NATIONAL WATER REFORM COMMITTEE (NWRC)

PROPOSED

NATIONAL STRATEGY (NHMS) AND HIGH-LEVEL IMPLEMENTATION PLAN

FOR HYDROLOGICAL MODELLING

2022-2027

02 SEPTEMBER, 2022

ACKNOWLEDGMENTS

The NWRC acknowledges the Traditional Owners and custodians of Country throughout Australia and acknowledges their continuing connection to land, waters and community. The NWRC pays respect to the people, the cultures and the Elders past and present.

The NWRC also acknowledges and sincerely thanks those individuals and organisations who have contributed information, ideas and comments to inform the development of this proposed National Strategy and High-Level Implementation Plan for Hydrological Modelling.

THE NATIONAL STRATEGY FOR HYDROLOGICAL MODELLING (NHMS)

Preamble

In June 2004, the Council of Australian Governments (CoAG) agreed to implement a National Water Initiative (NWI), intended to result in greater compatibility between water planning and regulatory regimes and in the adoption of best-practice approaches to water management nationally. The objective of the 2004 NWI was the development of a nationally-compatible, market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes, and an efficient and sustainable water industry.

Information and knowledge generation, including that from hydrological modelling, has been integral to water reform achievements under the NWI. This has provided a foundation to support evidence-based decision making about, for example, water resources plans and infrastructure developments; water management, river operations, and water use; and water utilities meeting growing water and service demands in the face of climate change, population pressures and changing community expectations and demographics.

To further support better planning and management of water in Australia, CoAG adopted a National Hydrological Modelling Strategy (NHMS) in November 2008. The National Water Reform Committee (NWRC) refreshed the NHMS in 2018 and put in place, and agreed to be the Management Committee for, a NHMS Collaborative Head Agreement (CHA).

An independent report was provided to the NWRC in 2021 to identify progress, impediments and possible remedies in implementing the NHMS and NHMS-CHA (the 2021 NHMS Report). The 2021 NHMS Report identified that there was strong support for having a NHMS – the key challenge was to how to make it work most effectively and efficiently. Private sector, research sector and water utility stakeholders were also keen to be involved in that conversation with governments.

The 2021 NHMS Report also outlined that a key output from the NHMS to date has been the development and promotion of a consistent hydrological modelling platform for all government agencies particularly involved in water resources planning and management – the Source modelling platform. Source has been developed and maintained by eWater Ltd on behalf of and in collaboration with Australian governments. Most Australian governments have agreed to adopt and use Source to support water planning and management. Various governments have invested significantly (upwards of $100 million) in the development and adoption of Source and consider that it is critical to maintain Source to ensure it adequately meets current and future government and community needs and industry standards. However, the NHMS is broader than Source and eWater Ltd's business is broader than both Source and the NHMS. Nevertheless, Source and other Australian water modelling assets need to be implemented, maintained, and further enhanced to keep them evolving to meet the needs of the future.

Stakeholders agreed that the benefits of having nationally compatible and coherent hydrological modelling platforms and the skilled human capacity around them to inform often complex and contested decisions are compelling. However, the NHMS is more than that. It also encompasses a significant body of information and knowledge and needs to

include necessary data collection and maintenance and have the best available science and hydrology incorporated.

The 2021 NHMS Report suggested that it was timely to refresh the NHMS and its future as a key enabler of the NWI. It recognised that continuously improving hydrological modelling will help build the information and knowledge base required to tackle national challenges of climate change, population growth, Closing the Gap and heightened community expectations for improved water planning and management to contribute positively to sustainability, liveability, resilience, productivity and equality. It recommended that further consideration be given to various NHMS matters, including:

- National leadership (including strategic direction and commitment);
- Roles, responsibilities and relationships (including governance and communications);
- Extent and scope;
- Community of practice and modelling capacity and capability development (including with the research and private sectors);
- Future innovation and research (new knowledge); and
- Funding.

Subsequently, the NWRC agreed that an updated national strategy for hydrological modelling be drafted and include a prioritised implementation program with tangible milestones and an underpinning, transparent, agreed investment framework, and arrangements for monitoring, reporting and reviewing its implementation, reflecting the findings and recommendations identified in the 2021 NHMS Report.

This document contains the proposed updated National Strategy (NHMS) and an accompanying High-Level Implementation Plan for the period 2022-2027, following further input in early 2022 from government agencies, water utilities, the research sector, the private sector and others with an interest in hydrological modelling in Australia.

This proposed updated National Strategy and accompanying High-Level Implementation Plan aim to build on the hydrological modelling advances made to date in supporting better water planning and management in Australia and to provide the corresponding enabling framework for the future, including for the Source modelling platform.

Objectives of the NHMS

The NHMS will enable the support services and network to help implement, maintain and enhance hydrological modelling to support better water policy, planning and management across Australia. In doing so, the NHMS will aim to ensure:

1. Governments and other relevant parties work cooperatively and on a national scale to ensure that resources and expertise are coordinated to achieve the hydrological modelling capability required to underpin world's best practice water policy, planning and management in Australia;
2. The hydrological modelling community is ready to meet the priority hydrological modelling needs of Australian governments, industries and communities;
3. Australia's existing hydrological modelling expertise is effectively utilised, further capacity in the field is actively nurtured and developed, and duplication of effort is avoided;

4. The functionality and application of hydrological modelling platforms, including Source, meet the needs of Australian governments, industries and communities;
5. Australia's hydrological modelling applications, systems and platforms incorporate the best available climate, water and water-related data, science and hydrological understandings;
6. Appropriate funding is available to support the implementation, on-going maintenance and enhancement of modelling platforms, including Source, and to develop and maintain a strong community of practice; and
7. Australia's modelling capability is exported internationally.

Scope

The scope of the NHMS covers the:

- technical hydrological modelling systems/platforms, such as Source, MUSIC and others (including their management and maintenance, their enhancements, and the documentation, standards and guidance required to develop and use them appropriately);
- capacity and capability building (including community/ies of practice and networks, and required training, education, communications and social licence to operate);
- research, development and innovation;
- all underpinned by appropriate governance and necessary funding;

to meet priority contemporary and future modelling needs for policy development and decision-making; water and associated infrastructure planning, management, assessment, operations, compliance, and accounting; water markets; scenario development, climate change and forecasting within water systems across a range of applications and geographies.

As outcomes, modelling platforms will build knowledge and support "quadruple bottom line" decision-making about:

- water quantity and availability at a range of temporal and spatial scales, and water resources planning, management and compliance (surface water and groundwater including their interactions);
- river and water infrastructure operations;
- impact of climate change/variability and landuse change (e.g. bushfires) on water resources;
- water quality assessment, management and evaluation;
- environmental water management;
- Aboriginal and Torres Strait Islander water rights and interests, including cultural water flows and objectives, values and management;
- floodplain management and flood operations and management;
- future water demand and supply (both urban and rural);
- integrated urban water planning, management and operations, and water sensitive urban design;
- required water data collection and dissemination capabilities, including for providing real-time or near-real-time water information for decision-making;
- water-coupled socio-economic drivers, feedbacks and impacts; and

- the uncertainties inherent in the data (recognising their provenance and lineage) and the models and, where relevant, in model predictions.

Modelling platforms will be:

- robust, reliable, dependable, fit-for-purpose, transparent, auditable and repeatable;
- highly automated / efficient work flows;
- relevant for pertinent/key aspects of water quantity, quality and the environment;
- suitable for all regions of Australia;
- capable of consistent and defensible model development and application;
- capable of enabling collaborative development and testing;
- adaptable and updateable in the light of new policy, drivers, or knowledge;
- adaptable to include Aboriginal and Torres Strait Islander water rights and interests, including cultural water flows and objectives, values and management;
- interoperable, flexible, able to link to new and existing models and other information systems, and supportive of collaborative and interdisciplinary processes and efforts, recognising the FAIR (Findable, Accessible, Interoperable, Reusable) Principles;
- professionally created, modern, thoroughly tested and well documented, including with up-to-date technology and guidance materials; and
- able to provide continuity of development and user-support services over the life of the model platform.

As outcomes, the hydrological modelling community/ies of practice will deliver:

- collaboration between governments, universities and research sectors and industry for improving hydrological modelling capability and developing the required workforce capacity;
- a consistent and coordinated approach to assist efforts in hydrological modelling education, training, professional development and communications, in language that is culturally, morally and socially appropriate;
- protection of intellectual property and sensitive information/knowledge and avenues for collection and application of Aboriginal and Torres Strait Islander water knowledge and values relevant to hydrological modelling;
- avoidance of duplication and reduction in inefficiencies including by:
    - collective decision making and investment in the Strategy;
    - facilitation of collaboration and coordination of national experts and model users;
    - communication, collaboration and cooperation about relevant research, development and innovation (RD&I) needs, priorities, opportunities and delivery;
- consistency of model application, development and documentation;
- transparency of models including their provenance;
- continuous improvement to modelling methods and processes (e.g. model parameterisation, calibration, testing, uncertainty quantification, communications and application); and

- development and innovation in modelling through access to research capacity.

The hydrological community/ies of practice will be:

- strong in capability developed through knowledge sharing, education and professional training to stay up-to-date about water modelling;
- portable and collegiate for domestic work, providing encouragement and guidance with developing and applying water models;
- resilient to changing regulatory, administrative and funding conditions in the long term; and
- able to avail opportunities from Australia's international activities, including contributing to and learning from the international hydrological modelling community.

Governance

Overall governance arrangements will be set out in a NHMS-CHA.

A national NHMS Steering Committee comprising the appropriate government agencies with advice from other key stakeholders will be established to oversee the implementation of the National Strategy and report to the NWRC. The roles and responsibilities of the NHMS Steering Committee will include to:

- lead the NHMS and collaborate on national hydrological modelling issues;
- keep the NHMS up-to-date as a national strategy to meet Australia's contemporary and future hydrological modelling needs;
- develop, monitor and report on a prioritised implementation program with an agreed investment framework for the strategy;
- support hydrological modelling communities of practice, including future capacity building in the government, utility, private, research and academic sectors and in Aboriginal and Torres Strait Islander peoples;
- inform and facilitate linkages in applied research and innovation to further develop modelling capability in agreed priority areas; and
- provide effective communication channels to enable strategic alignment and to inform business development and delivery of products and services relevant to the NHMS and relevant to the broader delivery of the NWI.

Implementation of the National Strategy will be undertaken in a manner consistent with the following Principles:

- Collaboration and Communication – engaging collaboratively in planning and management; ensuring communication and feedback is timely, honest, open, understandable and effective; while recognising that each party operates within its own constraints and boundaries and intellectual property and sensitive information/knowledge are to be protected;
- Resources – ensuring resources are used efficiently and effectively and integrated (where relevant) with other related programs;
- Decision-making – operating within agreed responsibilities and boundaries, being flexible and adaptable and using objective and factual data as the basis of sound-decision making; sharing and utilising collective learnings.

Reporting and Review

The NHMS Steering Committee will annually report on the progress of implementing the NHMS to the NWRC.

The NHMS will be reviewed every five years to ensure that it reflects the contemporary and future needs.

THE HIGH-LEVEL IMPLEMENTATION PLAN 2022-2027

Preamble

This High-Level Implementation Plan has been developed based on the recommendations of the 2021 NHMS Report and updated inputs in early 2022 from government agencies, water utilities, the research sector, the private sector and others with an interest in hydrological modelling in Australia.

The 2021 NHMS Report contained key recommendations regarding:

- National leadership and governance;
- National strategy and work program;
- Community of practice and capacity building;
- New knowledge and innovation;
- Communications; and
- Funding.

The 2022 updated inputs included views and information outlining:

- immediate and longer-term priority needs from hydrological modelling to inform and assist policy development and decision-making; water and associated infrastructure planning, management, assessment, operations, compliance, and accounting; water markets; scenario development, climate change and forecasting within water systems across a range of applications and geographies;
- initiatives already underway or proposed over the next 1-5 (possibly out to 10) years and directly or potentially relevant to addressing the recommendations of the 2021 NHMS Report and contributing to the proposed updated National Strategy, its objectives and outcomes.

Initial Proposed Actions

The recommendations in the 2021 NHMS Report were reaffirmed by the 2022 updated inputs and provide the basis for the initial proposed actions under the High Level Implementation Plan as shown in Table 1 below.

The initial proposed actions address the most pressing leadership and governance challenges facing the NHMS and set the foundation for a committed, communicative, collaborative and coordinated implementation program into the future. They also aim to clarify the pressing matters regarding how the NHMS and its future implementation relate to the business of eWater Ltd and vice versa, recognising that existing periods under the NHMS-CHA and the Source Project Agreement (SPA) are currently set to expire on 30 June, 2023. The initial proposed actions in the Table 1 below establish prerequisites for consideration of the suggested activities and initiatives for the remainder of the High-Level Implementation Plan outlined in Appendix A.

TABLE 1 INITIAL PROPOSED ACTIONS - PREREQUISITES FOR IMPLEMENTATION

PROPOSED ACTION	RESPONSIBILITY	TIMING	NHMS OBJECTIVE/S
1 Confirm the Terms of Reference for and establish the NWRC NHMS Steering-Committee (SC), chaired by the Australian Government, with membership from all NWRC jurisdictions, with the overall responsibility to collaboratively agree the NHMS and plan and oversee its implementation (Note 1)	NWRC	By 3rd qtr 2022	All (and 1 and 6 in particular)
2 Confirm the Terms of Reference for and establish the NWRC NHMS Advisory Group (AG), including BoM, CSIRO, GA, eWater and other public, water utility, private industry, water user, Aboriginal and Torres Strait Islander, research and education/training sector interests/representatives to be agreed, to provide technical and other advice to the NWRC NHMSSC about the direction and implementation of the NHMS and to assist with collaboration, consultation, communications and commitment concerning the NHMS (Note 1)	NWRC NHMSSC	By end 2022	All
3 Establish funding and other resources as agreed with the NWRC NHMSSC for a Secretariat and associated support for the NWRC NHMSSC and the NWRC NHMAG, recognising that cooperation and coordination require resourcing and commitment	NWRC	By 3rd qtr 2022	1 and 6
4 Finalise a more detailed NHMS Implementation Plan, having regard to the activities and initiatives suggested for consideration as set out in Appendix A and further clarification of activities and funding arrangements under programs relevant to the NHMS, including the IRMU program (MDBA and DAWE in collaboration with the Basin States). The Implementation Plan should include further development of modelling capability, appropriately informed by science, in priority areas to be agreed; further advancement of hydrological modelling communities of practice and networks and workforce capacity; and detailed arrangements for managing, monitoring, reporting and reviewing its implementation; again having regard to the activities and initiatives suggested for consideration set out in Appendix A.	NWRC NHMSSC with advice from the NWRC NHMSAG, in consultation with stakeholders	By mid 2023	All
5 eWater Ltd to meet with the NWRC NHMSSC for strategic conversations on matters relating to the broad direction of eWater Ltd and its modelling platforms and the direction and implementation of the NHMS, with the aim of reaching agreement on	eWater Ltd and the NWRC NHMSSC	By end 2022 and	1, 6 and 7

transparent, coherent, efficient and sustainable ways forward to enable a clear value proposition to be articulated to meet current and future needs of governments, industry and the community (Notes 1 and 2)		again by mid 2023	
6 Review the arrangements set out in the existing NHMS-CHA for their suitability to deliver the components of the agreed updated NHMS and its associated Implementation Plan and make amendments as required so that the arrangements and the NHMS-CHA are fit-for-purpose for the period beyond 30 June, 2023, this being the date for the initial term of the existing NHMS-CHA. The review should include consideration of clear funding and service commitments, work programming, reporting and review, with streamlined and more responsive governance and management arrangements (Notes 1 and 2)	NWRC upon advice from the NWRC NHMSSC in consultation with stakeholders	Before 30 June, 2023	All
7 Review and confirm/amend the eWater Ltd sustainable business model required to best deliver the relevant components of the agreed updated NHMS and its associated Implementation Plan and communicate the results (Notes 1 and 2)	eWater Ltd owners and Board	Before 30 June, 2023	1, 6 and 7
8 Monitor and report (to the NWRC) progress on each of the above proposed actions and undertake corrective actions and/or adjustments as agreed necessary to update and finalise the more detailed Implementation Plan	NWRC NHMSSC with advice from the NWRC NHMSAG	Initially up until mid 2023	All

NOTES

1. The need for reconsideration of governance approaches was identified by several participants in the preparation of the 2021 NHMS Report and subsequent discussions about an updated National Strategy and Implementation Plan. There has been very strong support for the establishment of a NHMS Steering Committee under the NWRC, and for a multi-stakeholder NHMS Advisory Group. In addition, it has been widely recognised that the existing governance arrangements for the NHMS-CHA, SPA and eWater are somewhat convoluted without sufficient "clear line of sight". That adversely affects transparent communication, collaboration, coordination and fully informed and informative decision-making, which is not helpful to governments, eWater or industry. Clarifying and resolving this requires substantially more conversation, analysis and deliberation by governments, eWater and the private sector. In that respect, the owners of eWater and its Board should review eWater's objectives and business model for the future, recognising that eWater is not everything about the NHMS and the NHMS is not everything about eWater – the current NHMS and the proposed updated National

Strategy are broader than the current Source and eWater products and services, and eWater's current and emerging products and services are broader than Source.

The following diagram (Figure 1) illustrates the suggested NHMS governance arrangements for further consideration and confirmation.

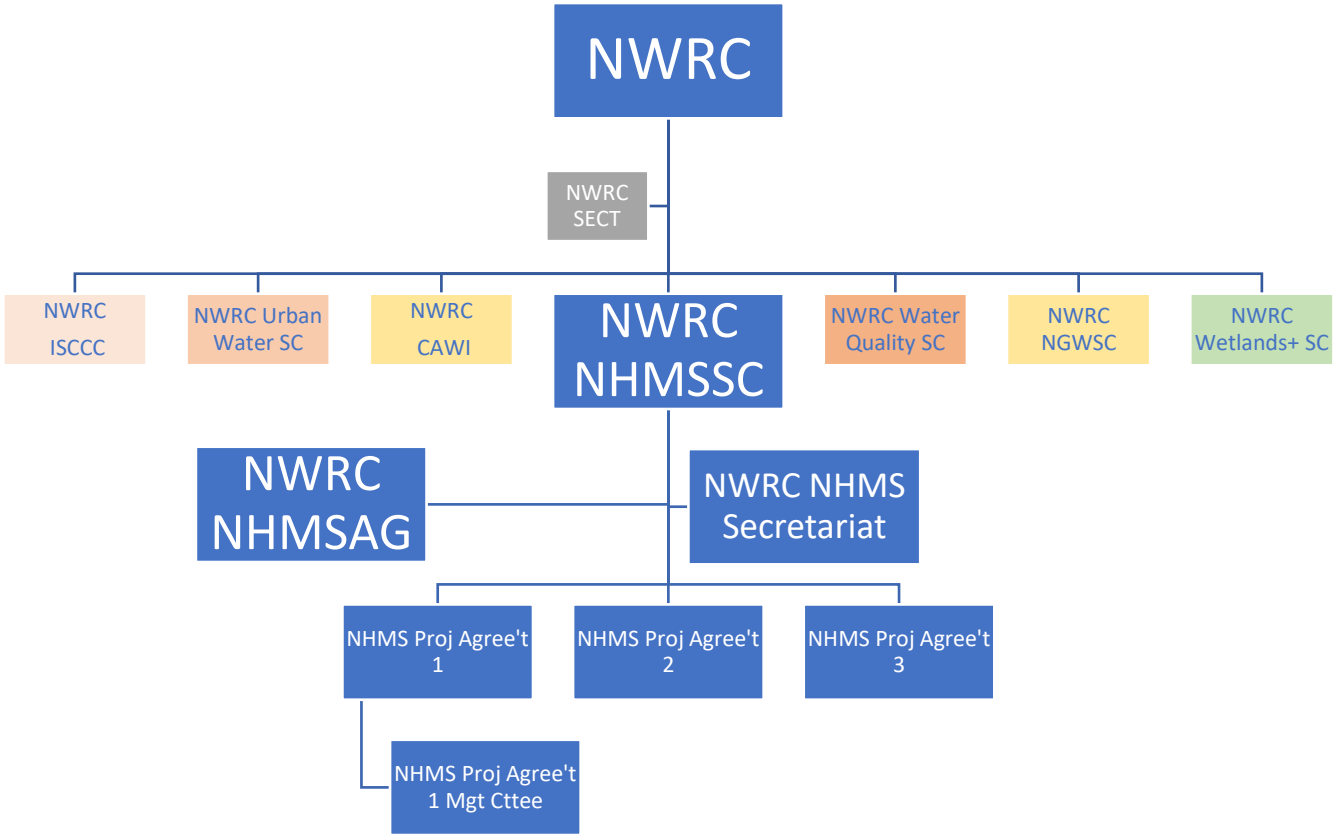


Figure 1 Suggested NHMS Governance Arrangements for Further Consideration and Confirmation

Details of the governance arrangements for the blue boxes in Figure 1 would preferably be set out in an updated fit-for-purpose NHMS-CHA. The detailed Terms of Reference and operating arrangements for the NWRC NHMSSC, NHMSAG and NHMS Secretariat will need to be developed and agreed, with provisions for review, evaluation and improvements. For example, the roles and responsibilities of the NWRC NHMSSC, recommended to be chaired by the Australian Government, with membership from all NWRC jurisdictions, are initially suggested to include:

- leading the NHMS and collaborating on national hydrological modelling issues;
- keeping the NHMS up-to-date as a national strategy to meet Australia's contemporary and future hydrological modelling needs;
- developing, monitoring and reporting on a prioritised implementation program with an agreed investment framework for the strategy;
- supporting hydrological modelling communities of practice, including future capacity building in the government, utility, private, research and academic sectors;
- informing and facilitating linkages in applied research and innovation to further develop modelling capability in agreed priority areas; and
- providing effective communication channels to enable strategic alignment and to inform business development and delivery of products and services relevant to the NHMS and relevant to broader delivery of the NWI. (The latter will require regular and ongoing communication between the NWRC NHMSSC and other groups reporting to and advising the NWRC such as the NWRC CAWI.)

The roles and responsibilities of the NWRC NHMSAG, recommended to have broad, multi-stakeholder representation, including enabling Model Custodian and Model User inputs, are initially suggested to include:

- providing technical and other advice to the NWRC NHMSSC about the direction and implementation of the NHMS. Advice, generally developed in consultation with stakeholders, with avenues for transparency about the nature of the advice and how it has been considered/acted upon, would likely include:
    - the content of and progress on the NHMS Implementation Plan;
    - requirements for and upkeep of a national model management system, including a catalogue/repository of the main available hydrological models and modelling systems and platforms mostly in use in or applicable to Australia;
    - priorities for and progress with strategic hydrological modelling enhancements required to advance the NHMS;
    - "best practice" hydrological modelling guidance and documentation;

    - mechanisms to build hydrological modelling capacity and capability, including communities of practice and networks, training and education programs, and priorities for them;
    - communications strategies, tools and guidance to improve transparency and stakeholder and community understanding of hydrological modelling purposes, principles, processes, results, audits and reporting;
    - priorities for and progress with hydrological data, knowledge and modelling RD&I required to advance the NHMS;
    - mechanisms to achieve cooperative, coordinated, and collaborative delivery of identified priority RD&I needs;
    - evaluation of the achievement of agreed NHMS objectives and outcomes and ways forward;
- assisting with collaboration, consultation, communications and commitment concerning the NHMS

This involves a substantial body of work which will need to be appropriately supported and adequately resourced for the governance arrangements to be effective.

Specific Project Agreements under the NHMS could take a number of forms, depending on the nature of the project and the arrangements for the agreement. For example, a Project Agreement could cover:

- a modelling platform such as Source, MUSIC and/or others; and/or
- an activity such as running a broad hydrological modelling community of practice, or coordinating and delivering a specific or broad RD&I portfolio or an education and training portfolio.

Whether or not a Project Agreement under the NHMS also requires a specific Management Committee to be included in the governance arrangements could also depend on the nature/complexity of the project and the form of the agreement, including the number and types of parties involved. It is suggested that the NHMS-CHA enable case-by-case consideration of such matters.

2. Many participants in the preparation of the 2021 NHMS Report and subsequent discussions raised concerns about funding and the articulation of a clear value proposition. This was especially in respect of providing the necessary resources to adequately maintain and keep contemporary the eWater Source modelling platform, given past, current and anticipated future investments, and the value of water entitlements, infrastructure and the economy derived from decisions informed by that platform. Appropriate funding will be required to support the implementation, on-going maintenance, RD&I for and enhancement of the Source modelling platform and to maintain a strong community of practice under the proposed updated National Strategy. If funding to support implementation is not available, the above initial proposed actions and the suggestions in Appendix A will require further consideration.

APPENDIX A

Activities and Initiatives Suggested for Further Consideration for Implementation

The 2021 NHMS Report and subsequent 2022 inputs outlined several activities and initiatives that were suggested so that the full extent of the NHMS tools and products have transparency, longevity and reliability, quality assurance and quality control, and are appropriately tailored to the questions that are being asked and need to be answered. The most frequently mentioned and relevant of these suggested activities and initiatives have been assessed and collated into Table A1 below for further consideration by the NWRC NHMSSC to finalise a more detailed Implementation Plan, taking advice from the NWRC NHMSAG with input from stakeholders.

In many instances the activities and initiatives outlined in Table A1 are not necessarily fully mutually exclusive, nor are they all at the same strategic or tactical levels. None of them on its own is a "silver bullet" to fully deliver the proposed updated National Strategy, its objectives and outcomes. However, collectively they should make a real positive difference, with some enabling early evidence of progress and benefits, while others will take considerable effort and time to show results. Further work is required to determine the relative priority of each of these suggested activities and initiatives and any co-dependencies and inter-relationships, together with considerations of funding and resourcing. This will likely involve some iterative work over the period of the initial proposed actions, outlined earlier, before the more detailed Implementation Plan can be finalised. For example, what goes forward under the MDB IRMU program will have an impact on certain suggested activities and initiatives.

In doing this work, it will be important to appreciate that success in model building and application for challenging interdisciplinary issues is about more than getting the science and engineering right. It is also about embedding model building in a social process that links and engages scientists, modellers, decision makers, interest groups and the wider public towards achieving impact beyond merely technical performance of a model, notwithstanding the critical importance of the latter for credibility and confidence. Activities and initiatives that enable the undertaking of processes and procedures for enhancing good modelling practice and facilitating and embedding how to effectively do collaborative and participatory modelling are also important.

Suggested Implementation Themes

Recognising the recommendations of the 2021 NHMS Report and further inputs, it is suggested that the more detailed Implementation Plan be broken down under the following themes and sub-themes:

1. Governance
   1.1 Leadership and Direction
   1.2 Management
   1.3 Monitoring, Evaluation, Reporting and Review

2. Funding

3. Technical Hydrological Modelling Systems/Platforms
   3.1. Management and Maintenance
   3.2. Enhancements
   3.3. Documentation and Guidance

4. Capacity and Capability Building
   4.1. Community/ies of Practice and Networks
   4.2. Training
   4.3. Education
   4.4. Communications and Social Licence

5. Research, Development and Innovation
   5.1. Needs
   5.2. Delivery.

Table A1 below lists suggested activities and initiatives aligning with the above suggested themes and sub-themes.

TABLE A1 ACTIVITIES AND INITIATIVES SUGGESTED FOR FURTHER CONSIDERATION FOR IMPLEMENTATION

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
A1 Governance	**A1.1 Leadership and Direction**	A1.1.1 Use the NHMS Steering-Committee, chaired and led by the Australian Government, with membership from all NWRC jurisdictions, to collaboratively set the direction for the NHMS and oversee its implementation	NWRC	Ongoing with periodic review and evaluation	All (and 1 and 6 in particular)
		A1.1.2 Use the NHMS Advisory Group, including BoM, CSIRO, GA, eWater and other public, water utility, private industry, water user, Aboriginal and Torres Strait Islander, research and education/training sector interests/representatives, to provide advice to the NWRC NHMSSC about the direction and implementation of the NHMS and to assist with collaboration	NWRC NHMSSC	Ongoing with periodic review and evaluation	All
	1.2 Management	A1.2.1 Use the NHMS-CHA to set out and action the overall governance and management arrangements for the NHMS and its associated Implementation Plan/s	NWRC NHMSSC	Ongoing with periodic review and evaluation	All
	A1.3 Monitoring, Evaluation,	A1.3.1 Monitor and report (to the NWRC) progress on the NHMS Implementation Plan and undertake	NWRC NHMSSC with advice from the NWRC NHMSAG	Annually	All

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
	Reporting and Review	corrective actions and/or adjustments as agreed necessary			
		A1.3.2 Evaluate and review achievement of the NHMS objectives and propose (to the NWRC) an updated NHMS and Implementation Plan for the following 5 years	NWRC NHMSSC with advice from the NWRC NHMSAG and stakeholders	By mid 2027	All
A2 Funding		A2.1 Establish and use a budget/funding process for specific projects in the Implementation Plan that can't or won't be met from already existing or proposed funding sources or other arrangements (noting that if funding to support implementation is not available, the more detailed Implementation Plan will require further iterative review and prioritisation) (Note A)	NWRC upon advice from the NWRC NHMSSC about the Implementation Plan	Initially, by mid 2023, then ongoing	1 and 6
		A2.2 Use the NHMS-CHA to set out and action the overall funding arrangements for the NHMS and its associated Implementation Plan/s	NWRC NHMSSC	Ongoing with periodic review and evaluation	6
A3 Technical Hydrological Modelling Systems and Platforms	**A3.1 Management and Maintenance**	A3.1.1 Provide initial advice to the NWRC NHMSSC about formalisation and harmonisation of current and proposed model management and maintenance activities and approaches, including requirements for a potential	NWRC NHMSAG in consultation with Model Custodians and Model Users, and input from CoP, with advice	By end 2023	2, 4 and 5

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		national modelling catalogue and/or repository and an associated knowledge management system for priority and nationally important models (Note B)	provided to the NWRC NHMSSC		
		A3.1.2 Establish and implement processes to undertake systematic and strategic reviews of and to publish and update a catalogue of the main available hydrological models and modelling systems and platforms mostly in use in or applicable to Australia (drawing on initiative A3.1.1 above). The processes should include input from hydrological community/ies of practice, and include coverage of capabilities compared with needs, alignment with the NHMS and its objectives and desired outcomes, identification of gaps, overlaps, strengths and weaknesses, risks and opportunities for improvements, including opportunities for research and development, and other suggested ways forward, drawing on approaches such as the Model Classification System and the Model Assessment Framework developed by the QWMN	NWRC NHMSAG with Model Custodians and Model Users and input from CoP, with advice provided to the NWRC NHMSSC	Overview by early 2024, more in-depth on a priority basis progressively by end 2026	1 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		A3.1.3 Subject to any findings from initiatives A3.1.1 and A3.1.2 above, generally, continue the current processes for managing and maintaining the other main modelling systems and platforms mostly in use in Australia	Model Custodians in collaboration with Model Users, with a watching brief by the NWRC NHMSAG	Ongoing	2 and 4
	A3.2 Enhancements (Notes C and D)	A3.2.1 Subject to the progress of systematic reviews under initiative A3.1.2 and informed by RD&I results under Sub-Theme A5.1, identify and publish the strategic hydrological modelling enhancement priorities to advance the NHMS and its objectives and desired outcomes	NWRC NHMSAG with Model Custodians and Model Users, and input from CoP, with advice provided to the NWRC NHMSSC	Overview by early 2024, more in-depth on a priority basis progressively by end 2026	1 and 4
		A3.2.2 Subject to the progress of enhancement priorities under initiative A3.2.1, improve functionality in and/or between existing models or modelling systems (eWater Source in particular) and/or develop new functionalities/models with interoperability on a priority basis to be confirmed by further consultation and funding arrangements, but having regard to: • coherent climate change scenarios	Model Custodians with input from Model Users and CoP, with a watching brief by the NWRC NHMSAG	Progressively on a priority basis to be agreed through until mid 2027	1 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		• fit-for-purpose handling of surface water and groundwater interactions (also noting the needs for nationally consistent groundwater modelling) • fit-for-purpose handling of non-stationarity in rainfall-runoff and stream and groundwater flows • fit-for-purpose handling of low flows, inundation flows, floodplain flows and forecasts and floodplain harvesting modelling in priority areas • fit-for-purpose handling of water trading, and social and economic inputs and analyses, including operation of water markets • fit-for-purpose representation of management, and enabling of accounting, of environmental water provisions, including event-based management • fit-for-purpose handling of water quality at various scales • fit-for-purpose handling of integrated urban water management at various scales			

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		• fit-for-purpose handling of coastal hydrology in priority areas • fit-for-purpose handling of uncertainty, including in data, conceptualisation, parameters, calibration approaches and predictions			
		A3.2.3 Engage with Aboriginal and Torres Strait Islander peoples to plan and improve functionality in eWater Source (and potentially other platforms) to address Aboriginal and Torres Strait Islander water rights and interests, including cultural flows, values and objectives and cultural and economic demands, assessments of impacts on those rights and interests, flows, values and objectives, and management of cultural water provisions, flows and demands, applicable to hydrological modelling	Through establishment of an Aboriginal and Torres Strait Islander hydrological modelling working group, and eWater working in consultation with jurisdictions and the NWRC CAWI (and potentially informed by the WERP and other programs), with a watching brief by the NWRC NHMSAG	By end 2024	1 and 4
		A3.2.4 Subject to the progress of enhancement priorities under initiative A3.2.1, improve functionality in and/or between existing models (eWater Source in particular) and/or develop new functionality/models with	Model Custodians with input from Model Users and CoP, with a watching brief by the NWRC NHMSAG	By end 2025	1 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		interoperability to improve fit-for-purpose water quality modelling, (including sediment, nutrient constituent and salinity modelling, and pathogens, heavy metals and other pollutants with the potential for toxicity) building on recent and proposed work by several jurisdictions, universities and consultants			
		A3.2.5 Subject to the progress of initiative A3.2.1, improve functionality in and/or between existing models (eWater Source in particular) and/or develop new functionality/models with interoperability to improve fit-for-purpose integration between catchment water (quality and quantity) management (including landuse changes and bushfire effects), environmental flows, cultural flows, coastal hydrology and integrated urban water management (including alternative water sources), building on recent and proposed work in some jurisdictions and by some water utilities, consultants and the CRCWSC/WSCA	Model Custodians with input from Model Users and CoP, with a watching brief by the NWRC NHMSAG	By end 2025	1 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		A3.2.6 Specifically, upgrade eWater Source, where applicable, to new and emerging software, including web applications, cloud computing, increased use of visualisation and connections with the digital earth systems environment, and make other enhancements in terms of speed, capability and capacity to interact smoothly with other technology platforms	eWater in consultation with Model Users and CoP (informed by BoM and GA and potentially progress with the IRMU program), with a watching brief by the NWRC NHMSAG	Initially, by end 2025, with periodic review	1, 4 and 7
		A3.2.7 Enhance rainfall, streamflow and flood forecasting capabilities and modelling with linkages to other modelling platforms to inform river and storage operations, flood and floodplain management, and management of environmental and cultural water provisions at a range of spatial and temporal scales to be prioritised	BoM in consultation with Model Custodians, informed by the EA NCWE, with a watching brief by the NWRC NHMSAG	Initially, by end 2025, with periodic review	1, 2, 4 and 5
		A3.2.8 Generally, subject to the progress of enhancement priorities under initiative A3.2.1, continue the current processes for enhancing the other modelling systems and platforms mostly in use in Australia	Model Custodians and Model Users and CoP, with a watching brief by the NWRC NHMSAG	Ongoing	2 and 4
		A3.3.1 Review and update existing “best practice” hydrological modelling	NWRC NHMAG in consultation with	Initially, by end 2023, with	2 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
	A3.3 Documentation and Guidance (Notes D and E)	guidance (e.g. as previously published by eWater, the MDBA and some jurisdictions) and augment as necessary to produce national guidance if needed in such areas as national harmonisation, standardisation of common processes, and/or formalisation of emerging techniques	stakeholders with advice to and approval by the NWRC NHMSSC	minimum five yearly reviews and updates thereafter	
		A3.3.2 As a matter of course, update manuals and guidance materials for model management and maintenance and for enhancements, including those listed in Sub-Theme A3.2, and new knowledge, including that from RD&I (listed in Sub-Theme A5.1)	Model Custodianships in consultation with Model Users and CoP, with a watching brief by the NWRC NHMSAG	Ongoing	4 and 5
		A3.3.3 Develop and publish national guidance on the development and various uses of future climate scenarios for hydrological modelling and associated decision-informing purposes	BoM in consultation with the NWRC ISCCC, with a watching brief by the NWRC NHMSAG	Initially, by end 2023, with periodic updates	2 and 4
		A3.3.4 Specifically, progressively update and publish documentation and guidance materials (User Manual and Scientific Reference Guide, including currency of underpinning science) for eWater Source and its plug-ins, building on “best practice” modelling guidelines	eWater in consultation with Model Users and CoP, (potentially informed by progress with the IRMU program), with a watching brief by the NWRC NHMSAG	Initially, by end 2023, followed by a regular program of updates	3 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		in eWater, the MDBA and some jurisdictions			
		A3.3.5 Specifically, develop and publish guidance, in culturally and socially appropriate language, about the application of eWater Source, AWRA-R, HydroJULES, SWIFT and other models being used to inform basin/catchment scale water resource assessments and planning and management (e.g. the respective model's relative benefits and limitations, when and where to use/not to use, contributions to NHMS outcomes etc) to inform and assist policy and plan makers and others	NWRC NHMSAG with information from eWater, CSIRO and BoM and potentially others in consultation with jurisdictions and CoP	By mid 2024	1, 3 and 4
		A3.3.6 Develop and publish national guidance about describing and handling uncertainty in hydrological modelling, including in data, conceptualisation, parameters, calibration approaches, and predictions, and in a way that builds understanding for decision makers	NWRC NHMSAG in consultation with Model Custodians and Model Users and CoP, for endorsement by the NWRC NHMSSC	By end 2024	2 and 5
		A3.3.7 Develop and publish national guidance, in culturally and socially appropriate language, about conducting and reporting model reviews, assessments and audits to build	NWRC NHMSAG in consultation with Model Custodians and Model Users and CoP	By end 2024	2

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		community understanding and confidence, drawing on lessons learnt from past processes	for endorsement by the NWRC NHMSSC		
		A3.3.8 Review and update, as needed, the (Australian) National Groundwater Modelling Guidelines to incorporate contemporary knowledge and approaches for environments and applications encountered nationally, including with respect to model classification, conceptualisation, suitability of data inputs and considerations of model outputs and uncertainty	NWRC NGWSC, potentially with assistance from the National Centre for Groundwater Research and Training, in consultation with Model Custodians and Model Users and CoP, with a watching brief by the NWRC NHMSAG	By end 2024	1 and 2
		A3.3.9 Review and update, as needed, ARR guidance, including with respect to nationally coherent climate change scenarios and inundation modelling	EA NCWE with support from BoM and CSIRO, with a watching brief by the NWRC NHMSAG	By end 2024 and periodically thereafter	1, 2 and 5
		A3.3.10 Consider whether any hydrological modelling guidance materials would benefit from being developed into standards under the Water Act 2007 and, if so, prepare applicable standards and roll them out with appropriate information, education and training	BoM in consultation with the NWRC NHMSSC and the NWRC NHMSAG and others, and advice to the NWRC	Initial opportunities confirmed by end 2024, followed by progressive development and implementation	2 and 4
A4 Capacity and	**A4.1 Community/ies**	A4.1.1 Facilitate connections between existing known CoP and networks and,	NWRC NHMSAG and MDBA and Basin States	By end 2022 and then ongoing	2 and 3

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
Capability Building (Notes F and G)	**of Practice and Networks**	specifically, connect the MDBA modelling practice group and the modelling networks established within and across the Basin States	modelling networks and eWater Source CoP convenors/coordinators		
		A4.1.2 Collate and publish an inventory of and continue existing relevant CoP and networks and share information about respective activities among them (e.g on noticeboards, provide links on respective web pages, newsletters, mentoring and training programs, webinars and event announcements) and connect existing convenors/coordinators	NWRC NHMSAG in consultation with existing CoP and networks convenors/coordinators	By mid 2023 and then ongoing	1, 2 and 3
		A4.1.3 Include water modelling CoP/networks specific sessions in conference programs such as MODSIM, HWRS and others that are relevant	Existing CoP and networks convenors/coordinators and respective conference organisers	Ongoing to suit respective conference schedules	1, 2 and 3
		A4.1.4 Establish connections between the existing relevant CoP/networks and the OMF and potentially the CUAHSI and others in the international hydrological modelling community	Existing CoP and networks convenors/coordinators and Australian members of the OMF and the CUAHSI and potentially others	By mid 2023 and then ongoing	3 and 7
		A4.1.5 Review operations and benefits from the existing CoPs and networks	NWRC NHMSSC in consultation with the	By end 2024	1, 2, 3 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		and consider whether a more formalised national COP/network is warranted	NWRC NWRCAG and existing CoP and networks convenors/coordinators		
	A4.2 Training.	A4.2.1 Conduct an audit of existing hydrological modelling and related skills across Australia and those likely to be required over the coming 10 years, identify gaps, opportunities and risks, and propose and arrange the delivery of future training and education programs, including consideration of a national curriculum in hydrological modelling	NWRC NHMSSC in consultation with the NWRC NHMSAG, DESE, the university sector and existing CoP and networks	By end 2023	2, 3 and 6
		A4.2.2 Subject to the results of the skills audit under initiative 4.2.1, generally, review/evaluate and continue/amend delivery of the current training programs associated with the modelling systems and platforms mostly in use in Australia, and expand these where required to include training in participatory modelling processes, engagement and communications	Model Custodians and Model Users in collaboration with training providers, with a watching brief by the NWRC NHMSAG	Ongoing	2 and 4
		A4.2.3 Encourage hydrological modelling specialists to participate in water leadership training programs, and cultural immersion and awareness, perhaps by two-way learning programs	NWRC NHMSSC with the PCT and IWC and other relevant providers and input from the NWRC CAWI	Ongoing	3

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		and local engagement with Aboriginal and Torres Strait Islander peoples and making specific spaces and/or programs available			
	A4.3. Education	A4.3.1 Conduct an audit and develop and publish a list of relevant hydrological modelling courses currently being offered in Australia	NWRC NHMSSC in consultation with the NWRC NHMSAG and universities, potentially informed by the work of the National Science and Technology Council on STEM career pathways	By end 2023, followed by regular updating of the list	1 and 2
		A4.3.2 Subject to the results of the education and skills audits under initiatives A4.3.1 and A4.2.1 respectively, and potentially informed by the work of the National Science and Technology Council on STEM career pathways, work with the university sector and DESE to develop and deliver a national curriculum in hydrological modelling, including agreed courses and subjects for undergraduates and practising professionals and post-graduate certificates, diplomas and other higher degree courses and research projects in a range of	NWRC NHMSSC in consultation with the NWRC NHMSAG, DESE and universities, potentially informed by the work of the National Science and Technology Council on STEM career pathways	By end 2024 with periodic review	1 and 2

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		hydrological and related modelling applications, systems and platforms			
	A4.4 Communications and Social Licence	A4.4.1 Establish and maintain a NHMS weblink (for example, under the NWRC weblink) to house information about the NHMS, including the National Strategy and its associated Implementation Plan, its projects and publications (including guidance documents) that emanate from it, and links to relevant websites such as those for CoP and networks	NWRC upon advice from the NWRC NHMSSC in consultation with the NWRC NHMSAG	Initially by end 2022, with regular updating	4 and 5
		A4.4.2 Develop and publish, with management mechanisms to enable easy and regular updating, a catalogue and/or repository of major modelling platforms and systems in use in Australia (building on needs and processes resulting from initiatives A3.1.1 and A3.1.2, and existing model catalogues and warehouses and management systems in some jurisdictions and potentially informed by progress with the IRMU program) (Note B)	NWRC NHMSSC in consultation with the NWRC NHMSAG, with inputs from Model Custodians and Model Users and CoP	Initially by end 2023, with regular updating	4 and 5
		A4.4.3 Aligning with advice about model management provided through initiative A3.1.1, further consider policy,	NWRC NHMSSC in consultation with the NWRC NHMSAG, with	By end 2025	2 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		data sharing, custodianship, governance controls and other requirements to enable additional development and increased availability of and access to modelling platforms, their inputs and outputs (notably including eWater Source), including managed access to regulated models, and consider implications for future national guidelines for model management, hydrological model provenance, and an updated national hydrological model repository (national data and model warehousing facility), including benefits, disbenefits, risks and opportunities associated with more open source platforms (Note B)	input from Model Custodians and Model Users and CoP		
		A4.4.4 Consider improved communications tools and develop and publish best practice communications guidance, potentially including case studies, to improve transparency and stakeholder and community understanding of hydrological modelling purposes, principles, processes, results, audits and reporting, building on experiences within jurisdictions, utilities	NWRC NHMSSC in consultation with the NWRC NHMSAG and inputs from Model Custodians, Model Users, CoP and other stakeholders	By end 2024 with periodic updates	2 and 4

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		and the private sector and academic research			
		A4.4.5 Further to initiative A4.4.4, develop and arrange delivery of a water modelling language and literacy program specifically for and by Aboriginal and Torres Strait Islander communities	NWRC NHMSSC in consultation with the NWRC NHMSAG and the NWRC CAWI	By end 2024 and ongoing	4 and 5
		A4.4.6 eWater Board to meet with the NWRC NHMSSC at least once a year on an occasion(s) other than the Annual General Meeting of eWater for strategic conversation on matters relating to the broad direction of eWater Ltd and its modelling platforms and the direction of the NHMS. (This initiative also contributes to Theme A1 - governance)	eWater Board and the NWRC NHMSSC, with input from the NWRC NHMSAG	At least annually	1, 6 and 7
		A4.4.7 Establish an independent process to review and assess models by using appropriate expertise	NWRC NHMSSC in consultation with the NWRC NHMSAG	Initially, by mid 2023, with a periodic refresh	3 and 4
A5 Research, Development and Innovation (RD&I)	**A5.1 Needs (Notes C, D and H)**	A5.1.1 Identify, publish and regularly update Australia's hydrological data, knowledge and modelling RD&I needs, opportunities and priorities, and mechanisms to meet them	NWRC NHMSAG with inputs from Model Custodians and Model Users, the university sector and existing CoP and networks and possibly review by the Government Scientists	Initially, by end 2023, with regular updating	5

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
			Group and/or the Forum of Australian Chief Scientists and the new One Basin CRC, and advice to the NWRC NHMSSC		
		A5.1.2 Subject to the progress and results of initiative A5.1.1, update the science around climate change and climate variability to improve data and conceptual and process understanding and to inform national guidance	BoM and CSIRO in consultation with the NWRC ISCCC, with a watching brief by the NWRC NHMSAG	Initially, by end 2023, with periodic updates	2, 4 and 5
		A5.1.3 Subject to the progress and results of initiative A5.1.1, improve data and conceptual and process understanding so that low flows, inundation flows, floodplain flows and forecasts and floodplain harvesting in priority areas can be modelled in a fit-for-purpose way	Initially, the MDBA and Basin States (potentially informed by the WERP and IRMU program), followed by other jurisdictions, with their respective research communities and advice to eWater and other Model Custodians	By end 2024	2, 4 and 5
		A5.1.4 Subject to the progress and results of initiative A5.1.1, improve data and conceptual and process understanding so that surface water and groundwater interactions in priority	BoM, GA and jurisdictions with their respective research communities	To be set by national and jurisdictional priorities	5

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		areas can be modelled in a fit-for-purpose way			
		A5.1.5 Subject to the progress and results of initiative A5.1.1, improve data and conceptual and process understanding and tools so that non-stationarity in rainfall-runoff and streamflow can be modelled in a fit-for-purpose way	BoM, GA and jurisdictions with their respective research communities	To be set by national and jurisdictional priorities	5
		A5.1.6 Subject to the progress and results of initiative A5.1.1, improve data, data management, and conceptual and process understanding and tools so that runoff, water quality, stream and coastal erosion and hydrology interactions in priority areas can be modelled in a fit-for-purpose way	Model Custodians and Model Users, with a watching brief by the NWRC NHMSAG	To be set by national and jurisdictional priorities	5
		A5.1.7 As a priority, improve data inputs, including baseline data, and respectful, agreed applications of Aboriginal and Torres Strait Islander knowledge to enable hydrological modeling to better reflect Aboriginal and Torres Strait Islander water rights and interests, including cultural flows, values and objectives and impacts on them in priority areas, and develop	Through establishment of an Aboriginal and Torres Strait Islander hydrological modelling working group supported by jurisdictions, with a watching brief by the NWRC CAWI and NWRC NHMSAG	To be set by Indigenous knowledge custodians (with advice from the NWRC CAWI)	5

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
		protection mechanisms with and by Aboriginal and Torres Strait Islander peoples for cultural knowledge, intellectual property and any sensitivities identified			
		A5.1.8 Subject to the progress and results of initiative A5.1.1, develop additional and/or updated tools for improved analyses of outputs from models and communication of results, including visualisation and interactive tools, with encouragement to apply state of the art user testing and user interface/user experience (UI/UX) practices	Model Custodians and Model Users, with a watching brief by the NWRC NHMSAG	To be set by government and industry priorities	4
		A5.1.9 As a priority, review and update the science, new technologies and algorithms informing the eWater MUSIC platform and incorporate them into the platform, subject to agreement and acceptance by industry and regulators	eWater informed by the MUSIC Technical Panel, with input by CoP and other stakeholders and a watching brief from the NWRC NHMSAG	By end 2024	5
	A5.2 Delivery (Note H)	A5.2.1 Review/establish as necessary information, communication, funding and other protocols to achieve coordinated and collaborative delivery of the identified priority research needs	NWRC NHMSAG with inputs from existing CoP and networks and possibly review by the Government Scientists Group and/or the	By mid 2023 and ongoing	1, 3 and 5

SUGGESTED THEME	SUGGESTED SUB-THEME	SUGGESTED ACTIVITY/INITIATIVE	SUGGESTED RESPONSIBILITY	SUGGESTED TIMING	NHMS OBJECTIVE/S
			Forum of Australian Chief Scientists		
		A5.2.2 Use the NWRC NHMSAG, or a sub-set of it, as a transparent "clearing house" to identify opportunities for and to assist cooperation, coordination and collaboration in the delivery of Australia's hydrological modelling RD&I needs and priorities	NWRC NHMSAG with inputs from Model Custodians and Model Users and existing CoP and networks and advice to the NWRC NHMSSC	Ongoing	1, 3 and 5
		A5.2.3 Provide further advice to the NWRC NHMSSC about any additional opportunities and utility associated with additional open modelling frameworks to further drive innovation, collaboration and model improvements, including consideration of pathways for integrating legacy software with open modelling frameworks (Note B)	NWRC NHMSAG in consultation with Model Custodians, Model Users, CoP and the OMF	By end 2026	2, 4 and 5

NOTES

A. In general, where required, each of the initiatives in the above table should be at least described in brief (1-2 page) documents, outlining, respectively, the initiative's objectives, scope, requirements, methodology and outputs/products, outcomes, co-dependencies and funding requirements/sources, together with any further background information to assist consideration of the undertaking of the initiative. Once the initiative is included in the finalised more detailed Implementation Plan, the responsible entity/entities for the initiative/s should keep the NWRC NHMSSC and the NWRC NHMSAG informed about progress in undertaking the relevant initiative/s.

B. The need for reconsideration of model management approaches was identified by several participants in the preparation of the 2021 NHMS Report and subsequent discussions about an updated National Strategy and Implementation Plan. Considerations include more open source modelling frameworks, nevertheless having appropriate mechanisms for managed access where required for regulatory and/or privacy and/or commercial-in-confidence purposes, to meet transparency expectations and the needs of the hydrological modelling community and decision makers. There is likely space for both proprietary and open-source approaches under the National Strategy, provided the necessary governance, quality controls, standards, IP arrangements, documentation, communications, incentives for innovation and commercialisation, and funding mechanisms are in place. All of these considerations are not mutually exclusive with several competing against each other, so a carefully balanced approach is required. Several actions have been proposed in the above table to further explore these challenges, identify and agree opportunities for improvement, provide guidance for ways forward and to review effectiveness over time.

   It has been suggested that documentation in a proposed 'catalogue' should have at least three aspects:

   1. what tools are available to use for what purpose (e.g. explain when to use Source or AWRA or MUSIC etc);
   2. what has been pursued and/or what has been done, even if a plug-in as such is not available;
   3. where models have been built and used by whom.

   Where possible, making these models and plug-ins available on-line would also be useful and would satisfy transparency requirements.

C. The proposed technical modelling enhancements and RD&I priorities, under Sub-Themes A3.2 and A5.1 respectively, have been distilled from long lists coming out of the 2021 NHMS Report and the 2022 discussions about an updated National Strategy and Implementation Plan. Generally, the modelling enhancements and RD&I priorities listed above were the ones mentioned by most people and assessed as being the most pressing and/or leading to the most benefit. More rigorous analyses, should that be possible, may result in a somewhat different list, though well-informed opinions do support the activities and initiatives suggested in Table A1.

D. The need for improved guidance materials, as listed under Sub-Theme A3.3, and education, training and communication about them and modelling in general, has been identified by all participants in the preparation of the 2021 NHMS Report and subsequent discussions about an updated National Strategy and Implementation Plan. This need has arisen as a result of growing expectations of stakeholders and improvements sought under the National Water Initiative (NWI) that there should be a consistent and transparent approach to applying models used to support water related decisions across the country to:

- improve modelling practice
- provide quality assurance, including evaluation and communication of uncertainty
- remove inconsistencies between model applications, including in adjoining catchments where the same model code is used in both, and in situations such as managed river systems that interact with one another
- improve decision making, including improving the use of science to improve the quality and robustness of decisions made and outcomes
- improve communication with end-users of model results: water managers, decision makers and the wider community
- provide a process that is transparent, robust and repeatable.

E. Guidance materials should be a point of reference for best practice for all those involved in the development, application and review of hydrological models, and those who use the outputs from models. Guidance materials do not need to prescribe just the one approach to modelling. Different guidance may be provided by different custodians and with differing purposes and scopes of applicability, though clarity about the relationships between guidance materials is encouraged. Hydrological and water related modelling generally is an active field of RD&I. Enhancements in modelling are driven by new knowledge, the need for better process descriptions, newly encountered management issues or changed behaviours, expanding computing capabilities and growing stakeholder expectations. Guidance materials should provide a reasonably comprehensive summary of what is considered good practice in modelling, based on historic and current literature and the experience of a variety of practitioners involved. The continual evolution of modelling techniques through adaptation and innovation should not only be acknowledged but encouraged.

F. While a broader national hydrological modelling community of practice is not yet established, some jurisdictions and practitioners, including Queensland, NSW and Victoria, and others, like the Groundwater Modelling Decision Support Initiative (GMDSI), have been effectively self-organising their own networks for training, capacity and capability building to good local effect but with limited or no national leverage to date. There are very useful lessons and information to be shared across these networks, involving not only software developers and modellers, but also including policy people, decision-makers, researchers, educators, the private sector and communications/engagement people. Each community of practice should consider future capacity building and skills requirements. Network activities should include developing processes and procedures for enhancing good modelling practice and facilitating and embedding how to effectively do collaborative and participatory modelling. These are important to the social licence to operate.

Providing greater clarity and transparency in the way that models are used and where the benefits and constraints lie can lead to transformative conversations and greatly increased water literacy, trust and confidence.

G. The 2021 NHMS Report and subsequent discussions have reinforced the vital need for future capacity building, including to get junior level people into the water modelling fraternity and to get mid-career modellers into water leadership roles. This will help to ensure that the necessary skills are there for the future. Those skills are not just being able to "push the buttons in models" but rather to also being able to appropriately apply models to help solve problems, communicate well and sufficiently inform and assist decision making. This also includes education, training and skills in developing processes and procedures for enhancing good modelling practice and facilitating and embedding how to effectively do collaborative and participatory modelling. To find new modellers and upskill junior staff, it has been suggested that it would be useful, for example, to develop a national curriculum (including tertiary short courses) in hydrological modelling, distributed across Australian universities. Water management agencies and the private sector could contribute in-course material and assist with delivery and mentoring. This could also be an integral element of the community of practice, and over time would develop better networks.

H. The need for more targeted and better coordinated RD&I activities to meet the needs of the hydrological modelling community and decision makers was identified by all participants in the preparation of the 2021 NHMS Report and subsequent discussions about an updated National Strategy and Implementation Plan. The work under the Murray-Darling Basin IRMU and WERP could be considered an important sub-set of the updated National Strategy and Implementation Plan, meeting priority research and innovation and modelling development needs not only of the Basin, but also with some specific opportunities for transferability elsewhere. As a minimum, the activities under the RD&I Theme should be designed to:
    - define and prioritise the strategic direction for RD&I investments;
    - maximise capture of the vast body of relevant RD&I to underpin the NHMS;
    - enhance the quality of, and increase, when and where justified, the quantity of observational data for analyses and for assimilation into hydrological models, to provide more precise, accurate and reliable information;
    - foster coordination, cooperation and collaboration;
    - protect cultural knowledge, intellectual property and sensitive information;

- integrate new knowledge and RD&I delivery with the design and implementation of hydrological modelling systems and platforms to inform decisions about water related information, policies, plans. Infrastructure, products, services and operational systems;
- evaluate outcomes;
- manage risk;
- communicate RD&I outcomes, including the publication of peer-reviewed methodological and application papers in the domestic and international literature on the use of NHMS platforms and products.

The following chart (Figure A1-1) illustrates a summary of the proposed overall High-Level Implementation Plan, including the initial proposed actions and the activities and initiatives suggested for further consideration.

Figure A1-1 NHMS Implementation Summary

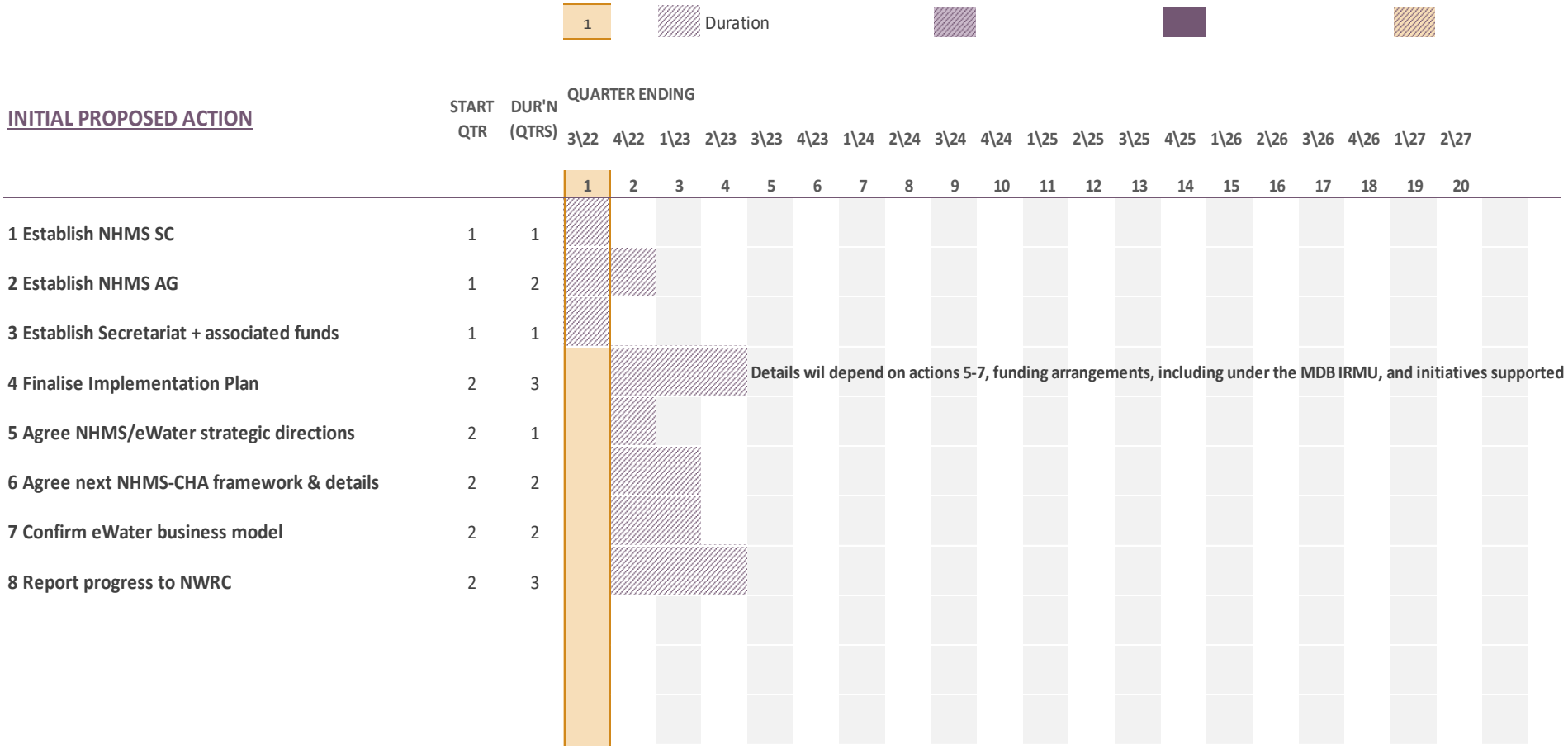


Figure A1-1 cont'd NHMS Implementation Summary

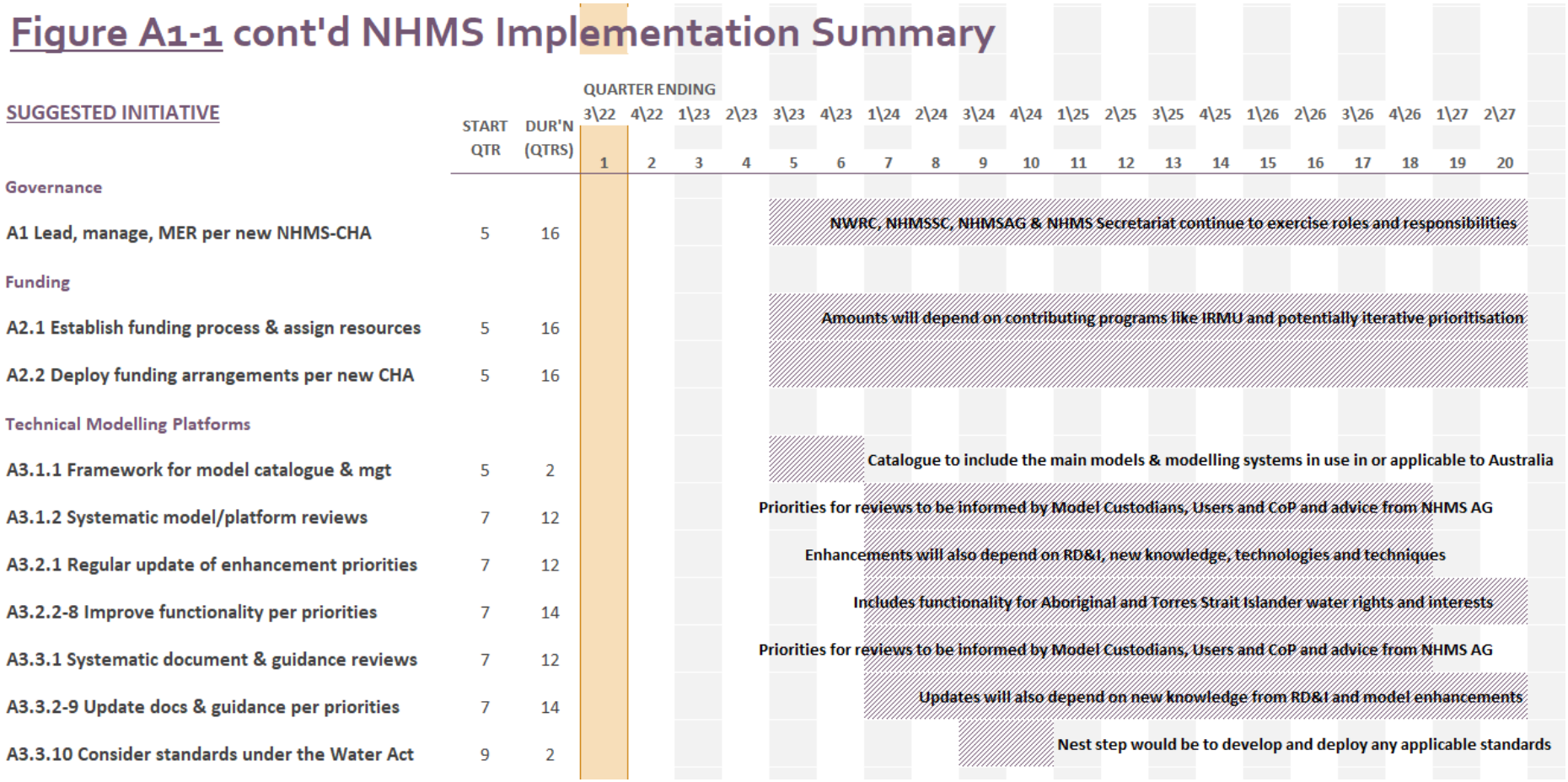
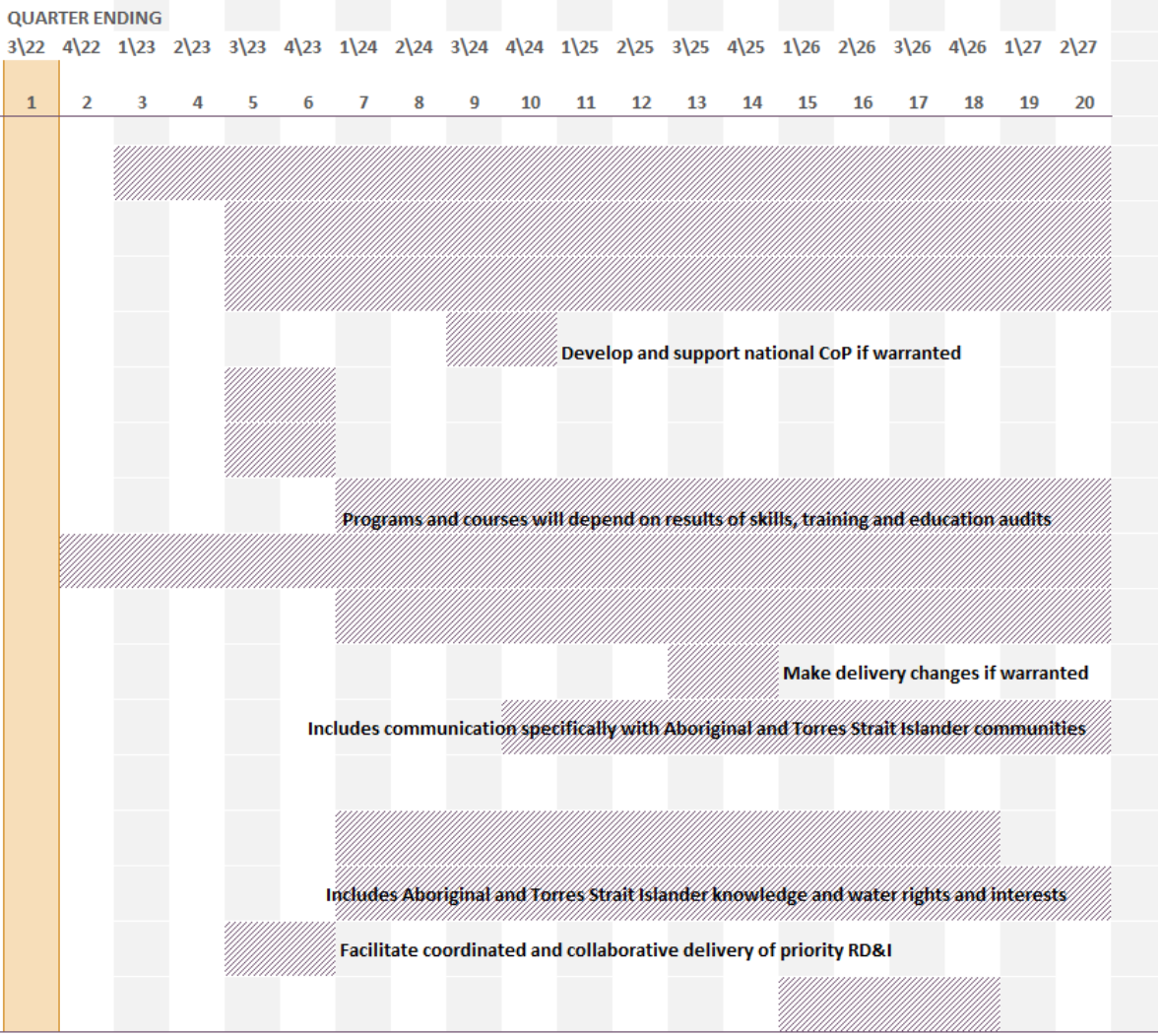


Figure A1-1 cont'd NHMS Implementation Summary

SUGGESTED INITIATIVE	START QTR	DUR'N (QTRS)
Capacity and Capability Building		
A4.1.1 Encourage existing modelling CoP	3	18
A4.1.2&4 Collate & connect modelling CoP	5	16
A4.1.3 Connect modelling CoP & conferences	5	16
A4.1.5 Consider a formalised national CoP	9	2
A4.2.1 Conduct a modelling skills audit	5	2
A4.2.2&4.3.1 Conduct training & education audits	5	2
A4.2.3&4.3.2 Update & deliver training & ed'tion	7	14
A4.4.1 Establish and maintain NHMS weblink	2	19
A4.4.2 Publish & regularly update model catalogue	7	14
A4.4.3 Consider opportunities for more openness	13	2
A4.4.4-6 Improve communication tools & delivery	10	11
Research, Development & Innovation (RD&I)		
A5.1.1 Regular update of RD&I priorities	7	12
A5.1.2-9 Improve science/tech per priorities	7	14
A5.2.1-2 Review modelling RD&I delivery	5	2
A5.2.3 Consider additional open modelling frames	15	4



APPENDIX B

Abbreviations Used in the Implementation Tables

ARR	Australian Rainfall and Runoff (Guidelines, housed by Geoscience Australia, and technically developed and managed by the National Committee on Water Engineering (NCWE) - a specialist committee of Engineers Australia. ARR's success comes from practitioners and researchers driving its development.)
AWRA-R	Australian Water Resources Assessment River model
BoM	Bureau of Meteorology
CoP	Communities of Practice
CRCWSC	Cooperative Research Centre for Water Sensitive Cities (a forerunner of Water Sensitive Cities, Australia (WSCA-Monash University))
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CUAHSI	Consortium of Universities for the Advancement of Hydrological Sciences (headquartered in the USA)
DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
DESE	Commonwealth Department of Education, Skills and Employment
EA NCWE	Engineers Australia National Committee on Water Engineering
eWater	eWater Ltd (a limited by guarantee public company with a membership-based constitution and its own Board. Its initial members were the Commonwealth Government and State Governments of NSW, Victoria, Qld and SA. Subsequently, the Governments of the ACT and WA became members. More recently, the Governments of Tasmania and the NT have become members.)
GA	Geoscience Australia
HydroJULES	An advanced terrestrial hydrological model that couples to the Joint UK Land Environment Simulator (JULES) and related models
IRMU program	Murray-Darling Basin Integrated River Modelling Uplift program (including funding from the DAWE and administered and managed by the MDBA with inputs from Basin States)
IWC	International Water Centre (Griffith University)
MDBA	Murray-Darling Basin Authority
NHMS	National Hydrological Modelling Strategy
NHMS-CHA	National Hydrological Modelling Strategy Collaborative Head Agreement
NWRC	National Water Reform Committee (Chaired by DAWE with members from each State and Territory Government)
NWRC CAWI	NWRC Committee on Aboriginal Water Interests
NWRC ISCCC	NWRC Interim Sub-Committee on Climate Change
NWRC NGWSC	NWRC National Groundwater Sub-Committee
NWRC NHMSAG	NWRC NHMS Advisory Group (proposed)
NWRC NHMSSC	NWRC NHMS Steering Committee (proposed)

OCS	Office of the Chief Scientist
OMF	Open Modelling Foundation
PCT	Peter Cullen Trust
QWMN	Queensland Water Modelling Network
SPA	Source Project Agreement
SPASC	SPA Steering Committee
SPATSG	SPA Technical Support Group
SWIFT	Short-term Water Information Forecasting Tools
WERP	Murray-Darling Basin Water and Environment Research Program (which will also be informing elements of the IRMU program)