteria used to assess a specific risk statement, and
- m is the number of vulnerability criteria used to assess a specific risk statement.

This results in a consequence score out of 10, which then relates directly to a consequence category in **Table 3**.

Value in terms of the productive base includes criteria such as primary use and accessibility of the groundwater resource and the availability of alternate summer water options. Whereas for GDEs value relates to the extent of GDEs in a GAU and the assessed value of those within.

Vulnerability typically includes criteria regarding aquifer properties, connectivity, and number of water users affected. For GDEs it includes sensitivity to change (in either water quality or quantity).

Likelihood

Likelihood explores the drivers of change to a resource or value. Thus, many likelihood criteria focus on estimated groundwater use (ratio to recharge, density, capacity for future increase), as well as groundwater level trends, climate change, and proximity of use to GDEs, coastlines and high-risk land use including plantation forestry.

Like scoring for Consequence, scores for individual likelihood criteria are summed for a Risk Statement, then standardised by dividing the actual score by the highest collective possible score (identified as “max” scores in **Table 1**) and expressed over a base of 10.

$$\boldsymbol{Likelihood} = \frac{\sum_{k=1}^{p} \boldsymbol{Likelihood(k)}}{(\boldsymbol{Max.Likelihood}) \times \mathbf{10}}$$

Where:

- p is the number of likelihood criteria used to assess a specific risk statement.

This results in a likelihood score out of 10, which then relates directly to a likelihood category in **Table 3**.

Overall Risk

Overall risk categories for each risk statement were derived by combining consequence and likelihood scores using the matrix provided in **Table 3**.

Table 3: Risk matrix for assessing consequence[*] and likelihood categories, and overall risk for Risk Statements in the GRAT.

		CONSEQUENCE				
		Insignificant *0-2*	Minor *2-4*	Moderate *4-6*	Major *6-8*	Catastrophic *8-10*
LIKELIHOOD	**Rare** *0-2*	LOW	LOW	MODERATE	MODERATE	MODERATE
	Unlikely *2-4*	LOW	LOW	MODERATE	MODERATE	MODERATE
	Possible *4-6*	LOW	MODERATE	MODERATE	HIGH	HIGH
	Likely *6-8*	MODERATE	MODERATE	HIGH	EXTREME	EXTREME
	Almost Certain *8-10*	MODERATE	MODERATE	HIGH	EXTREME	EXTREME

*Consequence descriptors are consistent with standard risk assessment procedures, which usually have qualitative or semi-quantitative definitions that relate to loss of income, life and/or another asset. However, for the GRAT, these categories are entirely quantitative and derived through the methodology outlined above.

2.2.3 Risk Evaluation

Risk evaluation is where a decision is made regarding whether a risk requires treatment or is acceptable given current controls. Risks which have been evaluated as 'not tolerated' will need to be treated. Overall risk of moderate to high is regarded as not tolerated and would require treatment.

In many circumstances it is likely that further information is required to fully comprehend the nature of the risk. This is likely to be the case where further information would provide greater confidence of the likelihood, or severity of consequence, of the risk (Note - confidence is dealt with in the risk treatment process step below – see **3.3 Risk Treatment**).

For overall risk to a GAU, numerical scores (e.g. N/A = 0, L=1, M=2, H=3, E=4) are assigned to each Risk Statement and summed to provide a ranking and overall score for each GAU. A similar process can be undertaken to determine overall risk for Risk Types (e.g. productive base, groundwater quality and GDEs). Using natural breaks in the overall scores, together with observation of the risk categories in the GRAT, GAU risk can be grouped into high, moderate, and low categories.

For evaluation of individual risks relating to specific Risk Statements, any risk greater than moderate should become the focus for treatment via specific, targeted programs.

2.2.4 Risk Treatment

Risk Treatment is the process to modify risk and involves the actions taken to reduce or avoid risk. Risks that have unacceptable consequences determined by Risk Evaluation will need to be treated or avoided. Treatment measures may be undertaken to reduce either the consequence or likelihood of the risk.

In this framework the Risk Treatment or management response is determined by the level of confidence in data/knowledge used to assess risk and the severity of risk determined overall for a GAU (**Figure 5**).

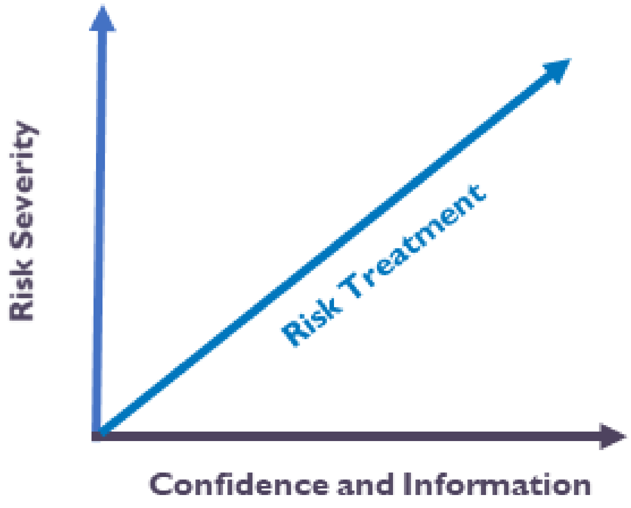


Figure 5: Model for Risk Treatment in the GRAT and management framework.

Confidence Level

Risk assessment revolves around future events and therefore aims to understand the uncertainties in achieving objectives clearly. Understanding the level of confidence associated with the risk assessment is necessary to inform Risk Treatment and communicate transparently with stakeholders.

The confidence level reflects uncertainty in datasets and knowledge gaps encountered during the assessment. It highlights areas which need further investigation and monitoring and the design of Risk Treatments.

In the management framework, confidence is assessed on the key datasets that are relied upon repeatedly in the GRAT such as bore data, depth to water table, aquifer storage, GDE connectivity and value (see **Chapter 3** for more information). This is paralleled with an assessment of dataset integrity and completeness, spatial coverage, and validation. Confidence level ratings and descriptions are included in **Table 4** in the section below.

Management Response

Management responses are provided at a high level and target overall GAU risk in the framework and are presented as a set of three generic treatments. The development of detailed, GAU specific risk controls and mitigation is out of scope at this scale; however, whilst treatment should focus on response to overall risk, it should be tailored to the spread of risk assessed across all GAU risk types.

Management responses (i.e. classified as high-active, moderate-reconnaissance and low – basic) are commensurate with overall GAU risk level and certainty of assessment (**Table 4**).

Management responses are detailed further below:

- **Basic** – basic and ongoing groundwater level and quality monitoring, standard well-permitting process, driller compliance, Groundwater Information Management System (GWIMS) database maintenance, ad-hoc interaction with groundwater users, review every 5 years.
- **Reconnaissance** – as for Basic PLUS increased data collection through permitting process, in-field data collection (bore audits, water use estimates), water level surveys in hot spots, increased intensity of water level and quality monitoring, policies to limit/manage well permitting, water balance models, conceptual models, pump tests, development of trigger levels – drawdown limits, water quality indicators, and local-scale investigations.
- **Active** – as for Reconnaissance PLUS additional regulatory measures (declaration of a GMA – licensing, metering, allocation, and specific groundwater zone management rules), increased intensity of monitoring in target areas, sophisticated groundwater models, conjunctive water management plans.

If overall risk is low, then Risk Treatment is recommended to only be Basic despite confidence levels in the risk assessment. If overall risk is moderate to high, then Risk Treatment would be either Reconnaissance or Active, dependent on the certainty in the assessment (**Table 4**). High confidence in a risk assessment is typically only achieved via a Stage 2 assessment.

Table 4: Management response matrix based on overall risk severity and level of confidence.

		ASSESSED OVERALL GMU RISK		
		LOW	MODERATE	HIGH
LEVEL OF CONFIDENCE	**LOW:** incomplete datasets, no data validation, limited to statewide, spatial datasets. Desktop assessment ***Confidence score 0-5***	Basic: Monitoring and review every five years	Reconnaissance: (field and modelling) investigations, increase monitoring, then reassess risk and (if required) declare GMA, introduce plans, licences, and policies	Reconnaissance: (field and modelling) investigations, increase monitoring, then reassess risk and (if required) declare GMA, introduce plans, licences, and policies
	MODERATE: near complete datasets, some data validation. Desktop assessment with some area-specific information ***Confidence Score 6-9***	Basic: Monitoring and review every five years	Reconnaissance: (field and modelling) investigations, increase monitoring, then reassess risk and (if required) declare GMA, introduce plans, licences, and policies	Active: Management through GMA declaration - licensing, regulation, comprehensive monitoring, and regular review
	HIGH: complete datasets, high level of data validation via area-specific studies Desktop assessment with refinement through targeted field studies ***Confidence score 10-13***	Basic: Monitoring and review every five years	Active: Management through GMA declaration - licensing, regulation, comprehensive monitoring, and regular review	Active: Management through GMA declaration - licensing, regulation, comprehensive monitoring, and regular review

2.3 Proof of Concept

The GRAT was developed using generic scoring categories in the risk criteria drop-down lists. Some of the risk criteria are generally accepted hydrogeological categories of risk and others are more reflective of local data and conditions. To test the tool and for proof of concept, the preliminary statewide implementation of the GRAT was interrogated for five GAUs comprised of different aquifers, geographic areas, level of knowledge and level of development (Smithton Syncline, Sassafras-Wesley Vale, Bruny Island, Mole Creek and Great Forester-Brid). As a result, minor alterations were made to risk criteria and the details within the drop-down risk categories of each criterion. These changes resulted in a more robust tool and a better reflection of Tasmanian groundwater resources.

The GRAT has also undergone a peer review by Dr Ray Evans of Salient Solutions to ensure it is fit for purpose and is in line with accepted national groundwater management and risk assessment practices. The review is designed to provide stakeholders with certainty and acceptance of the GRAT, the risk assessment approach, and risk assessment outcomes. Peer review comments are included in **Appendix 2**.

2.4 Limitations

Because the GRAT is based on the standard approach to semi-quantitative risk assessment, it is somewhat subjective and open to influence by the authors' experience, perceptions of risk and technical judgements. However, the GRAT does provide, for the very first time, a consistent framework to allow repeatability and transparency in risk assessment to groundwater resources and groundwater dependent values across Tasmania.

During development and preliminary statewide implementation of the GRAT, it became evident that critical datasets are lacking. Parts B & C of the GAP will allow collection of some new data in priority areas (see **Chapter 4**) to address these gaps.

Detailed Risk Treatment (controls and mitigations) was considered out of scope for this exercise. The framework only includes three generic management response options, however these can be built upon and tailored to specific GAUs in the future (this is explored further in **3.4 Case Study Areas**).

The GRAT is not designed to identify localised hotspots (i.e. specific point source issues, individual or property scale compliance issues). It may identify broader hot spots within a GAU however, which may require more localised assessment and/or management.

The management framework does not summarise or review the current groundwater planning and policy provisions or NRE Tas's current capacity to understand, describe and assess GAUs. The GAP outcomes will inform an internal review of groundwater management settings in 2024-25 as part of the RWUS.

2.5 Review Schedule

It is recommended that the GRAT is reviewed and re-implemented on GAUs every five years. In priority GAUs where targeted, GAU-specific studies are likely to occur in Parts B & C of the GAP, those GAUs may be reviewed in 3-5 years' time.

Regular review of the GRAT and risk outcomes enable the tool to adapt to incorporate evolving levels of information and to consider changed confidence in assessments for some areas. GRAT review also provides an opportunity to respond to evolving levels of departmental and scientific knowledge and community expectations.

The GRAT and associated management framework have been designed to be able to be reviewed and re-implemented in future by NRE Tas water resources staff. The process outlined in **Chapter 2** and further detailed in **Chapter 3**, provides a clear and transparent pathway for assessing risk. Supporting tools and information have also been developed to enable a streamlined update of risk in future, with minimal skill and resource requirements.

3. Groundwater Risk Assessment Tool and Management Framework Implementation

This chapter outlines the implementation of the GRAT and management framework in all 32 GAUs in Tasmania. Datasets and methods used to populate the GRAT are summarised, as are risk outcomes. Priority GAUs are identified, and appropriate management responses outlined. Four case study areas are presented in detail. This chapter is structured in terms of outcomes from the statewide application of the following components of the risk assessment framework: risk analysis, evaluation, and treatment.

3.1 Risk Analysis

To populate the GRAT for all 32 GAUs, a number of required datasets were identified, sourced, collated and analysed. Relevant datasets and analyses undertaken in preparation for implementation of the GRAT are detailed in **Appendix 1.** This information includes the specific criteria the dataset relates to, as well as associated methods, decision-trees, and assumptions.

Recommendations for future GRAT applications and key data gaps were also identified to inform Parts B & C of the GAP and priorities for future data collection, dataset creation and data analysis.

To support direct population of the GRAT with analysed data and for transparency and repeatability purposes, a master database was developed in MS Excel (*Data and Criteria Application.xlsx* – **Appendix 3**). This database has the 32 GAUs listed at the left-hand side and then a column(s) at right for each of the analysed datasets attributable to specific risk criteria in the GRAT. Again, for simplicity of linking the data from this database directly to the criteria in the GRAT, relevant column identifiers from this database were included in the GRAT for every criterion (see **Appendix 4**).

For transparency, all 32 GRAT assessments for each of the GAUs are included in **Appendix 4.**

3.2 Risk Evaluation

A summary of the risk levels assessed for each risk statement in each GAU is included in **Table 5**. A few GAUs stand out with a collection of high and extreme risks when visualised in this comparative and relative way (particularly Smithton Syncline). Two seawater intrusion-related Risk Statements were not applicable to nine inland GAUs (greyed cells). Several other Risk Statements were not assessable given paucity of data and failure to meet established thresholds to enable analysis (white cells) – refer to **2.2.2 Risk Analysis** and **Appendix 1** for further details.

Table 5: Summary of risks analysed for each risk statement and GAU (taken directly from the GRAT).

**Grey cells = not applicable, white cells = not assessable, green cells = low risk, yellow cells = moderate risk, orange cells = high risk and red cells = extreme risk.*

Risk Type	Risk Statement (abbreviated)	1_South West	2_King Island	3_Smithton Syncline	4_Rocky Cape-Arthur	5_Burnie Basalts	6_Leven-Forth-Wilmot	7_Sheffield-Spreyton-Kimberley	8_Mole Creek	9_Flinders Island	10_Upper South Esk	11-Pipers-Little Forester	12_Great Forester-Brid	13_Boobyalla-Tomahawk-Ringarooma	14_Musselroe-George-Scamander	15_Upper North Esk	16_Pittwater-Coal River	17_Bruny Island	18_Lower Derwent & Derwent Estuary	19_Huon North	20_Huon South	21_Tasman Peninsula	22_Little Swanport-Prosser	23_Swan-Apsley	24_Longford Basin	25_Macquarie	26_Fingal Range - St Marys	27_Jordan	28_Central Plateau	29_Sassafras - Wesley Vale	30_Tamar Estuary	31_Upper Derwent	32_Mt Barrow-Ben Lomond Ranges
Production base of water resources	**1.1** Extraction - existing groundwater users	LOW	MODERATE	EXTREME	MODERATE	HIGH	MODERATE	HIGH	MODERATE	MODERATE	LOW	MODERATE	MODERATE	LOW	LOW	LOW	LOW	LOW	LOW	MODERATE	LOW	LOW	MODERATE	LOW	MODERATE	LOW	LOW	MODERATE	MODERATE	HIGH	MODERATE	LOW	LOW
	1.2 Extraction - existing surface water entitlements	#N/A	LOW	HIGH	MODERATE	HIGH	HIGH	HIGH	MODERATE	LOW	#N/A	MODERATE	HIGH	HIGH	LOW	#N/A	MODERATE	#N/A	LOW	MODERATE	#N/A	MODERATE	MODERATE	#N/A	MODERATE	MODERATE	#N/A	MODERATE	#N/A	HIGH	MODERATE	LOW	#N/A
	1.3 Bore construction - confined leakage	MODERATE	LOW	HIGH	LOW	LOW	LOW	MODERATE	LOW	LOW	LOW	LOW	MODERATE	MODERATE	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	MODERATE	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
	1.4 Subsidence	LOW	LOW	HIGH	LOW	LOW	LOW	MODERATE	MODERATE	LOW	LOW	LOW	MODERATE	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	MODERATE	LOW	LOW	LOW	LOW	MODERATE	LOW	LOW	LOW
	1.5 Plantation forests - existing groundwater users	#N/A	MODERATE	EXTREME	#N/A	EXTREME	HIGH	HIGH	MODERATE	LOW	#N/A	MODERATE	HIGH	HIGH	#N/A	#N/A	LOW	LOW	MODERATE	HIGH	#N/A	MODERATE	MODERATE	#N/A	MODERATE	MODERATE	#N/A	LOW	#N/A	MODERATE	MODERATE	MODERATE	#N/A
	1.6 Climate change - existing groundwater users	LOW	MODERATE	EXTREME	MODERATE	HIGH	MODERATE	HIGH	MODERATE	LOW	LOW	MODERATE	LOW	LOW	LOW	LOW	MODERATE	LOW	LOW	MODERATE	LOW	LOW	MODERATE	LOW	MODERATE	LOW	LOW	MODERATE	MODERATE	HIGH	MODERATE	LOW	LOW
Water Quality	**2.1** Extraction - ingress from poorer quality aquifers	LOW	MODERATE	EXTREME	MODERATE	EXTREME	MODERATE	EXTREME	LOW	HIGH	LOW	MODERATE	MODERATE	LOW	MODERATE	MODERATE	EXTREME	MODERATE	MODERATE	EXTREME	LOW	HIGH	EXTREME	HIGH	EXTREME	MODERATE	LOW	EXTREME	LOW	HIGH	EXTREME	MODERATE	LOW
	2.2 Bore construction - poorer quality aquifers	MODERATE	MODERATE	EXTREME	LOW	MODERATE	MODERATE	MODERATE	LOW	MODERATE	LOW	LOW	MODERATE	LOW	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	LOW	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE	MODERATE	MODERATE	LOW
	2.3 Point and diffuse source pollution	#N/A	MODERATE	MODERATE	#N/A	MODERATE	MODERATE	MODERATE	LOW	MODERATE	#N/A	LOW	MODERATE	MODERATE	#N/A	#N/A	MODERATE	#N/A	HIGH	HIGH	#N/A	MODERATE	MODERATE	#N/A	MODERATE	MODERATE	#N/A	MODERATE	#N/A	MODERATE	MODERATE	MODERATE	#N/A
	2.4 Extraction - sea water intrusion	#N/A	MODERATE	EXTREME	MODERATE	HIGH	MODERATE	MODERATE	#N/A	MODERATE	#N/A	MODERATE	HIGH	LOW	MODERATE	#N/A	HIGH	#N/A	MODERATE	EXTREME	#N/A	MODERATE	HIGH	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	EXTREME	MODERATE	#N/A	#N/A
	2.5 Dryland salinity	#N/A	MODERATE	MODERATE	#N/A	MODERATE	MODERATE	MODERATE	LOW	EXTREME	#N/A	MODERATE	MODERATE	MODERATE	#N/A	#N/A	MODERATE	MODERATE	MODERATE	MODERATE	#N/A	MODERATE	MODERATE	#N/A	MODERATE	EXTREME	#N/A	MODERATE	#N/A	MODERATE	MODERATE	MODERATE	#N/A
Groundwater Dependent Ecosystems	**3.1** Extraction - water level GDEs	#N/A	HIGH	EXTREME	HIGH	MODERATE	LOW	MODERATE	MODERATE	HIGH	#N/A	#N/A	MODERATE	LOW	MODERATE	#N/A	LOW	#N/A	HIGH	MODERATE	#N/A	MODERATE	MODERATE	#N/A	LOW	LOW	#N/A	MODERATE	#N/A	MODERATE	MODERATE	MODERATE	#N/A
	3.2 Extraction - seawater intrusion GDEs	#N/A	EXTREME	HIGH	HIGH	MODERATE	MODERATE	LOW	#N/A	EXTREME	#N/A	MODERATE	MODERATE	LOW	MODERATE	#N/A	LOW	#N/A	HIGH	MODERATE	#N/A	MODERATE	MODERATE	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	MODERATE	LOW	#N/A	#N/A
	3.3 Plantation forests - water level GDEs	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	LOW	MODERATE	MODERATE	MODERATE	MODERATE	LOW	LOW	LOW	MODERATE	MODERATE	MODERATE	LOW	MODERATE	LOW	LOW	LOW	MODERATE	LOW	MODERATE	MODERATE	LOW	MODERATE	LOW
	3.4 Climate change - GDEs	MODERATE	MODERATE	EXTREME	MODERATE	MODERATE	MODERATE	HIGH	MODERATE	MODERATE	LOW	MODERATE	MODERATE	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	LOW	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	LOW
	3.5 Land use - GDEs	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	HIGH	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE	MODERATE	MODERATE	LOW	LOW	LOW	LOW	LOW	MODERATE	LOW	MODERATE	MODERATE	MODERATE	MODERATE	LOW

To assess overall risk, numerical scores (e.g. N/A = 0, L=1, M=2, H=3, E=4) were assigned to each Risk Statement risk category and summed to provide a ranking and overall score for each GAU. A similar process was undertaken to determine overall risk for the three Risk Types (e.g. productive base, groundwater quality and GDEs). Overall risk scores and the contribution of each risk type to the overall score, is graphically displayed in **Figure 6**. Smithton Syncline by far scored the highest risk with relatively equal contributions for each of the three risk types. GDEs contribute to risk in Rocky Cape-Arthur and Musselroe, George and Scamander, whilst groundwater quality contributes low risk in Huon South, Fingal Range-St Marys and the Central Plateau.

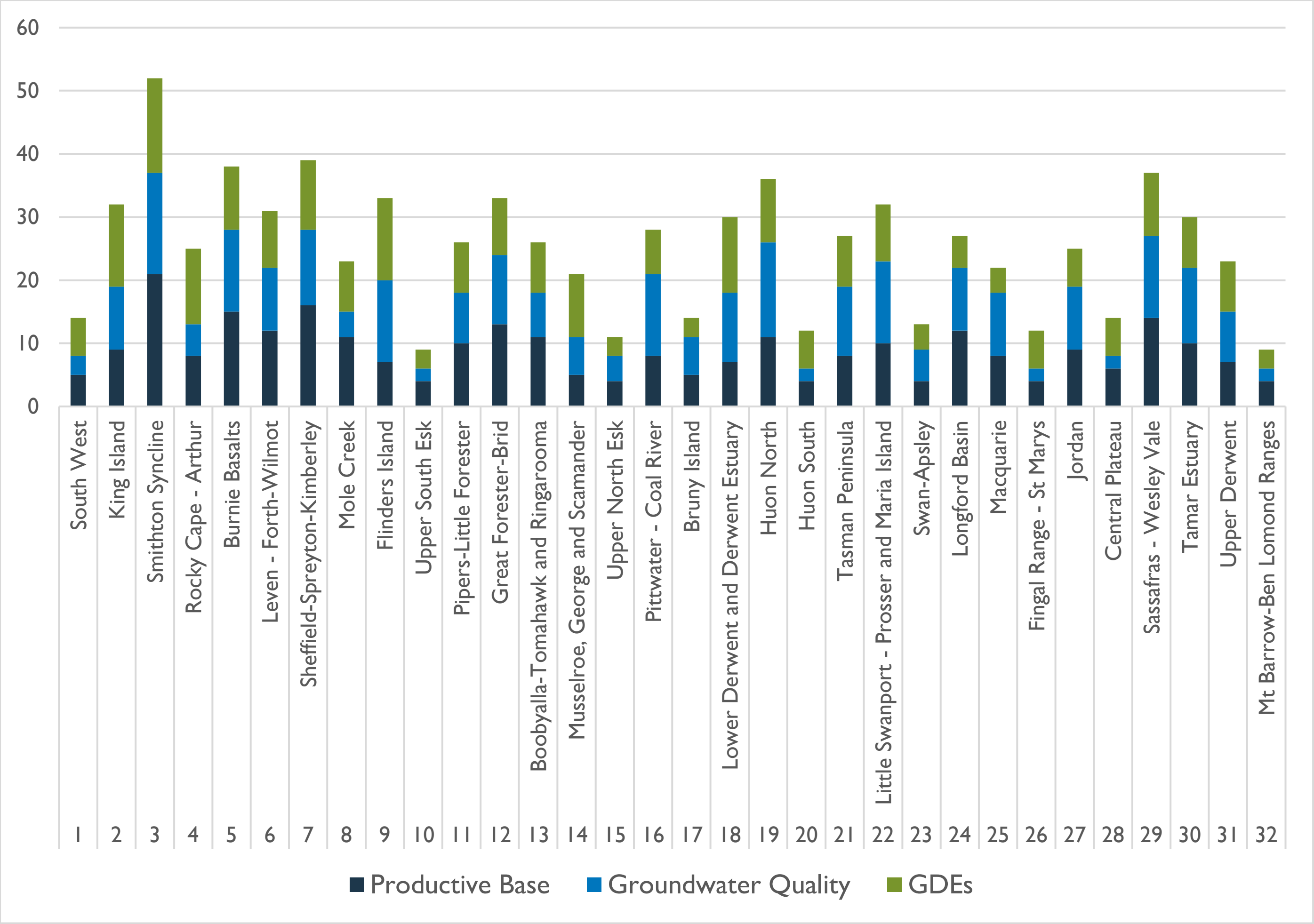


Figure 6: Comparison of overall risk and contribution of risk type scores for GAUs.

Using natural breaks in the overall scores, together with visualisation of the risk categories in the GRAT (summarised in **Table 5**), GAU risk was grouped into high, moderate and low categories (**Table 6** and **Figure 7**). Classifying the overall risk outcomes in this manner guides the prioritisation of GAUs for Risk Treatment and helps to inform the requirements and target areas for Parts B & C of the GAP, and application of future Stage 2 assessments.

Whilst Smithton Syncline was assessed as having the highest risk overall, Sheffield-Spreyton-Kimberley, Burnie Basalts, Sassafras-Wesley Vale and Flinders Island all scored high risk overall and high risk for two of the three risk types. Great Forester-Brid and Huon North scored high risk overall and high risk for one of the three risk types.

Table 6: Comparison of overall risk and risk type scores for GAUs

Overall and risk type scores based on sum of risk statement scores in the summary matrix (*Table 5***): blank = 0, Low=1, Moderate=2. High=3, Extreme=4. High-red, medium-orange, and low-yellow risk categories were then assigned based on the classes outlined below each risk header.*

GAU No.	GAU Name	Productive Base Risk	Groundwater Quality Risk	GDE Risk	Overall Risk
		13-24=H	12-20=H	12-20=H	33-64=H
		9-12=M	8-11=M	8-11=M	25-32=M
		0-8=L	0-7=L	0-7=L	0-24=L
1	South West	5	3	6	14
2	King Island	9	10	13	32
3	Smithton Syncline	21	16	15	52
4	Rocky Cape - Arthur	8	5	12	25
5	Burnie Basalts	15	13	10	38
6	Leven - Forth-Wilmot	12	10	9	31
7	Sheffield-Spreyton-Kimberley	16	12	11	39
8	Mole Creek	11	4	8	23
9	Flinders Island	7	13	13	33
10	Upper South Esk	4	2	3	9
11	Pipers-Little Forester	10	8	8	26
12	Great Forester-Brid	13	11	9	33
13	Boobyalla-Tomahawk and Ringarooma	11	7	8	26
14	Musselroe, George and Scamander	5	6	10	21
15	Upper North Esk	4	4	3	11
16	Pittwater - Coal River	8	13	7	28
17	Bruny Island	5	6	3	14
18	Lower Derwent and Derwent Estuary	7	11	12	30
19	Huon North	11	15	10	36
20	Huon South	4	2	6	12
21	Tasman Peninsula	8	11	8	27
22	Little Swanport - Prosser and Maria Island	10	13	9	32
23	Swan-Apsley	4	5	4	13
24	Longford Basin	12	10	5	27
25	Macquarie	8	10	4	22
26	Fingal Range - St Marys	4	2	6	12
27	Jordan	9	10	6	25
28	Central Plateau	6	2	6	14
29	Sassafras - Wesley Vale	14	13	10	37
30	Tamar Estuary	10	12	8	30
31	Upper Derwent	7	8	8	23
32	Mt Barrow-Ben Lomond Ranges	4	2	3	9

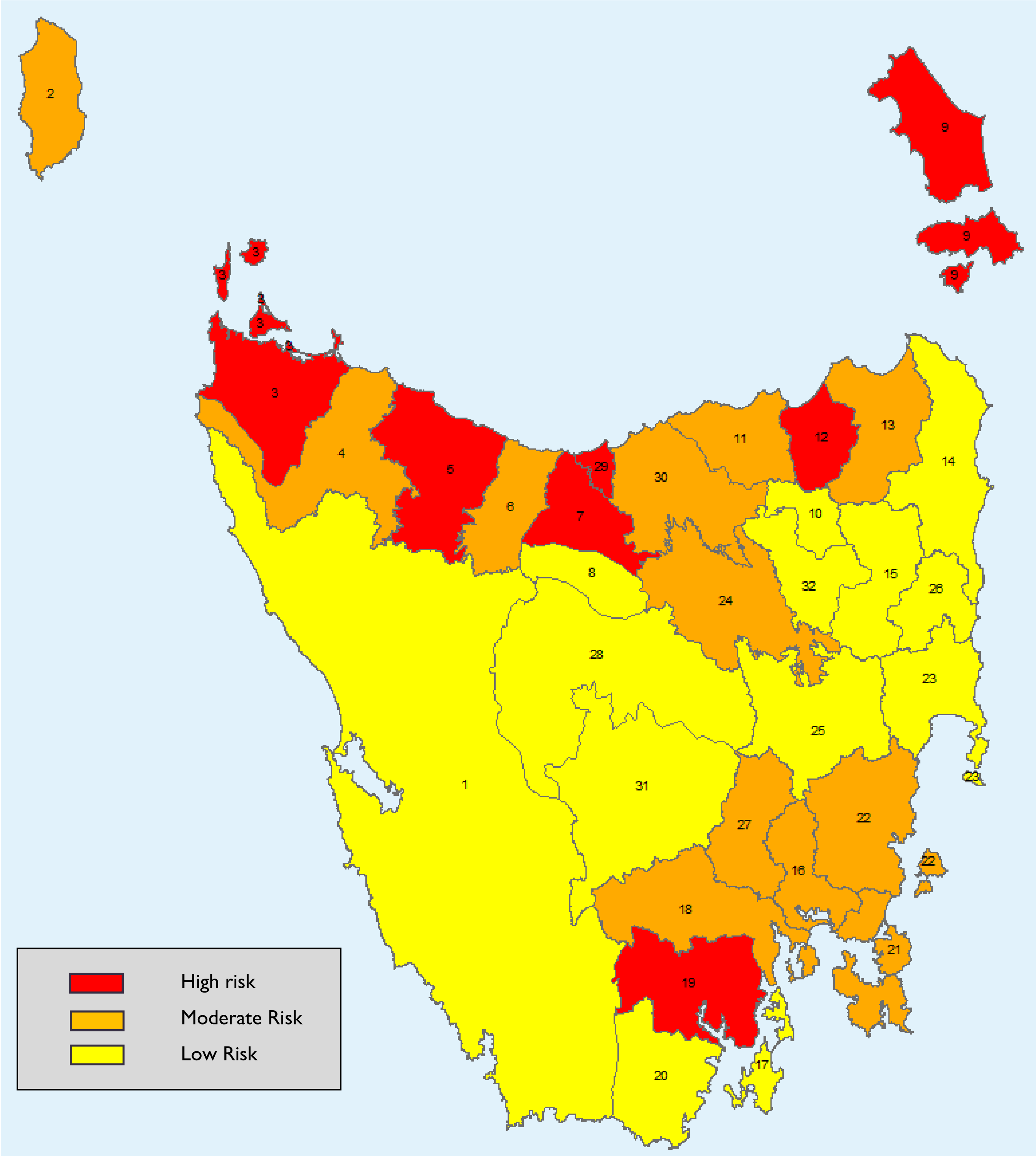


Figure 7: Summary of overall risk for GAUs.

3.3 Risk Treatment

Risk Treatment or management response is determined by the level of confidence in data/knowledge used to assess risk and overall risk severity.

3.3.1 Confidence Level

Confidence was assessed based on the key datasets that are relied upon repeatedly in the GRAT (such as bore data, depth to water table, aquifer storage, GDE connectivity and value) (**Table 7**). These data gaps are regarded as having the most impact on risk scores.

Only the Tasman Peninsula had more than 20% of its bores containing key data attributes. Aquifer storage and recharge estimates are preliminary and desktop in nature, regarded as having low confidence. This is similar to groundwater use, where Sassafras-Wesley Vale is the only GAU with increased certainty due to the ability to validate the crude desktop approach with groundwater use and allocation information from historic surveys.

The groundwater monitoring network is regarded as having good coverage in 8 of the 32 GAUs. The certainty of GDE value, connectivity and depth to water information is highly variable across GAUs. Overall, Sassafras-Wesley Vale is the only GAU regarded as having moderate confidence in risk assessment outcomes.

Table 7: Summary of confidence ratings for GAUs, based on key data gaps.

** 5 bore attributes include Purpose, Casing, Yield, Depth & TDS; ^ Good distribution within GAU but not necessarily in areas of high risk.*

GAU No.	GAU Name	% Bores 5 Attributes	Aquifer Recharge & Storage Estimates	DTW Knowledge	Estimated GW Use	GW Monitoring	Connectivity	GDE Value	TOTAL SCORE	Confidence Class
		0 = <20% 1 = 20-50% 2 = >50%	0 = preliminary 1 = refined	0 = <50% GAU area 1 = >50% GAU area 2 = area specific	0 = preliminary desktop 1 = supporting info 2 = field use survey	0 = not available 1 = local areas 2 = good coverage^	0 = <50% GDE area 1 = >50% GDE area 2 = area specific	0 = <50% GDE area 1 = >50% GDE area 2 = area specific		LOW = 0-5 MOD = 6-9 HIGH = 10-13
1	South West	0	0	0	0	0	0	1	1	LOW
2	King Island	0	0	1	0	0	0	1	2	LOW
3	Smithton Syncline	0	0	1	0	2	0	1	4	LOW
4	Rocky Cape - Arthur	0	0	0	0	0	1	0	1	LOW
5	Burnie Basalts	0	0	1	0	2	1	0	4	LOW
6	Leven - Forth-Wilmot	0	0	1	0	2	1	1	5	LOW
7	Sheffield-Spreyton-Kimberley	0	0	1	0	2	1	1	5	LOW
8	Mole Creek	0	0	1	0	1	1	0	3	LOW
9	Flinders Island	0	0	1	0	0	0	1	2	LOW
10	Upper South Esk	0	0	0	0	0	1	0	1	LOW
11	Pipers-Little Forester	0	0	1	0	1	1	0	3	LOW
12	Great Forester-Brid	0	0	1	0	2	0	1	4	LOW
13	Boobyalla-Tomahawk and Ringarooma	0	0	1	0	1	1	0	3	LOW
14	Musselroe, George and Scamander	0	0	0	0	0	1	0	1	LOW
15	Upper North Esk	0	0	0	0	0	1	1	2	LOW
16	Pittwater - Coal River	0	0	1	0	2	1	1	5	LOW
17	Bruny Island	0	0	1	0	0	0	1	2	LOW
18	Lower Derwent and Derwent Estuary	0	0	1	0	0	1	0	2	LOW
19	Huon North	0	0	1	0	1	1	0	3	LOW
20	Huon South	0	0	0	0	0	0	1	1	LOW
21	Tasman Peninsula	1	0	1	0	1	1	0	4	LOW
22	Little Swanport - Prosser and Maria Island	0	0	1	0	1	1	1	4	LOW
23	Swan-Apsley	0	0	0	0	1	1	1	3	LOW
24	Longford Basin	0	0	1	0	2	1	1	5	LOW
25	Macquarie	0	0	1	0	1	1	1	4	LOW
26	Fingal Range - St Marys	0	0	0	0	1	1	1	3	LOW
27	Jordan	0	0	1	0	1	1	1	4	LOW
28	Central Plateau	0	0	0	0	0	1	1	2	LOW
29	Sassafras - Wesley Vale	0	0	1	1	2	1	1	6	MOD
30	Tamar Estuary	0	0	1	0	0	1	0	2	LOW
31	Upper Derwent	0	0	1	0	1	1	1	4	LOW
32	Mt Barrow-Ben Lomond Ranges	0	0	0	0	0	0	0	0	LOW

3.3.2 Management Response

Based on confidence levels and overall risk levels described above, recommended management responses for each GAU are recorded in **Table 8**.

Sassafras-Wesley Vale is the only GAU that is currently regarded as requiring active management. This GAU is currently the only GMA in Tasmania, and groundwater is licensed and allocated in accordance with the Sassafras-Wesley Vale Water Management Plan (2012)[4].

Other GAUs are recommended to have a combination of Basic and Reconnaissance Risk Treatments. GAUs requiring further investigation particularly include Smithton Syncline, Burnie Basalts, Sheffield-Spreyton-Kimberley, Flinders Island, Great-Forester-Brid, and Huon North. Four of these GAUs, are the focus of case studies in the following sections where risk evaluation and treatment are explored in more detail.

Given the generic, over-arching nature of the Risk Treatment options provided for each GAU in **Table 8**, it is recommended that more GAU-specific mitigation and management measures are identified to actively manage groundwater in priority areas, and especially where confidence is increased, to tailor treatments to the spread of risk across all risk types (i.e. specific criteria within the three risk types – productive base, groundwater quality and GDEs), as well as overall risk.

Table 8: Summary of confidence ratings, overall risk and recommended management responses for GAUs.

GAU No.	GAU Name	Overall Risk	Confidence Class	Management Response
1	South West	LOW	LOW	BASIC
2	King Island	MODERATE	LOW	RECONNAISSANCE
3	Smithton Syncline	HIGH	LOW	RECONNAISSANCE
4	Rocky Cape - Arthur	MODERATE	LOW	RECONNAISSANCE
5	Burnie Basalts	HIGH	LOW	RECONNAISSANCE
6	Leven - Forth-Wilmot	MODERATE	LOW	RECONNAISSANCE
7	Sheffield-Spreyton-Kimberley	HIGH	LOW	RECONNAISSANCE
8	Mole Creek	LOW	LOW	BASIC
9	Flinders Island	HIGH	LOW	RECONNAISSANCE
10	Upper South Esk	LOW	LOW	BASIC
11	Pipers-Little Forester	MODERATE	LOW	RECONNAISSANCE
12	Great Forester-Brid	HIGH	LOW	RECONNAISSANCE
13	Boobyalla-Tomahawk and Ringarooma	MODERATE	LOW	RECONNAISSANCE
14	Musselroe, George and Scamander	LOW	LOW	BASIC
15	Upper North Esk	LOW	LOW	BASIC
16	Pittwater - Coal River	MODERATE	LOW	RECONNAISSANCE
17	Bruny Island	LOW	LOW	BASIC

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[4] https://nre.tas.gov.au/water/water-management-plans/adopted-water-management-plans/sassafras-wesley-vale-wmp

GAU No.	GAU Name	Overall Risk	Confidence Class	Management Response
18	Lower Derwent and Derwent Estuary	MODERATE	LOW	RECONNAISSANCE
19	Huon North	HIGH	LOW	RECONNAISSANCE
20	Huon South	LOW	LOW	BASIC
21	Tasman Peninsula	MODERATE	LOW	RECONNAISSANCE
22	Little Swanport - Prosser and Maria Island	MODERATE	LOW	RECONNAISSANCE
23	Swan-Apsley	LOW	LOW	BASIC
24	Longford Basin	MODERATE	LOW	RECONNAISSANCE
25	Macquarie	LOW	LOW	BASIC
26	Fingal Range - St Marys	LOW	LOW	BASIC
27	Jordan	MODERATE	LOW	RECONNAISSANCE
28	Central Plateau	LOW	LOW	BASIC
29	Sassafras - Wesley Vale	HIGH	MODERATE	ACTIVE
30	Tamar Estuary	MODERATE	LOW	RECONNAISSANCE
31	Upper Derwent	LOW	LOW	BASIC
32	Mt Barrow-Ben Lomond Ranges	LOW	LOW	BASIC

3.4 Case Study Areas

The following four GAUs have been identified as case study areas to conduct a deeper dive into risk assessment outcomes, major knowledge gaps and recommended management responses.

3.4.1 Smithton Syncline

Risk Evaluation

Smithton Syncline GAU recorded the highest risk overall and for each risk type. Groundwater in this GAU is a highly valuable and accessible resource with high quality (low TDS) and high-yielding bores. The primary aquifer being the Precambrian dolomite, however, is not robust (estimated storage to recharge ratio of 26) and there are many groundwater and surface water users in the area, with high propensity for interference between users and inter-connectivity between groundwater and surface water resources. Depth to groundwater is shallow and the landscape typically has low relief, particularly near the coast. Adjacent aquifers are poorer in water quality (i.e., generally higher TDS) and the region supports medium to high-risk land uses such as dairying and plantation forestry. GDE extent, value and sensitivity is high.

Over 20% (estimated 23%) of mean annual recharge is potentially being extracted from bores and there are areas of high-density groundwater use; both factors present as high risks. Interest in groundwater development within the GAU has continued solidly over the past 5 years (78 new bores and 106 new permits). Localised declines in summer (January-April) groundwater levels have been recorded across the GAU, such that 4 of 18 monitoring bores with the last 10 years of record exhibit declines of <10 cm/yr.

Risk Treatment

Due to high risk and low confidence, this GAU has been classified as requiring Reconnaissance Risk Treatment (**Table 8**). As a result, this GAU is the first priority for bore audits and groundwater use surveys and a suite of other dataset development/refinement recommendations outlined in **Chapter 4**.

It is likely that this GAU will require Active Risk Treatment (i.e. dedicated groundwater management) once confidence has been increased in the risk assessment, which is scheduled for 3-5 years' time.

3.4.2 Burnie Basalts

Risk Evaluation

Burnie Basalts GAU has been assessed as high risk overall and high risk for both productive base groundwater quality. It has moderate risk for GDEs. Two Risk Statements were assessed as extreme: the potential for plantation forestry to cause water level declines and reduced water availability, and the potential for extraction to cause ingress of poor-quality water from adjacent aquifers. Almost all other Risk Statements were assessed at high or moderate risk level.

The primary Tertiary basalt aquifer is not robust (estimated storage to recharge ratio of 42) yet the GAU already supports many groundwater and surface water users. It is estimated that current groundwater use is moderate (14%) compared to mean annual recharge. Despite an already high numbers of bores, there has been a high level of ongoing interest in groundwater development in the area over the last 5 years (68 new bores and 74 new permits). Localised declines in summer (January-April) groundwater levels have been recorded across the GAU, such that two of five monitoring bores with the last 10 years of record exhibit declines of <10 cm/yr. Waterbodies are typically gaining in this area and there is some evidence of aquifer confinement with the presence of artesian bores in some locations. The extent of plantation forestry is considered large (>10,000 ha) and there are extensive areas of shallow water tables (<10 m). GDE sensitivity is considered high and extent and value moderate.

Risk Treatment

Due to high overall risk and low confidence, this GAU has been classified as requiring Reconnaissance Risk Treatment (**Table 8**). As a result, this GAU is another priority for bore audits and groundwater use surveys and a suite of other dataset development/refinement recommendations outlined in **Chapter 4**.

This GAU may require Active management once confidence has been increased in the risk assessment, which is scheduled for 3-5 years' time.

3.4.3 Huon North

Risk Evaluation

Huon North GAU has been assessed as high risk overall and high risk for groundwater quality. It has moderate risk for productive base and GDEs. Two Risk Statements were assessed as extreme: the potential for groundwater extraction to cause ingress of poor-quality water from adjacent aquifers and seawater intrusion. Two other Risk Statements were assessed as high: the potential for water quality impacts from point and diffuse sources, and the potential for plantation forestry to cause water level declines and reduced water availability.

There are more than 500 bores in this GAU (the fourth highest number for all 32 GAUs), however aquifer robustness is considered moderate (estimated storage to recharge ratio of 89) and recent interest in groundwater permits over the last 5 years is only considered moderate in the Tasmanian context (28 new bores and 43 new permits). It is estimated that current groundwater use is moderate (13%) compared to mean annual recharge. Ten percent of bores are within 100m of main waterways, moderate-high risk land uses and GDEs, and there are extensive areas of shallow water tables (<10 m). The target Permian aquifer is at least partially confined with artesian conditions recorded in several bores.

The groundwater monitoring network and dataset is currently inadequate as no 10-year trends could be assessed for this GAU. GDE sensitivity and connectivity is considered high and extent and value moderate.

Risk Treatment

Due to high overall risk and low confidence, this GAU has been classified as requiring Reconnaissance Risk Treatment. As a result, this GAU is another priority for bore audits and groundwater use surveys and a suite of other dataset development/refinement recommendations outlined in **Chapter 4**.

This GAU may require Active management once confidence has been increased in the risk assessment, which is scheduled for 3-5 years' time.

3.4.4 Great Forester-Brid

Risk Evaluation

Great Forester-Brid GAU has been assessed as high overall risk and high risk for productive base. It has moderate risk for groundwater quality and GDEs. Three Risk Statements were assessed as high: the potential for current extraction to impact on existing surface water entitlements, the potential for plantation forests to impact on groundwater users via recharge interception and direct extraction, and the potential for current extraction to cause seawater intrusion. Other Risk Statements were typically assessed as being moderate and only two were low.

The target Tertiary sediment aquifer is considered moderately robust (estimated storage to recharge ratio of 51), partially confined and the number of bores in the GAU is considered low (<200). Risk to the water resources in this GAU is largely because of surface water (predominately gaining waterbodies, large number of surface water allocations and key waterways used for conveyance of irrigation water). Depth to water table is typically shallow (< 10 m) and the area of current plantation extent is high (>10,000 ha).

Despite the low number of bores and therefore estimated groundwater use (4% of annual recharge), local declines in groundwater level have been observed in the monitoring network such that two of three monitoring bores with the last 10 years of record exhibit declines in water level of 7 cm/yr. and 11 cm/yr. GDE connectivity and sensitivity is high whilst extent and value is moderate. More than 10% of bores are within a setback distance of 35 m of mapped GDEs. Soils are typically sandy and the hydraulic gradient to the coast is low.

Risk Treatment

Due to high overall risk and low confidence, this GAU has been classified as requiring Reconnaissance Risk Treatment. As a result, this GAU is another priority for bore audits and groundwater use surveys and a suite of other dataset development/refinement recommendations outlined in **Chapter 4**. This GAU may require Active management once confidence has been increased in the risk assessment, which is scheduled for 3-5 years' time.

4. Information Gaps and Recommendations

This chapter identifies the key data gaps and priorities to inform future investment in monitoring, management, and investigation of groundwater resources. Recommendations are also included for how to best address gaps and achieve value and efficiency. Implementation of the priorities outlined will further support the GRAT and improvement in knowledge of priority groundwater areas where it is currently limited.

4.1 Data Management

Whilst not directly related to core gaps in the GRAT, revision of the GWIMS database is required to support future implementation of the GRAT and priority data collection.

GWIMS functionality is fundamentally limited in its current state due to ongoing maintenance and original data migration issues. Repairs to several aspects of GWIMS are required to improve user-experience in the short-term and to accommodate data collection in the long-term.

Key bore attributes required from GWIMS for successful implementation of the GRAT include:

- Location
- Drilled date
- Total depth
- Screen interval (Screen from and Screen to)
- Purpose
- Status
- Yield
- Yield date
- Salinity as TDS
- TDS date
- Depth to water as SWL
- SWL date
- Aquifer hydraulic conductivity (K)
- Aquifer storage coefficient (S/Sy)

Very few records of the latter two fields currently exist in GWIMS and therefore it is recommended that K/S data from grey literature be uploaded. The literature to be searched should include Government technical reports and publicly available consultant reports for industry licence applications and approvals.

An additional bore attribute that should be added to GWIMS is annual groundwater use (GW Use expressed in ML) to enable recording of extraction estimated through either metering (M), field audit (F) or desktop assessment (D) – the M/F/D codes should be used to identify the source of the groundwater use estimate via a Use_Method attribute. Finally, the year to which the use estimate applies should be recordable through a Use_Year attribute.

It is currently difficult for NRE Tas staff to upload data to GWIMS and exporting bulk downloads of the above-mentioned fields requires the specialist access and querying by Information and Communication Technology (ICT) staff. For the recent GRAT implementation, NRE Tas Water Management and Assessment Branch staff could not perform the downloads and had to submit requests to ICT.

It is therefore recommended that an IT solution to database functionality becomes the highest priority. GWIMS should be readily accessible to NRE Tas staff for rapid and frequent data uploads and downloads. These critical improvements should be implemented in time for direct upload of results from Parts B & C of the GAP.

4.2 Monitoring

Monitoring networks must consider spatial and temporal coverage, and the ability to identify and understand local flow systems, or emerging issues. Monitoring networks are passive in characterising and understanding delayed impacts, i.e. an impact may be occurring but yet to be identified by the monitoring - this aspect must be guided by predictive modelling or by rigorous groundwater system conceptualisation.

Approximately 120 monitoring bores are located across Tasmania. Whilst some GAUs have several, many have none and therefore groundwater trends are unknown. Issues with groundwater monitoring and trend data that was available (in terms of completeness of accuracy of record) were also identified during the application of the GRAT.

A review of the existing groundwater monitoring network is required to rationalise, replace, and extend the network as required, in response to GRAT risk outcomes and NRE Tas requirements. This is the priority task which will inform the need for the installation of loggers in existing monitoring/investigation bores; and drilling, construction and equipping of new monitoring bores, as well as additional resources. Water quality monitoring requirements should be included in the network review and consider areas with high water quality risks. Salinity as TDS can be misleading because it depends on several variables that are not currently recorded in GWIMS. These include seasonality, method of bore purging and sampling (e.g., airlift, pump, bailer), and whether it was a laboratory or field analysis (instrumentation calibration in the latter case).

Standard Operating Procedures should also be developed to support groundwater level and quality data collection and QA/QC processing of data post collection and prior to ingestion into Aquarius (NRE Tas's water data management system) and GWIMS. As there is currently very limited routine analysis of monitoring bore data, it may be worthwhile setting alarm warnings within Aquarius for some monitoring bores where triggers exist or can be developed.

4.3 Datasets

A number of critical but currently unavailable datasets were required for the Stage 1 implementation of the GRAT. As a result, these had to be estimated using crude and rapid desktop methodologies. The following sections offer a priority list of recommendations to address critical knowledge gaps identified throughout the implementation of the GRAT and thereby provide greater confidence in future GRAT assessment and outcomes. Priority to develop or refine any of these datasets should be based on the number of Risk Statements that would be impacted by the improved dataset. These are the recommendations which largely inform Parts B & C of the GAP.

Purpose and magnitude of existing groundwater use

- Volume of groundwater use had to be estimated for Stage 1 using a crude method involving bore yields measured at the time of drilling. An alternative approach using irrigated areas from land use mapping and a theoretical crop water requirement was adopted for comparison. The former approach was the most comparable to the only known area of groundwater use – Sassafras-Wesley Vale. Both methods are typically regarded as being highly inaccurate.
- Only a small proportion of all bores have a recorded Purpose and those that do have likely not been verified since the time of drilling and/or permit application.
- A field audit of bore location, elevation, construction, purpose, and volume of extraction should be a priority in all GAUs with High levels of risk. Other worthwhile data to collect whilst onsite includes depth to water table below ground level, field water quality (Electrical Conductivity/ pH/Temperature) (where possible) and total bore depth.

Surface water and groundwater connectivity

- Connectivity has only been mapped in the past using crude desktop methods in regions assessed under the Tasmanian Sustainable Yields Project (TasSY Project) and the National GDE Atlas and is not comprehensive. Connectivity information was only available for ~60% of GDE area.
- There has been minimal field verification in any priority regions, or in remaining areas of the State.
- Options to address this gap include a desktop assessment, and/or reconnaissance field (flow/radon-222) studies, the latter of which could also be used to verify TasSY and GDE Atlas mapping.
- Priority should be given to those GAUs with High or Extreme levels of risk to surface water users and/or GDEs.

Depth to water table

- Stage 1 only assessed Depth to Water table (DTW) for GAUs that had >50% spatial coverage with historical water level records (albeit on different dates) and the output was percentage of bores with DTW <10 m, rather than an interpolated water table surface. Whilst indicative, the metric did not take into consideration the location of the water level records relative to the risk source (e.g., land use) or receptor (i.e., bore or GDE) being assessed.
- Crude desktop methods are available; however, the most meaningful new knowledge will come from field mapping of water table (and ground surface) elevation during bore audits. Accordingly, priority GAUs should correlate with those for groundwater use above. Secondary GAUs include those not necessarily rated as high risk overall but rated high risk for DTW specific criteria (1.5, 2.3, 2.5).

Aquifer storage

- Stage 1 used GAU area to estimate storage volume in the absence of mapped aquifer extents. Likewise, mean bore depth was used in the absence of mapped aquifer thickness. Other simplifications were average historical recharge across the GAU and an assumed uniform value of 0.05 for aquifer specific yield.
- A rigorous desktop assessment could be used to accurately map 3D aquifer geometry (spatial extent and thickness), apply clipped recharge rasters and locally relevant storage coefficients (ideally from historical pumping tests recorded in unpublished reports) to derive more appropriate storage estimates.

Value, dependency, and sensitivity of GDEs

- GDE value information was obtained directly from Conservation of Freshwater Ecosystem Values (CFEV) datasets where they overlaid the GDE Atlas datasets. As a result, all Terrestrial GDEs and a proportion of Aquatic GDEs were unable to be assigned value information.
- Options to address this include developing and implementing an Integrated Conservation Value (ICV) type ruleset for unassigned GDEs via a desktop, GIS exercise.
- GDE sensitivity estimates could be made more robust if aquatic (wetland, river, waterbody classifications) and terrestrial (vegetation communities/species) were used to assign sensitivity. However, neither the current nor alternate approach is as vital as site-specific investigations to truly improve sensitivity risk.
- Level of groundwater dependence was taken directly from the GDE Atlas layers, however some discrepancies between the groundwater dependency category and the ecosystem type were acknowledged (in some instances springs and alpine peat swamps were identified as having moderate potential for groundwater dependency – whereas these should presumably be high). These should be sense checked and updated in Atlas layers.
- Remote sensing options may exist for better interpreting level of groundwater dependence of GDEs (i.e., Water Observations from Space – WofS, and Normalised Difference Vegetation Index - NDVI). This could also be used to assign level of dependence to terrestrial GDEs which are currently unassigned.

4.4 Groundwater Management

GAU boundaries

Consider refining the GAU boundary for Leven Forth Wilmot (GAU no. 6). Currently the Forth River is the eastern GAU boundary which is problematic for the application of GDE and several other risk criteria.

GAU boundaries may also be adjusted over time in response to GMA declaration, stakeholder consultation and NRE Tas requirements.

Mitigated risk assessment

A mitigated risk assessment could be undertaken in the future by identifying current mitigation measures in place (i.e. existing water management plans, well works permits or well setbacks) to identify areas of residual risk and further target response measures accordingly. Existing controls will be identified in 2024-25 as part of the scheduled groundwater policy and management setting review.

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Appendices - available in separate report

(see Groundwater Risk Assessment Tool and Management Framework – Appendices)

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