Department of Planning and Environment

dpie.nsw.gov.au

Guidance on strategic planning outcome - Understanding water security

Regulatory and assurance framework for local water utilities

December 2022

Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

Published by NSW Department of Planning and Environment

dpie.nsw.gov.au

Guidance on strategic planning outcome - Understanding water security

First published: December 2022

Department reference number: PUB22/1213

Acknowledgements

This guidance was developed in partnership with the local water utilities sector. We particularly acknowledge the contribution of members of the Town Water Risk Reduction Program's working group on local water utility strategic planning of this guidance.

Contents

1. Introduction

Local water utilities can best meet the needs of their customers, and manage key risks, when their decisions and activities are based on effective, evidence-based strategic planning.

The NSW Department of Planning and Environment is committed that all local water utilities should have in place effective, evidence-based strategic planning. This will ensure utilities deliver safe, secure, accessible, and affordable water supply and sewerage services to customers. It will also ensure they can manage keys risks now and into the future, and in the event of significant shocks. Local water utilities remain responsible for conducting strategic planning.

The department gives assurance of effective, evidence-based strategic planning. Local water utilities not making dividend payments[1] are encouraged, but not compelled, to use the department's assurance framework, experience and capacity to support effective strategic planning.

Through the department's assurance role under section 3 of the Regulatory and assurance framework for local water utilities (PDF, 1613.11 KB) - Regulatory and Assurance Framework - we establish what outcomes we expect effective, evidence-based strategic planning to achieve (see section 3.2 of the Regulatory and Assurance Framework) and assess if a utility's strategic planning achieves these outcomes to a reasonable standard (see sections 3.3 and 3.4 of the Regulatory and Assurance Framework).

We give separate, optional guidance in the department's guidance Using the Integrated Planning and Reporting framework for local water utility strategic planning (PDF, 573.33 KB) to explain how utilities can achieve the strategic planning outcomes to a reasonable standard using the *Integrated Planning and Reporting Framework* for councils under the *Local Government Act 1993*.

1.1 Purpose of this document

This document supplements the Regulatory and Assurance Framework and gives guidance on achieving the outcome of understanding water security to a reasonable standard.

This guidance is consistent with the objectives and principles established under the Regulatory and Assurance Framework, including being outcomes focused and risk-based.

This document sets out good practice **for all local water utilities** to apply when doing strategic planning to achieve the outcome of understanding water security.

[1] Sections 3 and 4 of the Regulatory and Assurance Framework, are also the Guidelines for council dividend payments for water supply or sewerage services, under section 409(6) of the *Local Government Act 1993.* Before taking a dividend payment from a surplus of the council's water supply and/or sewerage business, a council must have in place effective, evidence-based strategic planning in accordance with section 3 of the Regulatory and Assurance Framework.

1.2 Structure of this document

This guidance is structured providing:

- the expectations for achieving this outcome to a reasonable standard
- an appendix with optional 'how to' guidance that helps utilities achieve assurance expectations
- an appendix providing templates, case studies and tools useful for utilities to achieve assurance expectations.

1.3 Review of this guidance

As part of our commitment to continuous improvement, we will review the performance of the Regulatory and Assurance Framework within 2 years from finalisation. There will also be periodic reviews of the full suite of relevant regulatory and assurance documents, which will happen at least every 5 years.

The department is undertaking water security pilot projects and case studies, including using regional water strategy data and modelling for water security analysis. We expect lessons learned from pilot projects and case studies to be available in 2023. This guidance may be updated to align with lessons learned.

We welcome feedback on this guidance and will update it when needed based on feedback or a 'lessons learned' review following our assessment of strategic planning by local water utilities.

2. Oversight of local water utility strategic planning

Under section 3 of the Regulatory and assurance framework for local water utilities (PDF, 1613.11 KB), the department establishes what outcomes it expects effective, evidence-based strategic planning to achieve (see section 3.2) and assesses whether a local water utility's strategic planning achieves these outcomes to a reasonable standard (see sections 3.3 and 3.4).

Councils making a dividend payment from a surplus of their water and/or sewerage business must meet the expectations set out in section 3 and section 4 of the Regulatory and Assurance Framework.[2] Local water utilities not making dividend payments are encouraged, but not compelled, to utilise the department's assurance framework, experience and capacity to support effective strategic planning.

For effective, evidence-based strategic planning to occur, the department expects strategic planning to achieve the following outcomes to a reasonable standard:

- Understanding service needs
- Understanding water security **(this guidance)**
- Understanding water quality
- Understanding environmental impacts
- Understanding system capacity, capability, and efficiency
- Understanding other key risks and challenges
- Understanding solutions to deliver services
- Understanding resourcing needs
- Understanding revenue sources
- Make and implement sound strategic decisions
- Implement sound pricing and prudent financial management
- Promote integrated water cycle management

A **reasonable standard** is met if the utility considers and addresses an outcome in a way that is:

- **sufficient:** underpinned by evidence-based analysis that supports the conclusions reached
- **appropriate:** underpinned by relevant departmental guidance and industry standard approaches to conduct planning and reach conclusions

---

[2] Sections 3 and 4 of the Regulatory and Assurance Framework, are also the Guidelines for council dividend payments for water supply or sewerage services, under section 409(6) of the *Local Government Act 1993.* Before taking a dividend payment from a surplus of the council's water supply and/or sewerage business, a council must have in place effective, evidence-based strategic planning in accordance with section 3 of the Regulatory and Assurance Framework.

- **robust:** underpinned by evidence that draws on appropriate sources and recognises and rebuts potential alternative interpretations.

The assessment considerations the department will apply and how these may be addressed are set out in more detail in the Regulatory and Assurance Framework.

3. Guidance on understanding water security

Under section 3.2 of the Regulation and Assurance Framework, the department expects utilities to achieve to a reasonable standard the strategic planning outcome **understanding water security**. This includes considering:

- What is the local water utility's access to current and potential water supply sources?
- How will the local water utility address current and future risks around continuity and reliability of access to water supply sources?

3.1. Understanding water security

Understanding water security is important to ensure long-term continuous access to reliable water supply. Uninterrupted long-term access to water contributes to public health, economic development opportunities, social amenity, and liveability – allowing communities to grow and thrive.

Water security ensures a local water utility can meet the water supply needs for customers and community, over time and in response to changes to supply and demand, including the impacts of climate change, population growth and extreme events (see Box 1).

Water security analysis assesses the long-term risk a regional city, town, or community faces in accessing a reliable water source. Assessing the risk considers the availability of water, operating conditions, and service levels that meet customer and community needs, values, and preferences.

Box 1 – Key challenges and opportunities for water security

Australia has a highly variable climate, and rainfall is especially variable. This makes it vital that we understand as much as we can about our climate so we can work out how we manage our water supplies. The frequency and duration of wet and dry events determines how much water we have available.

NSW is already experiencing trends of higher average temperatures and reduced cool season rainfall. There are indications from climate models that drought conditions may become more frequent and severe, and last longer.

Higher demand from a growing population, alongside reductions in supply, will increase water scarcity, putting further pressure on all users, including the environment (Productivity Commission, National Water Reform Issues Paper, May 2020, p.2).

Source: *NSW Water Strategy 2021.*

Planning for water security is not one size fits all. Water sources and water supply systems differ across regional NSW and customers and communities also have different needs, values, and preferences for water security.

In relation to surface water and groundwater systems in regional NSW, local water utilities and the NSW Government share responsibility for water security for town water supplies.

The NSW Water Strategy takes a strategic and integrated approach to looking after the state's water. It sets the overarching vision and objectives to guide water service delivery and management across NSW, aligned with the 12 regional water strategies and the 2 metropolitan water strategies – the Greater Sydney Water Strategy and the Lower Hunter Water Security Plan. Together, the strategies will improve the resilience of NSW's water services and resources.

Regional water strategies bring together the most up-to-date information and evidence in an integrated package that includes policy, regulatory, educational, technology, and infrastructure solutions. Based on best evidence, the strategies aim to balance different water needs and deliver the right amount of water of the right quality for the right purpose at the right times.

The strategies look at the next 20 to 40 years to understand a region's water needs to meet future demand, the challenges and choices involved in meeting those demands, and the actions available to manage risks to water availability.

Local water utilities are responsible for having in place effective, evidence-based strategic planning for their services. This includes considering risks to secure and reliable water supply to customers taking into account long-term access to secure water sources as well as emerging and acute risks to water security.

Regional water strategy modelling outputs have the potential to provide input data for a utility's water security analysis. The modelled data consists of climate data at selected locations across the state (rainfall and evapotranspiration), as well as streamflow data.

As part of the preparation of regional water strategies, the department tried to model the operation of town water supply systems for many local water utilities across the state. However, the level of detail of this modelling was designed to obtain a regional understanding of water management risks. It may not be fit for purpose for town water security analysis, and further modelling and analysis may be required. It is the local water utility's responsibility to ensure the streamflow and climatic data, and the representation of supply systems and infrastructure within a modelling framework, is fit for purpose for water security analysis.

Achieving the outcome of understanding water security is critical to adequately considering any current and future water security risks and water security service levels for water supply services.

This should help the utility:

- consider any options/solutions for service delivery it develops and evaluates as part of the strategic planning outcomes of understanding solutions to deliver services and understanding resourcing needs
- make strategic decisions under the strategic planning outcome of make and implement sound strategic decisions, especially when setting water security service levels and contingency and emergency measures.

In the following sections we set out **what** the department's expectations are for **understanding water security** to a reasonable standard. In Appendix A and Appendix B, we provide optional guidance and case-studies and tools on **how** some of these expectations could be met.

3.2 What is the local water utility's access to current and potential water supply sources?

The local water utility should understand available water sources

To inform its understanding of water security, the local water utility should identify, and understand, its access, or potential access, to sources of water and the characteristics of these water sources.

Water sources available to the local water utility may include:

- surface water – collected from rivers, reservoirs, and weirs
- groundwater – extracted from aquifers
- recycled water – sourced from sewage, greywater, or other wastewater
- stormwater – collected from runoff in urban areas
- rainwater – collected from rooftop runoff
- seawater – extracted from an estuary or the ocean
- imports of water from other service providers (for example, via transfer pipelines).

For each available water source, the utility should understand:

- the location and the communities the water supply currently services or may service
- current and future water availability and reliability considerations, including those set out in relevant regional water strategies
- relevant water sharing plans, entitlements, allocations, and trading rules within water sources, including environmental flow requirements
- the local water utility's existing water access licences and works approvals under the *Water Management Act 2000* and any requirements for, or limitations of, any water access licences and associated works approvals
- the level of treatment required to satisfy the requirements for the protection of public health under the *Public Health Act 2010* and the Australian Drinking Water Guidelines.

The local water utility should understand the climate-resilience of its water sources

To support water supply resilience and security in the face of climate change, population growth, and drought, the local water utility should consider diverse water sources, including climate resilient sources that do not rely directly or indirectly on rainfall.

A water source's level of climate resilience relates to its rainfall independence. A water source may:

- directly rely on rainfall resulting in a lower level of climate resilience (for example, surface water, stormwater, rainwater, or groundwater connected to surface water that is recharged by rainfall events)[3]
- indirectly rely on rainfall resulting in a medium level of climate resilience (for example, deeper groundwater sources not connected to surface water, recycled water where surface water or groundwater are the primary sources of drinking water)
- not rely on rainfall, which results in a high level of climate resilience (for example, desalinated seawater, recycled water where seawater is the primary source of drinking water).[4]

3.3 How will the local water utility address current and future risks around continuity and reliability of access to water supply sources?

Water security analysis is critical to understanding the risk a regional town or community faces to long-term continuous access to a reliable water supply and water for sanitation. That is, to meet the water needs of customers and the community.

Local water utilities are responsible for managing water security access risk and that information used for analysis is fit for purpose.

Robust analysis will help inform the utility's considerations of available water sources, current and future system capacity and capability, and the sizing of system infrastructure (see guidance on the outcome of understanding system capacity, capability, and efficiency). It will also help inform its tactical planning to respond to droughts, extreme events, and other shortfall events (see also guidance on the outcome of understanding other key risks and challenges).

The local water utility should understand the long-term availability and reliability of access to water from relevant water sources and any risks to access now and into the future

To analyse to a reasonable standard the availability and reliability of access to water from a water source, the local water utility should take a long-term outlook and consider climatic conditions and any potential changes to them. To do so, the utility should use a combination of:

- historical streamflow data (1889-current)
- paleo-stochastic climate data
- NARCliM[5] climate projections

---

[3] Note that each of these have different levels of climate resilience. Rainwater and stormwater runoff from hardened urban areas are more climate resilient than surface water because they are not affected by antecedent conditions. Storage also affects a water supply's climate resilience. Similarly, different aquifers can widely vary in their climate resilience depending on the size of the aquifer relative to the annual recharge (and draw on the aquifer).

[4] Water Services Association of Australia 2020. All options on the table: Urban water supply options for Australia. https://www.wsaa.asn.au/publication/all-options-table-urban-water-supply-options-australia

[5] NSW and Australian Regional Climate Modelling (NARCliM) generated detailed climate projections and data for NSW

- other appropriate datasets.

The local water utility should not use historical streamflow data solely for assessing future availability and reliability of access to water. Historical climate data of the past 130 years does not represent a period long enough to understand the risks of drought and drought severity. Also, it does not provide forecast impacts of climate change. Utilities that access water from different sources, should use data consistently in the assessment of their water sources (for example, for rainfall and evapotranspiration).

As part of the development of the regional water strategies, we have developed new climate datasets (rainfall, evapotranspiration, streamflow). We are making these datasets progressively available via the SEED Open Data Portal. This data combines historic and paleo-climate data, as well as incorporates climate change information. This may provide a source of data for utilities, or they may choose to develop their own datasets.

The analysis should be based on robust rainfall run-off and streamflow modelling and appropriate water resource models (for example, such as Source, IQQM, or WATHNET) and reflect the utility's water delivery arrangements (for example, where utilities receive water from another utility).

Water resource models rely on assumptions and probabilistic algorithms to understand water supply reliability. As a result, all models have limitations that local water utilities relying on model outputs should consider and understand.

The analysis should consider any risk to access to water associated with:

- the characteristics of the water source and arrangements for the delivery of water to the utility's access point, including operating conditions and operating rules set out in water sharing plans, and impacts of physical delivery conditions
- the raw water quality of the water source, and any potential future changes in water quality due to extreme events or land use changes in the upstream catchment
- other critical assumptions and the impact on water security of changes to those assumptions.

To understand the water security of its supply systems, the local water utility should apply sound water security criteria and service levels

Water security risk of water supply systems is generally defined and measured in terms of water supply restriction (that is, some water can be supplied, but some water uses are restricted) and shortfall events (that is, the utility cannot supply any water or meet a determined (minimum) level of supply).

It is therefore critical to understand and determine the level of service and/or risk appropriate for a utility's water supply systems in consultation with customers and the community, given the:

- risks to the availability and reliability of access to water under changing climatic conditions and water resource management policies
- probability of extreme drought events
- lead times to access new water sources and supply options

- need to design and size current and future system capacity and capability to meet agreed water security service levels
- cost of service restrictions
- availability of contingency measures (such as water carting) to respond to shortfall events outside of determined service levels or other unforeseeable extreme events.

To understand long-term water security of water supply systems, the utility should develop and apply sound water security criteria and service levels, considering the following approaches.

- An approach that describes water security service levels in the terms of frequency, duration, and severity of supply restrictions (that is, agreed reduction in supply) and the likelihood of needing to rely on contingency measures to respond to shortfall events.
- Defining enduring supply, where water supplies are capable of meeting customer and communities' minimum needs during periods of prolonged and extreme drought, irrespective of the length of a drought and the impact of climate change.
- Another credible and robust approach, with a clear justification for its application.

The local water utility should assess the water security of supply systems against these water security criteria and service levels taking account of availability and reliability of water access from relevant water sources, the capacity and capability of its supply systems, and the demand for water now and in the future

The utility should assess the water security of supply systems against its selected service level approach, taking account of:

- its understanding of availability and reliability of access to water from existing and potential water sources (as set out above)
- the service needs, values and preferences of customers and communities
- current and future water needs (demands) in water systems over the long-term horizon, during average years and extreme events, and opportunities for demand reductions
- current and future capacity, capability, and efficiency of its supply systems, including the capacity and constraints of any headworks infrastructure, the time taken for systems and storages to fill and empty, and the relative costs of accessing, treating, and distributing water.

The guidance on the outcome of understanding service needs provides further advice on demand analysis and forecasting and on understanding customers' needs, values, and preferences.

The guidance on the outcome of understanding system capacity, capability, and efficiency provides further advice on current and future capacity, capability, and efficiency of supply systems.

Appendix A gives optional how-to guidance for water security analysis. Links to models and data are available in Appendix B.

The local water utility's water security analysis should be proportionate to the scale and complexity of the water supply system and the likelihood and consequences of supply shortfall

Very small and simple systems with demonstrated high levels of water security may not require complex modelling and analysis. The local water utility should identify systems for which it does not apply complex modelling and analysis, or systems that do not rely on complex modelling, and provide clear justification as to why this is not required.

The local water utility should have an adaptive approach to responding to water security risks, understand acute risks to its water supply, and put in place contingency measures to respond to shortfall or extreme events

To deal with uncertainty in the reliability of access to water and acute risks to its water supply, the local water utility should apply an adaptive 'readiness options'[6] approach to stage a response to reduced streamflows, drought conditions, and other extreme events.

This approach allows a local water utility to progressively implement options as drought conditions progress as well as consider and implement contingency measures to respond to shortfall events outside of determined service levels or other unforeseeable extreme events (for example, raw water algal blooms, turbidity due to bushfire contamination, infrastructure failure due to flooding, and other natural system events).

The guidance on the outcome of understanding other risks and challenges contains additional guidance about risks relevant to the continuity and reliability of water supply.

As discussed above, the local water utility should, in consultation with its customers and community, determine the level of risk appropriate for its water supply systems.

The local water utility should identify the triggers to commence implementing each drought response option. For example, the utility should clearly identify the timing of water conservation measures, supply restrictions, and planning or investment in contingency or new water supply options, with reference to total water available, streamflows, groundwater or dam levels, or some other relevant trigger.

Identifying triggers to undertake in advance enables a local water utility to fast-track a contingency or new water supply. These include:

- planning and environmental approvals
- town water supply access licences and works approval
- the design and documentation of the contingency works or augmentation options
- land acquisition
- construction of the time-critical components of the contingency works.

[6] 'Readiness options' refers to the part-implementation of options to shorten lead times for implementation in the event of extreme drought or other emergency. This approach should highlight the different pathways of infrastructure provision or other measures that might be triggered as a result of different changes in circumstance.

This adaptive management approach can improve the resilience of the utility's water supplies. The approach enables the utility to appropriately schedule future investment in major infrastructure and improve the readiness of future supply options.

A local water utility should consult with customers and community to determine the level of service and/or risk appropriate for its supply systems, including appropriate water restriction levels

Levels of service in supply systems are often set with reference to water restrictions. Appropriate water restriction levels are specific to local water utilities, and they should set them in consultation with customers and the community.

A local water utility should set restriction levels that:

- articulate the service level outcomes, and any broader outcomes, such as integrated water cycle management outcomes that supply restrictions should achieve
- measure the achievement of outcomes, including water-saving targets or trends as volumes or percentages from evidence-based information, typically from recent past events
- align to the level of inconvenience and discomfort customers and community are willing to endure during drought conditions and how much they are willing to pay to increase water security
- maintain liveable communities, including considering whether to provide water for greening and cooling
- do not necessarily apply in a uniform way across customers or sectors of the community (for example: a utility may decide restrictions only apply to residential customers; or that certain types of businesses are subject to restrictions while others are not)
- are clearly communicated with its customers and community.

Appendix A: Optional how-to guidance for understanding water security

To support utilities in achieving the strategic planning outcome **understanding water security** to a reasonable standard, we offer the following optional how-to guidance.

The optional how-to guidance in this section covers a variety of areas that may help address one or more of the expectations set out in section 3.

Water security analysis approach in the terms of frequency, duration, and severity of water restrictions

A design approach that describes planning for water security in terms of frequency, duration, and severity of water restrictions can also be referred to as an ‘x/y/z approach’, where:

- ‘x’ refers to the total time spent in drought restrictions expressed as a percentage
- ‘y’ refers to the number of years restrictions apply expressed as a percentage
- ‘z’ refers to the reduction in demand during restrictions expressed as a percentage.

For example, a 5/10/10 design approach requires the total time (duration) spent in drought restrictions should be no more than 5% of the time, the restrictions should not apply more frequently than 10% of years, and when they do apply, should provide 90% of the unrestricted dry-year demand (severity = 10% reduction in demand) through a repetition of the worst drought on record commencing at the time restrictions are introduced. This assumes the storage is already drawn down before the start of the drought, providing an additional storage buffer (that is, factor of safety). See Appendix B for more information about the 5/10/10 design approach.

Modelling climate variability through paleo-stochastic climatic dataset

Paleo-climatic data is reconstructed from sources such as tree rings, cave deposits and coral growth. Through this process, it is possible to extend the instrumental datasets to cover the past 500 to 1000 years.

The paleo-stochastic climate data is generated by running computer variations of the 500-year paleo-climatic dataset. The paleo-stochastic climate data is 10,000 years of daily rainfall, evapotranspiration, and temperature data representing the variability of the long-term climate at each climate station. Included in this 10,000-year data set are periods of higher rainfall and extended periods of lower rainfall.

The department has stochastic climate data available for climate stations across NSW. The primary purpose is to use stochastic climate data as input data for water modelling that analyses water-related outcomes of river basins under long-term climate. We are progressively making these datasets available on the SEED Open Data Portal.

We make current information on climate data and modelling available in the following fact sheets.

- New climate data and modelling
- New climate analysis informs NSW's regional water strategies

How to use NSW Regional Water Strategy paleo-stochastic and climate data for town water security analysis

What stochastic data is available?

In recent work for the regional water strategies, the department developed stochastic datasets of 10,000-year periods of climate. The department bases this stochastic data on mathematical models that generate datasets with the same statistical properties (for example, the same mean and standard deviation) as the 130-year historical instrumental climate record (for rainfall and evaporation), but with different sequencing of wet and dry years, months, and days. This change in sequencing represents the same climate conditions, but with different weather on any given day, month, or year. Most of these datasets (excluding the NSW South Coast region)[7] also incorporate the characteristics of longer-term climate variability, using paleo-climate proxy records over the past 500 years.

Identifying when to use stochastic data

Stochastic data can provide valuable insights about the uncertainties in supply system yield associated with climate variability, outside of the variability observed in the instrumental record. But the level of effort to apply and interpret this data for yield analysis is higher than simply using data from the instrumental record. The department suggests the following approach to help local water utilities decide whether the benefits of using stochastic data for yield analysis outweighs the additional effort for any given application.

Figure 1 provides a four-step flow chart. These four key elements relate to the consequences of supply shortfalls, the availability of contingency supply measures, the risk of supply shortfalls when assessed without the stochastic data, and the climate dependency of water sources. The department recognises in preparing this flow chart there are elements of subjectivity in classifying responses that are best left to the judgment of the local water utility. When assessing risk using the non-stochastic data at step 3 in Figure 1, one identifier of risk would be the projected yield using the 5/10/10 rule dropping below the projected demand over the water utility's planning horizon.

[7] Note that for the South Coast region, the department has generated a number of stochastic 10,000-year sequences - one based on the 130-year historical climate record, and others where the historic record has been perturbed to account for increasing or decreasing numbers of east coast lows, which were found to be the dominant determinant of dry sequences in the South Coast region.

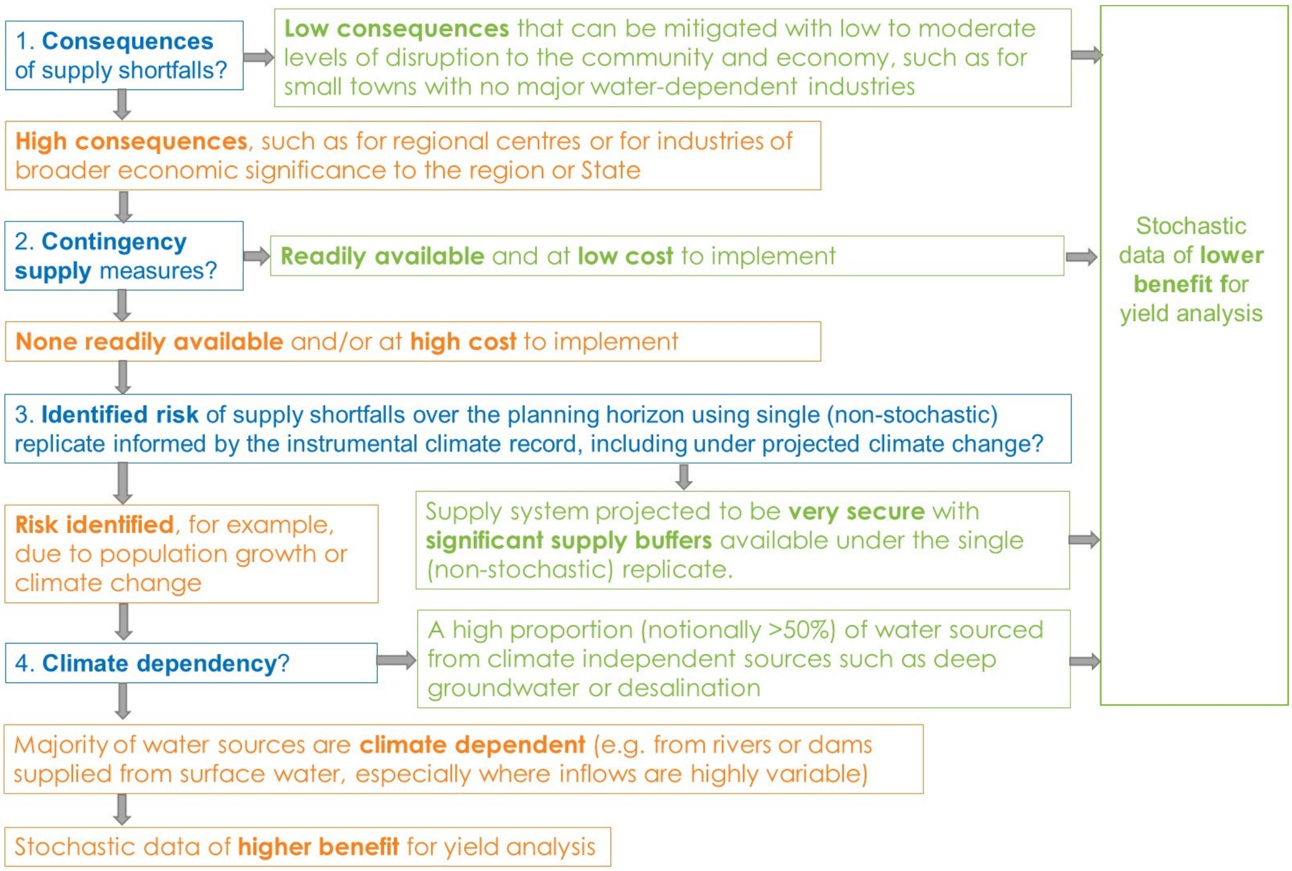


Figure 1. Guide to assessing when stochastic data provides higher benefit for yield analysis by local water utilities

The added effort required to apply the stochastic data will depend upon the complexity of the supply system. This potentially includes additional skills (writing scripts to automate data processing because spreadsheet applications cannot readily process 10,000 years of daily time step data), and longer water resource model run times and/or computer hardware requirements.

Step-by-step guidance for water security analysis for water supply system on unregulated surface water sources

An unregulated surface water source is one where there is no entitlement system at all or where there is an entitlement system that does not allow the placing of orders for upstream release of a licensed allocation.

The department recognises there are different ways to prepare and use stochastic climate data for water security analysis. After undertaking a case study that explored different approaches,[8] the department suggests the following approach for water security analysis for systems on unregulated surface water sources. The suggested approach may be refined in the future after

[8] HARC (2022) Modelling Town Water Supply Security Using NSW Regional Water Strategy Climate Data – Project Report; the project report is available from the department upon request and will be made available on the department's website.

wider application of the stochastic datasets. The approach differs from that of some major water utilities, and the how-to guidance for regulated surface water systems described above, as follows.

- **The smaller supply systems that local water utilities operate on unregulated river sources are more likely to require daily time step modelling**. This is due to typically smaller storage capacities and storage carryover relative to inflows and demands in unregulated sources in regional NSW than is typically available for regulated surface water sources and major water utilities.
- **Using stochastic data on a daily time step requires a much higher level of computing power, but this additional computing power requirement reduces when using multi-replicates**. The quantum of computing power requirements increases when running water resource models using a single 10,000-year sequence, relative to running 130-year replicates of the same total length. This is due to the need to store more information in computer memory at any given time for a 10,000-year run. Using replicates also takes advantage of parallel computing (running more than one replicate on a computer at the same time), which significantly reduces model run times. The 130-year replicates are also easier to post-process in spreadsheet applications than a single 10,000-year daily sequence (due to row number limitations in spreadsheets).
- **The use of a 130-year replicate enables a direct comparison against a yield estimate derived from the instrumental record**. This places the stochastic data yield estimates in a familiar context for local water utilities and highlights the risks to the utilities of relying on a single estimate of yield based only on the instrumental record. Due to the way the stochastic data incorporates the paleo-climate information, there is no equivalent 500-year historical reference climate dataset against which to compare the stochastic data behaviour. Stochastic data for the South Coast of NSW does not incorporate paleo-climate information. Hence, 500-year replicates were less preferred when using DPE's stochastic dataset at the current time. Using 130-year replicates provides a direct measure of yield uncertainty, obviating the need for the more complicated statistical techniques required to estimate yield uncertainty when using the 10,000-year sequence as a single replicate.
- **Performance criteria for local water utilities might be lower than for major urban water utilities, hence there might be less need to design supply systems for very low likelihood events** (that is, with an annual likelihood much lower than 0.8% or 1 in 130). Using 130-year replicates also prevents the risk of local water utilities mispresenting average return intervals associated with very low likelihood historical droughts. This requires more complex statistical analysis because the stochastic model has only been trained on 130 years of climate data (or up to 500 years of inferred climate data when using the paleo-climate information), not 10,000 years of climate data.

The local water utility should take the following steps after it identifies a need to use the stochastic data, as discussed above.

- **Step 1: Obtain the 10,000-year stochastic dataset** for rainfall and evaporation published on the SEED Open Data Portal.

- **Step 2: Divide the stochastic dataset into 130-year sequences**, starting from year zero. This will create 76 replicates, covering a total of 9,880 years. Subject to the checks at Step 3, you can discard the past 120 years, which does not represent a full-length replicate.
- **Step 3: Plot the daily cumulative deviation from average rainfall over the whole 10,000-year sequence, as shown in** Figure .
    - Ensure the driest period over the 10,000 years is wholly contained within a single replicate. If this most severe drought event is split over two replicates, shift the start year of all the replicates such that this drought event becomes wholly contained within a single replicate. This will ensure the output yield distribution is likely to capture the lowest yield for any possible 130-year replicate.
    - Ensure the driest period over the 10,000 years is not contained within the last 120 years of data. If it is, then shift the start year of all the replicates to ensure the last replicate wholly contains this drought event.

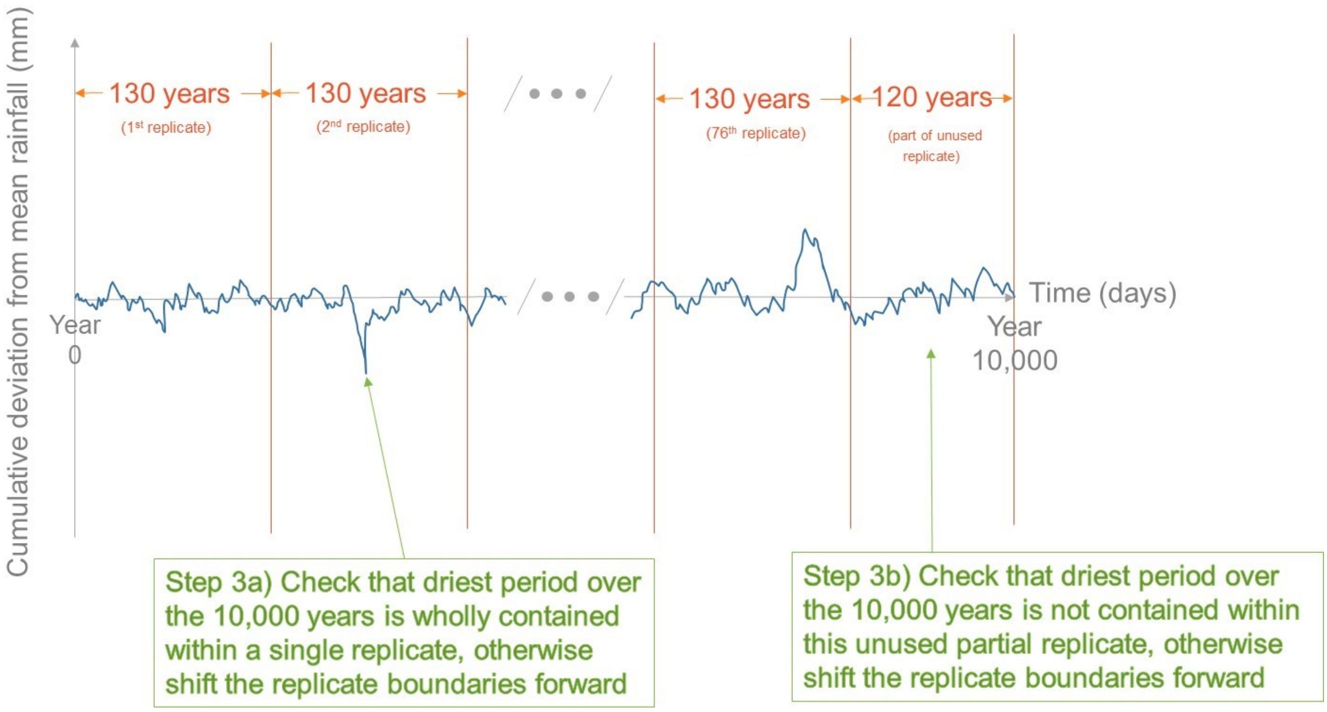


Figure 2. Cumulative deviation from mean rainfall checks of stochastic data replicate boundaries

- **Step 4: Run these 130-year datasets through the rainfall-runoff models and demand models**, each in turn, to generate inputs to the water resource model (Source).
- **Step 5: Run the water resource model** (Source) **and estimate yield.** For a given water supply system configuration, we recommend applying the same trigger for water restrictions (or the same trigger design criteria) across all stochastic replicates. You can repeat the yield analysis with different restriction triggers if required for testing the sensitivity of the yield analysis results to different restriction triggers.
- **Step 6: Check the reservoir inflow characteristics of the replicate that generates the lowest yield** (and/or any other yield of interest) over periods corresponding to critical reservoir

drawdown periods for the supply system, relative to those same inflow characteristics over the instrumental record. This could include, for example, checking minimum inflows over 1 month, 3 months, 6 months, 12 months, 18 months and/or 3 years. This information will help place the yield results in context to interpret whether the inflows and the minimum yields generated are plausible, given these inflow conditions.

- **Step 7: Check the order of the ranking of replicates by yield magnitude if running different climate or supply system scenarios.** Replicates that generate the lowest and highest yields should do so across different scenarios. Any radical re-ordering of replicates warrants further investigation of the causes. For example, the stochastic replicate that generates the lowest yield under historic climate conditions is also likely to rank as the lowest or near the lowest under climate change conditions. If, however, it ranks much higher, it would warrant further investigation into why this change occurred and whether the way in which the stochastic data was adjusted for the climate change scenario was appropriate.
- **Step 8: Undertake any other locally relevant checks of the data,** if needed, to confirm that the stochastic data is generating plausible outputs from the water resource model. This could include, for example, checking operating rule behaviour under extreme dry conditions not experienced under the instrumental historical climate sequence.

To prepare stochastic data for the climate change impact assessment, apply seasonal (monthly) factors to the input rainfall and evaporation data for the location of interest and for the climate change scenario of interest.[9] You can use other approaches where they can be justified.

Yield analysis results can be interpreted from the above as a distribution indicating the likelihood (from 1% – or ~1/76 – to 99%) of a given yield being available from a supply system over a 130-year period. Local water utilities can then use this information to undertake their strategic planning using a risk-based approach. Such an approach considers the uncertainty in yield estimates (narrow or wide) due to climate variability, the consequences of assuming that any given yield within that distribution is available to supply customers over the local water utility's planning horizon, and adaptive actions to minimise regret if yields are lower than planned for.

Guidance on system yield analysis for water supply systems on regulated surface water sources

A regulated surface water source relies on a licensed water access entitlement regime with centralised allocation of water. Users can place orders for release of a licensed allocation, generally from an upstream surface water storage.

Paleo signals in the generation of paleo-stochastic streamflow series can provide an indication of additional climate variability, including on risks of drought and drought severity, compared to the instrumental climate record.

[9] Climate change scenarios should be available for most locations on the SEED Portal.

Regional water strategies use this process to assess long-term water availability risk for all users. The modelled outputs also include a future climate (NARCliM 2-degree warming) scenario, which are used for stress-testing systems in regional water strategies. Stochastic climate data for climate stations across NSW is available on the SEED Open Data Portal.

The department will continue to update guidance material using lessons from pilot projects and case studies, including on how to use regional water strategy data and other climate datasets that become available with advances in climate science and modelling. Water security analysis for town water supply systems on regulated systems can use stochastically generated paleo-climate data as the basis of assessing risk and to assist in system planning, with NARCliM scenarios used for sensitivity-testing to understand potential worst-case implications.

The following provides a summary process for completing this analysis based on the modelled outputs available.

System behaviour modelling

The department undertakes system behaviour modelling to determine town daily shortfall volumes based on preliminary estimated demand and monthly demand pattern. It uses:

- historical streamflow data (from 1889-current)
- paleo-stochastic data set (10,000 years)
- NARCliM climate projections (10,000 years).

The datasets available include rainfall, evapotranspiration, and modelled streamflow.

Model outputs are also available for estimated 40-year town water demand growth scenarios. These model outputs consist of 1,000 x 40-year replicates (with annual growth).

Water security criteria

The primary criteria for town water security analysis should be the likelihood of water supply system shortfalls or 'failure'. This would typically be the failure of the primary water supply system(s). We define this as the inability to supply restricted demand (nominally 150 L/p/d for residential and restricted non-residential demands, without shutting down businesses) for a critical period (typically one month). Where possible, the utility should consider the duration and frequency of restrictions.

The utility should also consider the nature of drought contingency works in combination with drought contingency measures. This includes time to implement, and requirements to ensure an enduring supply (that is, an ongoing minimum essential supply). For some systems, enduring supply may involve water carting, while for others, emergency groundwater bores may be an option. However, for larger systems, major capital works that are triggered by falling dam storage levels may be necessary. For these systems, the frequency of reaching the trigger for major drought contingency works may also be an important water security criterion.

Post-modelling analysis

Using the paleo-stochastic dataset, the process should include the following.

Assess likelihood of shortfalls and duration/frequency of restrictions

1. Confirm definition of town water supply 'shortfall' and associated water security criteria (for example, annual probability of one or more shortfalls should not be greater than 0.1%). The water security criteria should take into consideration the system size and the alternative supply arrangements (or drought contingency measures) a utility can put into place during a drought to provide an enduring supply.
2. Review unrestricted town water demand (including monthly pattern) included in existing model outputs and assess adequacy. Also review assumed growth rates (based on 40-year replicates), where applicable.

   Note: Where modelled town water demands differ significantly from current demand estimates, the utility should review the discrepancy before considering the need for updated model runs. Discrepancies in town water demands may not be critical for small towns on large regulated systems (that is, where the town water demand is so small that the demand discrepancy is not significant to the model outputs).
3. Estimate minimum acceptable restricted town water demands (assumed to be around 150 L/p/d for residential and based on moderate to major restrictions).
4. Using monthly model outputs, assess the frequency and duration of shortfall events and determine the annual likelihood of shortfalls. Note, utilities can review other model outputs (including dam storage levels and allocations, if available) to confirm the reliability of the shortfall estimates.
5. To assess future water security, the utility can use model outputs for 40-year growth replicates. Undertake initial analysis using the full 40-year growth period. To better understand when water security may become critical under future demands, consider reanalysing the data in 10-year growth increments (that is, years 1–10, years 11–20, years 21–30 and years 31–40).
6. Define preferred level of service criteria for frequency and duration of any water restrictions. Typical target criteria are:
   - total time spent in restrictions expressed as a percentage (for example, not exceed 5% of the time)
   - the number of years restrictions apply expressed as a percentage (for example, not exceed 10% – 1 in 10 years).
7. Where possible, review the estimated duration and frequency of water restrictions, based on agreed levels of service, associated triggers for restrictions, and drought contingency measures.
8. Assess the overall level of town water security under existing and future town water demands. Larger systems may also require additional analysis of risks to assess the likelihood of triggering major drought contingency works (enduring supply).
9. To stress-test the system, complete an analysis of the NARCliM climate dataset for items 4 to 7 above.

Initial assessment of augmentation options

10. If water security is considered inadequate, review the relevant regional water strategy to assess if any infrastructure or non-infrastructure options have already been considered that would improve town water security in the relevant regulated source. Consider obtaining further modelling outputs associated with relevant RWS options in the regional water strategy (where available).
11. Consider additional non-infrastructure solutions to improve town water security (for example, through an annual water determination process, leaving more water in storage, changes to level of service criteria, water carting).
12. If additional infrastructure is still required, use the shortfall analysis already undertaken to assess the preliminary sizing of potential augmentation options (for example, groundwater bores, off-river storage, pipeline to major dam, connecting to different water source). Design the proposed augmentations to sufficiently address the shortfalls and achieve the desired level of security.

Guidance for water security analysis for water supply system on groundwater sources

To assess water access risk to groundwater sources, the utility could use the following approach.

- **Identify regulatory constraints**

  Identify regulatory constraints with respect to entitlement and authorisations the local water utility currently holds to take groundwater, as well as any future authorisations the utility may need to seek to meet the future demands (if known).

- **Assess capacity and performance**

  Assess the capacity of the bores and their associated infrastructure to pump and deliver groundwater supply in the context of any constraints in their location, configuration, design, construction, structural integrity, condition, and maintenance and operating regime.

- **Assess sustainable daily and annual extraction**

  Assess the long-term sustainable extraction from each bore and scheme. This takes into account the constraints of acceptable impacts on the environment, cultural values, surface water resources, and other existing authorised groundwater supply bores (including basic landholder rights) under current and possible future climate scenarios. It should accord with the criteria set out in the *Assessing groundwater applications fact sheet* available in the department's groundwater document library.

- **Assess drought resilience**

  Assess each bore's sustainable extraction under drought scenarios. Base it on expected groundwater conditions and water supply demands and existing authorised users in the vicinity of the town's bores.

- **Assess water quality constraints**

Assess the risks to the ongoing suitability of the groundwater quality as a supply source. Consider the inherent lithology and water chemistry of the groundwater system, its vulnerability to contamination from land use, and the potential to induce changes to the groundwater quality from pumping and natural climate variation.

- Assess water security vulnerability

  Apply a risk-based methodology when assessing the ability of the bores/borefield and scheme to deliver the long-term sustainable extraction and drought resilience under current and future climate based on the steps above.

  Base potential changes to recharge from future climate on previously completed reported work when using numerical modelling. This includes NARCliM climate data, the paleo-stochastic rainfall and evaporation data, and the regional water strategies (for alluvial aquifers).

Resources

The department makes available the following resources to help utilities assess the water access risk to current and potential groundwater sources.

- Process guidance for developing a brief and engaging a consultant
- Scope of works
- Form 1 – Background information for assessment
- Form 2 – Departmental involvement

We make these resources available on request, and we will post them on the department's website.

Appendix B: Templates, case studies and tools

To support utilities in achieving the strategic planning outcome of **understanding water security** to a reasonable standard, we give the following optional templates, case studies, and tools.

NSW and Australian Regional Climate Modelling (NARCliM) generated detailed climate projections and data for NSW

The NSW and Australian Regional Climate Modelling NARCliM is a partnership between the NSW, Australian Capital Territory, and South Australian governments creating regional climate change projections for south-eastern Australia to address climate change. NARCliM designs the projections to assist decision makers produce informed policy, climate adaptations, and risk management.

The partnership released NARCliM 1.0 projections in 2014. It then released a second set of NARCliM projections in 2020 (NARCliM 1.5), and a third set is in development (NARCliM 2.0). Water security assessment currently uses NARCliM 1.0 and 1.5 projections.

More information about NARCliM is available here:
https://www.climatechange.environment.nsw.gov.au/climate-projections-used-adaptnsw.

Sacramento rainfall-runoff model

The Sacramento Model is a catchment water balance model that relates runoff to rainfall with daily data. The model contains five stores and has 16 parameters.

NSW has collected historical rainfall data (instrumental records) for about 130 years. The Sacramento rainfall-runoff model correlates approximately 130 years of recorded rainfall to shorter duration stream-gauging records and provides 130 years of historical streamflow data.

The Sacramento Model is provided with the Source installer. It is also available through the Rainfall Runoff Library on eWater Toolkit.

NSW Government planning policies encompass the risks of climate variability and climate change

The NSW Government has a range of planning policies to address the risks of climate variability and climate change.

The NSW Climate Change Adaptation Strategy sets out an ambitious approach to climate change adaptation. The strategy provides a framework that will strengthen and expand action to adapt to the unprecedented cycle of heatwaves, droughts, bushfires, storms, and floods. The suite includes actions to:

- develop trusted and robust metrics and information on climate change risks
- complete climate change risk and opportunity assessments
- develop and deliver adaption management plans
- embed climate change adaption in NSW Government decision making.

The Climate Risk Ready NSW Guide provides practical Guidance for the NSW Government sector to assess and manage climate change risks and builds on national and international best practice.

The NSW Common Planning Assumptions are the agreed information assets (datasets, parameters and assumptions, models, and analytical tools) the NSW Government and external stakeholders use to prepare proposals, business plans, and strategies that rely on projections. The assumptions leverage and bring together the latest assumptions and datasets from across NSW Government agencies and external stakeholders who use and generate data.

The 5/10/10 design approach

The approach for undertaking a secure yield analysis applying the 'NSW Security of Supply' method, also known as the 5/10/10 design approach is set out below. This method is based on the draft NSW Guidelines for Assuring Future Urban Water Security, 2013.

The NSW Security of Supply method was developed in the 1980s after lessons learnt from the severe 1978-83 drought. It aims to enable regional NSW water utilities to size their water supply headworks systems on a sound, robust, and cost-effective basis.

Commonly referred to as the '5/10/20 design approach', the '5/10/10 design approach' later replaced it due to the 53% reduction in average annual residential water supplied per property in the 20 years from 1991.

The 5/10/10 design approach aims to ensure full demand can be met in wet, average, and most dry years, with only water restrictions of moderate duration, frequency, and severity required to ensure continuity of the water supply during extended drought periods. See Figures 3 and 4.

As it can cope with effectively a '1-in-1,000 year' drought, it is sufficiently robust to maintain continuity of supply in significantly more severe future droughts than have occurred in the past 130 years, albeit with a higher level of drought water restrictions.

Under the 5/10/10 design approach, water supply headworks systems are normally sized so that:

a) time spent in restrictions does not exceed 5% of the time (5% duration – Figure 3)
b) there is no need to apply restrictions in more than 10% of years (10% frequency – Figure 3)
c) the severity of restrictions does not exceed 10%. Systems should meet 90% of the unrestricted dry year water demand (that is, 10% average reduction in consumption due to water restrictions) through simulation of the worst recorded drought (Figure 4) commencing

at the time restrictions are introduced (with a commencing storage volume equal to the restriction volume C in Figures 3 and 4).

This enables utilities to operate their systems without restrictions until the volume of stored water approaches the restriction volume C, which is typically about 65% of the storage capacity (refer to Figure 3). If at this trigger volume, the utility imposes drought water restrictions that reduce demand by an average of 10%, the system would be able to cope with a repeat of the worst recorded drought, commencing at that time, without emptying the storage (as shown in Figure 4).

'Secure yield' is the highest annual water demand a headworks system can supply while meeting the 5/10/10 design rule.

Water security is achieved if the secure yield of a water supply is at least equal to the unrestricted dry year annual demand.

Figure 3 shows the results of simulating an example utility's storage behaviour for 120 years of observed historical daily streamflow, rainfall, and evaporation data. It shows:

- it is possible to supply unrestricted water demand for more than 95% of the time and more than 90% of years (that is, whenever the storage volume is above the restriction volume C). To satisfy the 5/10/10 design rule, a utility must impose restrictions whenever the volume of water in storage falls below the restriction volume C
- a 10% reduction in demand is applied when the storage falls below restriction volume C
- the (then) worst historical drought shown in Figure 3 is for approximately a 5-year period from January 1939 to December 1943
- the minimum simulated usable storage volume is approximately 30% of the full storage capacity.

Figure 3. Duration and frequency of restrictions under 5/10/10 design approach

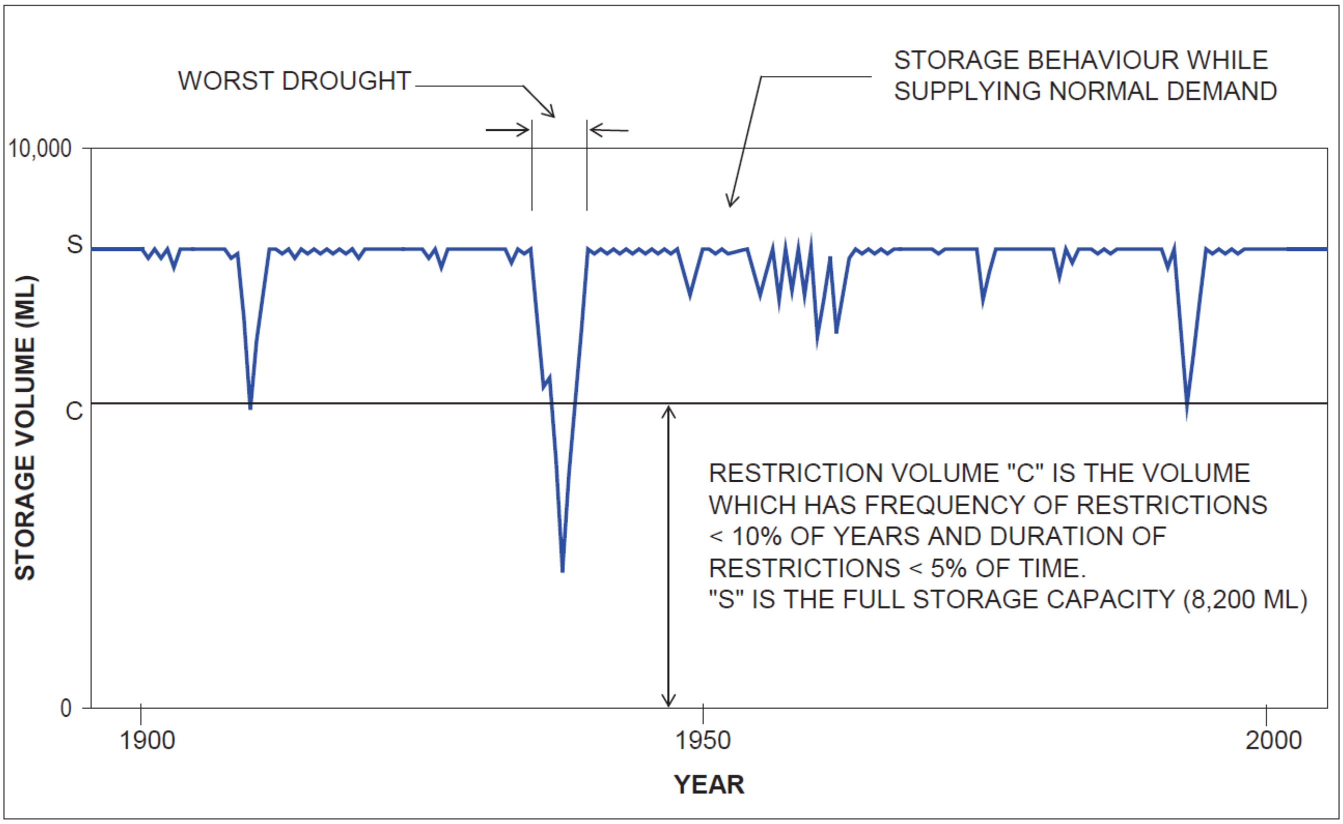
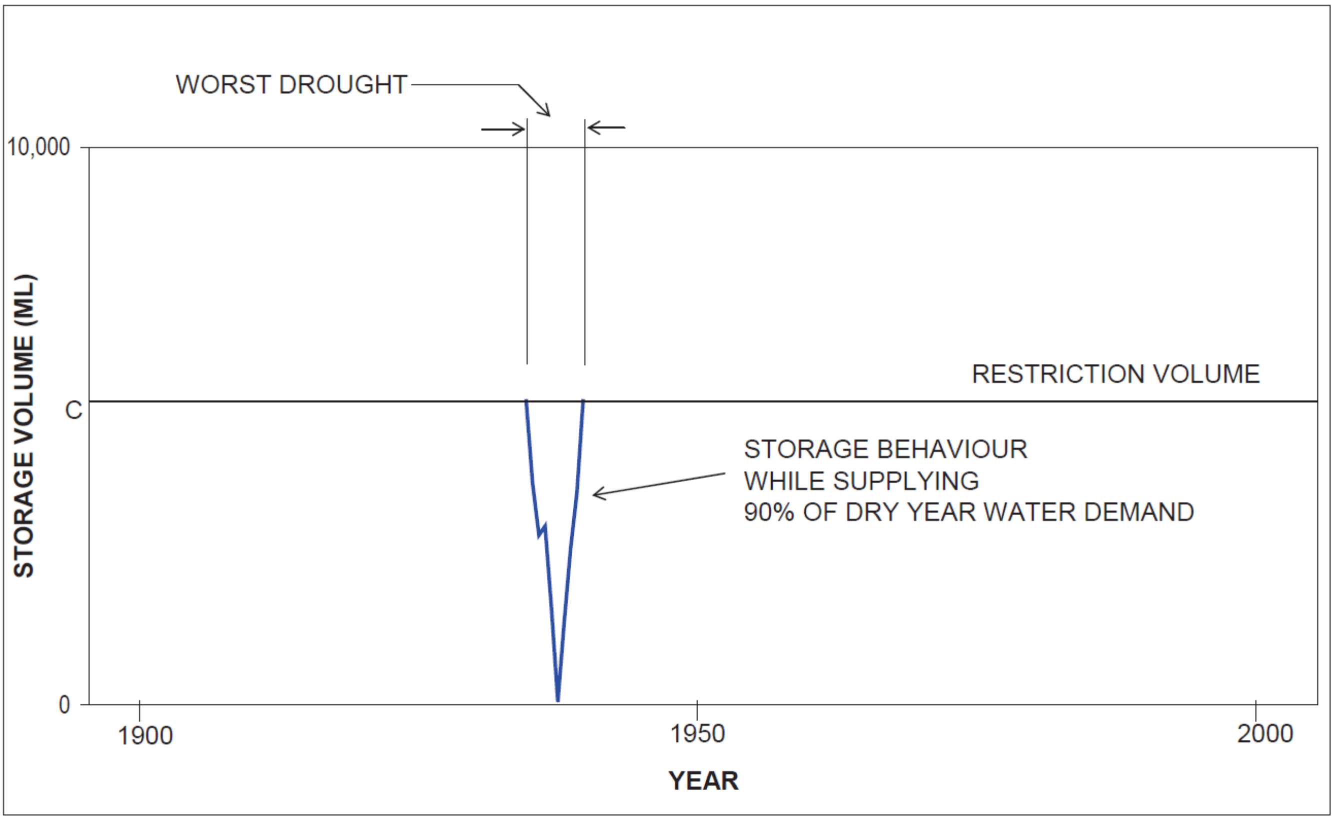


Figure 4 shows the results of simulating storage behaviour for the worst drought identified in Figure 3 (5-year drought from January 1939 to December 1943) on the following basis:

- a 10% reduction to the unrestricted dry year water demand for the full 5-year drought as the storage volume is below the restriction volume C
- the commencing storage volume for this simulation is the restriction volume C, and the resulting minimum simulated usable storage volume is approximately 2% of the full storage capacity.

Figure 4. Duration and frequency of restrictions under 5/10/10 design approach



Note: Figure 4 shows the simulated storage behaviour for the worst drought identified in Figure 3 (approximately 5 years from January 1939 to December 1943) while supplying 90% of the unrestricted dry year demand, with a commencing storage volume equal to the restriction volume C (5,400 ML).

The requirements of the 5/10/10 design rule approximates the severity of a '1-in-1,000 year' drought and is necessary to enable a utility to manage its system in a drought of similar severity to the worst drought in the 130-year historical record, with only moderate water restrictions.

As Figure 3 and Figure 4 both simulate the first year of the worst drought for this example utility, the water supply system must be able to cope with effectively a 6-year drought, rather than the 5-year worst historical drought in Figure 3. It is important to note that the analytical process for the 5/10/10 design rule is iterative and only identifies a solution when all 3 requirements have been met.

Water supply sources summary template

Table 1 provides a template that could be useful as a starting point for a utility to detail the basic description of various water supply sources and individually list each water supply, name, storage or supply details, and relevant infrastructure, and note any relevant operational rules.

The Queensland Department of Regional Development, Manufacturing and Water uses a similar template.

Table 1: Water supply sources summary

Source	Details	
Surface water – dam/weir	Location	Address Close landmark / [x] km from [town] in [direction] Latitude and longitude coordinates
	Watercourse	Watercourse name Adopted middle thread distance – AMTD [x] km
	Catchment	Name
	Water plan	Part of the [name] water supply scheme
	Owner	Who owns and operates the infrastructure
	Capacity	[x] ML
	Minimum operating level	[x] m
	Entitlement	Type, annual volume, priority group, uses
	Entitlement conditions	Any conditions that potential limit the take of water under the entitlement For example, maximum extraction rate, announced allocations, cut-off rules
	Water quality issues	Any water quality issues/none
	Significant other uses of source	Other uses of the supply source For example, [community Y], local irrigated agriculture, environmental flows
Surface water – river extraction	Location	Address Close landmark / [x] km from [town] in [direction] Latitude and longitude coordinates
	Watercourse	Water course name Adopted middle thread distance – AMTD [x] km
	Water plan	Part of the [name] water supply scheme
	Entitlement	Type, annual volume, priority group, uses

Source	Details	
	Entitlement conditions	Any conditions that potentially limit the take of water under the entitlement For example, maximum extraction rate, announced allocations, cut-off rules
	Water quality issues	Any water quality issues/none
	Significant other uses of source	Other uses of the supply source For example, [community Y], local irrigated agriculture, environmental flows
Surface water – off-stream storage	Location	Address Close landmark / [x] km from [town] in [direction] Latitude and longitude coordinates
	Watercourse	Watercourse name Adopted middle thread distance – AMTD [x] km
	Capacity	[X] ML
	Entitlement	Type, annual volume, priority group, uses
	Entitlement conditions	Any conditions that potentially limit the take of water under the entitlement For example, maximum extraction rate, announced allocations, cut-off rules
Groundwater – bores	Location	Address Latitude and longitude coordinates
	Aquifer	Aquifer name
	Entitlement	Type, annual volume, priority group, uses
	Entitlement conditions	Any conditions that potentially limit the take of water under the entitlement For example, maximum extraction rate, announced allocations, cut-off rules
	Sustainability / safe yield / vulnerability	Comments on sustainability of the aquifer, include the safe yield of the bore and its vulnerability

Source	Details	
	Water quality issues	Any water quality issues/none
	Significant other uses of source	Other uses of the aquifer For example, [community Y], local irrigated agriculture
Seawater – desalination plant	Location	Address Latitude and longitude coordinates
	Intake location	Latitude and longitude coordinates
	Capacity	[X] ML/d
	Constraints	Any constraints on the operation of the plant For example, discharge limits
Recycled water	Water source	Sewage treatment plant name
	Treatment capacity	[X] ML/d
	Quality	Suitable for [x] end use
	Applications	Uses of recycled water For example, irrigation of local parks and gardens, supplied to local irrigated agriculture, recycled water for drinking.
Stormwater	Water source	Area covered by rainwater harvesting scheme
	Treatment capacity	[X] ML/d
	Quality	Suitable for [x] end use
	Applications	Uses of recycled water For example, irrigation of local parks and gardens, supplied to local irrigated agriculture, recycled water for drinking.
Rainwater	Water source	Area covered by rainwater harvesting scheme Information about household rainwater tanks
	Treatment capacity	[X] ML/d

Source	Details	
	Quality	Suitable for [x] end use
	Applications	Uses of rainwater For example, irrigation of local parks and gardens, supplied to local irrigated agriculture,

Case study: Modelling town water supply security using NSW regional water strategy climate data

The department recently completed a case study of a hypothetical town water supply system to explore ways in which water security analysis can use stochastic datasets of climate of 10,000 years in length (incorporating paleo-climate information where appropriate) developed and used by regional water strategies.

In the study, two approaches were tested with the stochastic datasets.

- The 5/10/10 design approach as above in Appendix B.
- An "alternative approach" informed by supply system yield assessment approaches used in other jurisdictions. The report labels this approach as 'alternative', not because it is new or innovative, but because it makes different assumptions to the 5/10/10 design approach for demand patterns, water savings under restrictions, and storage buffers set aside for unforeseen events.

Modelling has used both approaches to estimate supply system yield. Results are compared and discussed.

Hydrology and Risk Consulting (HARC) Ltd supported the study. The final project report is available from the department upon request and will be made available on its website.