Water Information
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Australian Government
Bureau of Meteorology

Department of Environment
and Resource Management

National Information Management Protocols for Water Quality Monitoring

Report B
Implementation Strategies

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Tomorrow's Queensland:
strong, green, smart, healthy and fair

Toward Q
Tomorrow's Queensland

Queensland Government

Version History

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Executive Summary

Water quality information is currently being captured and used to support the objectives of numerous organisational bodies across Australia.

Under the Commonwealth *Water Act 2007*, the Australian Government has given the Bureau of Meteorology (the 'Bureau') the responsibility for integrating comprehensive water information (including water quality information) to provide access at a national level and to support broader national objectives. In response to this initiative, and in consultation with water information users, the Bureau is currently developing the Australian Water Resources Information System (AWRIS). The intention is for AWRIS to store and manage water data of various types in a secure central repository. This system will have the capability to receive, standardise, organise and interpret water data, and make them freely available to all users.

Critical to the successful development of AWRIS will be the Bureau establishing a standardised approach to water data provided to AWRIS. As part of this initiative, the Queensland Department of Environment and Resource Management (DERM) was funded to identify what water quality information is being captured by the various agencies, government bodies, councils and water authorities across Australia and to develop a nationally standardised approach to water quality metadata. This project (4QLD01.08 Water Quality Metadata and Standards) has built on earlier work undertaken by DERM in this area, and has resulted in the drafting of a National Water Quality Data Set (NWQDS).

The key recommendation from this project is that the Bureau considers incorporating the proposed NWQDS in its entirety as the required water quality metadata component of AWRIS. It is envisaged that in the future the identified water quality information would be provided by the various water organisations to the Bureau on a regular basis for loading into AWRIS.

The findings from Project 4QLD01.08, documented as National Information Management Protocols for Water Quality Monitoring, have been partitioned into three separate reports:

Report A Water Quality Metadata Guidelines outlines recommendations for improving standardisation in existing metadata practices. It focuses on two main proposals:

- NWQDS conceptual data model – describes a list of core data elements for water quality and how they inter-relate. It provides clear definitions and terminology and highlights the areas where coding systems are needed in order to successfully identify and integrate water quality data at a national level.
- standard naming conventions – coding protocols for technical references (methods) and water quality determinands have been defined to facilitate data integration and compatibility. Their functionality can potentially be applied to any number of different water quality data, enabling related data from multiple aligned sources to become interoperable and exchangeable.

A brief summary of draft recommendations for enhancements to the Bureau's existing Water Data Transfer Format (WDTF) quality coding, as proposed by Grant Robinson, NSW Office of Water (NOW), is also included in the report. These were partially developed in tandem with this project to enhance the final outcomes. They aim to make the application of quality-A, B and C simpler and pertinent to all Bureau data categories, not just Category 9 (water quality).

Report B Implementation Strategies (this document) considers options for the Bureau to implement a standardised approach to metadata and chronicles the:

- benefits of a nationally standardised approach to water quality metadata
- the challenges/implications that will need to be considered in the application of the project's recommendations.

Report C Project Activity Report comprises collated data garnered from the various consultation processes that were conducted with lead water agencies, regional NRM bodies and councils across Australia throughout the course of the project, namely:

- water quality metadata and standards survey – to gauge and compare national practices and identify the existing systems currently being used to manage physico-chemical water quality data.
- water quality metadata workshop – to gain consensus on components of the proposal for Information Management Protocols (IMP) at a national level, the outcomes of which were used to develop and refine the recommendations contained within Report A.
- naming conventions discussion paper – to foster debate on the proposed standard coding format for characterising technical references and determinands for water quality.
- quality coding paper – overview, provided by Grant Robinson, of the need for improvements to current WDTF quality codes.
- ongoing feedback – to provide the opportunity for a continual flow of input on the draft recommendations from all interested parties throughout the lifecycle of the project.

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1 Introduction

The Bureau of Meteorology (the 'Bureau') is receiving water quality data from organisations across the nation to enable reporting on the condition of waterways and aquifers at different scales.

The strategy for developing a better understanding of national water quality is reliant on the participation of state and jurisdictional stakeholders submitting water quality information to the Australian Water Resources Information System (AWRIS). It is therefore important that each water quality data provider has a data management system that can supply water quality data that meet the Bureau's requirements as well as meet its own specific water resource needs.

Nationally there is currently no recommended or consistent way information is coded by organisations in the collection, analysis and storage of water quality data. This restricts the interoperability[π] of data sets between organisations and within and between jurisdictions. It also constrains the longer term goals of the Bureau to collate data from multiple agencies at a national level.

From an information-sharing perspective, the ability to exchange and collate data using a consistent format and metadata that are designed to enable integrated analysis of large data sets collected by multiple agencies is desirable.

Data sets published by different agencies for widespread use tend to be stored in systems that differ in structure, format and vocabulary. To access these data, users may need to navigate directories and supporting documentation in order to locate the metadata needed to correctly interpret and use the data. The need for standardised water quality metadata that can help overcome the heterogeneity in hydrologic and water quality data from different sources to allow easy collation and interpretation is evident.

An earlier project (3QLD1.3), funded through the Bureau's Modernisation and Extension (M&E) program to review water quality information issues in Queensland, resulted in the development of Information Management Protocols (IMP). These proposed guidelines were developed to encourage improved consistency across different organisations in the collection, analysis and storage of water quality data. The project concluded that the uptake of IMP would lead to greater transparency and understanding of water quality data and better water resource management decisions.

IMP developed in that project have been reviewed, revised and extended by project collaborators to meet the wider needs of water quality data providers nationally. To this end, this current project (4QLD01.08) proposes a standardised approach to water quality metadata which includes:

- a recommended list of core data elements and metadata requirements
- a conceptualised data transfer process from data providers to the Bureau
- a proposed standard naming convention for technical references and determinands for discussion.

[π] Interoperability is the property of a system whose interfaces are allowed to work with other products or systems, present or future, without any restricted access or implementation.

Details of the proposals are incorporated into the National Water Quality Data Set (NWQDS) and naming conventions contained in Project Report A – Water Quality Metadata Guidelines.

The purpose of this report (Report B) is to scope possible strategies for the implementation of the proposed metadata guidelines. Section 2 of this report details the benefits data suppliers may expect from implementing the metadata guidelines. Section 3 outlines some implementation options.

This document also identifies a number of elements the Bureau may need to consider when developing strategies to facilitate uptake of changes by industry (Section 4), as well as potential challenges to be addressed (Section 5).

1.1 Method for developing implementation strategies

During this project, considerable effort has been invested in engaging with water quality data providers nationally to ensure that the final recommendations are representative of the wider industry. The opportunities for input included:

(i) participation in the national Water Quality Metadata and Standards Survey (December 2010) and

(ii) attendance at a 2-day national Water Quality Metadata Workshop in Brisbane (February 2011), with subsequent opportunity to review and provide input into the draft recommendations.

A list of participants in these and other engagement activities is available in Appendix A.

The project also utilised feedback relating to the development of the National Water Information Standards (NWIS) provided in interviews and water industry forums organised by GHD on behalf of the Bureau (GHD, 2010). While not confined to the issues of water quality metadata, the perspectives provided in relation to water information generally were considered to be relevant.

2 Making a case for change

Current issues experienced by data suppliers, managers and users in relation to water quality data include:

- ensuring consistency of data and metadata across multiple data sets
- determining whether data are fit for purpose
- assessing data quality.

At a national level these are considered significant issues, as indicated by the recent level of investment in developing standards. How these issues are viewed at an organisational scale depends on how severely their ability to fulfil their goals and responsibilities regarding water quality management and decisions is impacted. In addition, the importance for data standards is highlighted when there is a greater separation between data collectors and data users.

Feedback from data managers in lead water agencies during the national water quality metadata workshop indicated that, from their perspective, the most important issues to be addressed are the need for:

- sufficient metadata to ensure users have confidence that the data are fit for purpose and comparable – these metadata should include information about the sampling and analytical methods
- effective and efficient exchange of information
- collecting data once, with the knowledge that the data can be used many times/in many ways
- sharing capabilities and building capacity in jurisdictions
- the ability to benchmark systems
- ensuring the interests of the public are protected
- data quality to be appropriately coded so users have a known level of confidence in the data with respect to its accuracy, precision and management.

2.1 Develop a 'model' business case

Comprehensive and quality data are central to data analysis and interpretation. To this extent, metadata underpin the entire data 'value chain' and there is a 'strong case for metadata being given immediate attention' (GHD, 2010, p. 49). This would seem to indicate that there is widespread support to enhance water information systems to better support metadata.

Recognition of the need for standardisation of metadata is not a recent phenomenon. Data managers and users are well acquainted with the associated issues, and accept the need to improve existing data management arrangements. Many have reported difficulty in getting commitment from their organisations to invest in improving the situation. The exertion of external forces (such as change to regulations) pressing for change to internal data management systems may be welcomed by many.

In addition, the supply chain of data is subject to the nexus of organisational responsibilities. One of the biggest challenges associated with persuading organisations to adopt a standardised system and commit to long term resourcing is dealing with their concerns that 'the main benefits accrue at the national level through improved interoperability, consistency, and comparability of data across jurisdictions, whilst the cost of adoption rests with operational agencies whose needs are dictated by local management considerations for which national comparability of data is often of little interest' (GHD, 2010, Appendix C).

Consequently, there is a need for a 'model' business case to be built and made available to those requiring help to gain approval for investment in the necessary changes. Questions to be addressed in the business case could include:

- What are the benefits and cost-savings to be gained (including problems solved)?
- What are the uses for data from a national perspective to justify significant investments?
- What are the implications (short and long term) of not improving the current situation?
- What are the critical success factors?
- What are the alternative options and the costs and impacts of those options?
- What are the assumptions and constraints?

2.2 Benefits

Identifying where benefits will accrue is critical for building a business case. Stakeholders canvassed at the NWIS development forum (GHD, 2010) identified the main advantages to modernising and expanding current water information systems as:

- **Return on investment (ROI) ↑** – data will be more readily found, accessed and shared, thereby increasing their potential usability.
- **Costs ↓** – standardised data requirements will allow systems and software to be developed and shared widely; and improve efficiencies in accessing data.
- **Confidence in data ↑** – serve as a guide by which organisations can operate to improve integrity of data: consistency; quality; and standards in data collection, analysis and storage.
- **Data access, combining + sharing ↑** – promote interoperability between water monitoring organisations by enhancing the potential for archiving and sharing data.

Data managers involved more recently in this project's water quality metadata workshop articulated similar perspectives, but identified a number of benefits specifically related to water quality metadata (Table 1). They also recognised that their ability to respond to change would depend on factors such as:

- the amount of change required and whether the costs associated with making the changes are affordable or can be justified against other priorities
- the current costs and difficulties associated with not being able to readily combine and share data at organisational, jurisdictional and/or the national level.

Table 1 List of benefits of a nationally standardised approach to water quality metadata identified at the national Water Quality Metadata Workshop (Brisbane 2011)

Identified Benefit and Considerations	N*	J*	O*
Efficiencies/cost savings			
Standard parameter name/numbers/methods and interoperability between databases should mean that it is easier to share data, minimising the work for combining and collating it.	•	•	•
Receiving and sending data between organisations, whether at local, regional, jurisdictional, or nationally to the Bureau, will be more straightforward.	•	•	•
Greater return on investment (ROI) into water quality monitoring where data have multiple uses and/or users.		•	•
Streamlined searching and efficient retrieval of relevant data to answer questions regarding water quality and its effect on water resource management.	•	•	•
May make it easier to determine data coverage, and where extra effort needs to be invested, making it useful for future planning at state/national level.	•	•	•
Standardised approach encourages consistency and quality of data.		•	•
Provides a standard model for helping to structure a water quality database, rather than accepting vendor's model.		•	•
Standardisation of data requirements could enable commercial developers to be innovative in developing mobile applications.			•
Data analysis and reporting			
Easier to track progress or performance of strategies, policies and legislation relating to water quality.	•	•	•
Standard nomenclature enables valid data modelling/reporting comparisons and consistency in reporting.	•	•	•
Ensures organisations' data meet jurisdictional and national requirements – no data 'massaging' required.		•	•
Can confidently combine and compare data from different sources and assess fitness for purpose.	•	•	•
Data can be combined and/or compared with greater confidence which should facilitate a better understanding of condition and trend, and cause and effect.	•	•	•
Standard nomenclature and descriptions facilitate shared understanding of data – reducing ambiguity/error – and improving interpretation of data.	•	•	•
A national standard would provide data managers with 'ammunition' to push for support to invest in improved internal standards and systems.		•	•
Standardised approach encourages documentation of sampling methodologies within the organisation.			•

*Benefits may or may not be applicable at the different scales – national (N), jurisdictional (J) and/or organisational (O).

	N*	J*	O*
Data sharing, communication and collaboration			
Influences organisations to store data in readily comparable formats.		•	•
Provides a model for best practice to which organisations can align their systems or specify in projects or service agreements.			•
Facilitates data transfer within and between organisations.	•	•	•
Enables easier/quicker data discovery resulting in less time spent determining whether it is 'fit for purpose', and faster response times for analysis, reporting and decision making.	•	•	•
Identifies data provenance, which will improve the understanding of what other organisations are doing, and will provide a network of contacts for future work in water quality.	•	•	•
Facilitates collaborative or data sharing agreements between different organisations and/or jurisdictions (e.g. Murray Darling Basin). Formalised structure/specification enables negotiation with other players at that jurisdiction.		•	•
Allows alignment between local goals and a national vision.	•	•	•
Fosters collaboration through improved data availability to more potential users, researchers and organisations with similar interests/problems.	•	•	•
Increases agency's trust in data provided by regional organisations or community groups.		•	•
Makes data (largely publically-funded) available to the community.	•	•	•
Reduces data misinterpretation through a common terminology and consistency in naming parameters, making reporting to other organisations potentially easier.			•
Creates capability for better data access through central web portals to display collated information.		•	•

3 Implementation options

The implementation options presented here have been shaped by the direction of discussions with key stakeholders during this project, and as such may not represent all possibilities available to the Bureau.

The Bureau's existing approach to developing NWIS is expected to strongly influence the way in which the recommendations from this project are implemented. This includes the collaborative processes they already use to develop standards; the roadmap they have drafted for that development process; and the establishment of a national forum of industry collaborators to provide input into proposed changes.

Options for addressing technical issues, such as how to accommodate the additional data generated are not addressed in this report. These issues would need to be considered further once there is greater clarity around the Bureau's requirements.

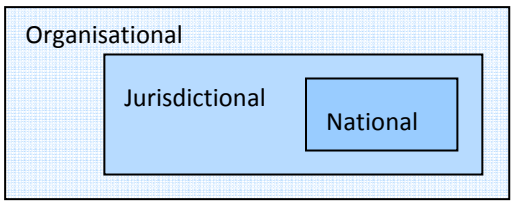
3.1 Core data sets

The Bureau has identified that it will require a minimum set of data and metadata in order to publish water quality information. Items such as the determinand (parameter) measured and the water body sampled are critical to the use of the data. However, beyond these core data elements, the Bureau is expected to require a much broader set of metadata from data providers such as those proposed in the NWQDS.

While the merit of the full complement of core data elements may be recognised by the Bureau, it may decide that it only requires a subset of them. Should this be the case, an attendant recommendation from this project would be that the Bureau continues to promote the benefit of the full set of core data elements to the water industry. This would contribute significantly toward the water industry enjoying the documented benefits.

It may be that different data elements and metadata may be relevant at the national, jurisdictional and organisational level:

- **National** – A required set of metadata elements based on the Bureau's guidelines, and supplied as per requirements in the Water Regulations 2008 (the 'Regulations').
- **Jurisdictional** – National + common metadata elements at the jurisdictional level, chosen from a standard list developed by the water industry in conjunction with the Bureau taking the view that the value of the data is enhanced by the ability to be shared.
- **Organisational** – National + jurisdictional + metadata set developed to meet organisational business or specific project needs.



3.2 Options

Irrespective of the extent to which the recommendations from Report A are accepted, the Bureau will still need to make decisions in relation to two key components of its implementation strategy.

a) Release rate – the rate at which their set of metadata requirements are released.

b) Uptake rate – the rate at which suppliers are required to supply the data sets once requested by the Bureau.

The rate of release is something for which the Bureau is solely responsible, while the uptake or adoption rate will rely on initiatives by both the Bureau and data suppliers. The combination of these two factors will fundamentally affect the length of time it will take the industry to transition from the current situation to a standardised system. They will also impact on key issues such as resources required to implement change, and the time it will take to achieve key benefits such as data interoperability.

3.2.1 Release rate

Currently the Bureau plans to introduce more detailed specification of metadata requirements under proposed amendments to the Regulations. Following a period of testing with data providers it intends to gradually roll out the requirements into a new online document to be called *Metadata requirements.* Once included the metadata will be a mandatory part of the requirements (BoM, 2010).

What isn't yet clear is whether the plan is to introduce one category at a time, or some other sequence. There is a concern that the Bureau will progressively release the metadata requirements over an extended period of time, which would put organisations under pressure to constantly change their systems to meet the new needs. Implementing changes to data management systems in a piecemeal way to cater for changes to new metadata requirements or the Water Data Transfer Format (WDTF) would be inefficient and costly.

The Bureau has commenced developing metadata requirements for Category 1 – Surface water resource information, with plans for each of the other data categories, including Category 9 (water quality information) over the next 12 to 18 months.

The work undertaken for this project to develop water quality metadata protocols pre-empts much of the Bureau's work on the other categories. The opportunity exists for the Bureau to use this to its advantage even though the data requirements for water quality are more complex and extensive than those of other Categories. The lessons learned and the recommendations made around Category 9 metadata can be used to inform the process and requirements for other categories.

If the 'rollout' occurs one category at a time, the issue of having to make multiple changes is less of a concern for water quality data providers as all the relevant metadata are contained in the one area. However, if the plan is to take a more piecemeal approach the costs will be magnified. Clarity around this would give an element of certainty for planning purposes.

3.2.2 Uptake rate

The sooner the entire metadata set is collected and supplied to the Bureau, the sooner the water information reform goals can be achieved. However, the capacity, expertise and drive to invest in this area will vary both within and between jurisdictions. Some will be willing and able to make fundamental changes to enable them to supply the Bureau with the required metadata. For others the preference will be to change their systems and practices as little as possible.

Critical mass will be achieved as more organisations take up the new requirements. The pace at which progress is made toward reaching a tipping point in the industry will be dependent on the resources available and the incentives to invest in change.

Four potential implementation options are described below, with release and uptake strategies varying.

***Option A*: All metadata released at once** by the Bureau **+ All metadata taken up at once** by industry

Pros: Short transition phase, with immediate benefits. It is clear at the outset regarding what is required of data providers.

Cons: Potentially high immediate costs and need for resources; organisations may find it difficult to accommodate timeframes, redirection of resourcing prioritisations and disruptions to operations due to capability and capacity to rapidly change.

***Option B*: All metadata released at once** by the Bureau **+ Staged uptake** by industry

Pros: Investment in change strategically planned; achieve partial benefits in the interim until fully implemented; planned uptake (also a 'con'); it is clear at the outset regarding what is required of data providers.

Cons: Extended transition phase with a prolonged period of time of sub-optimal benefits achieved.

***Option C*: Staged release of metadata requirements** by the Bureau **+ All metadata taken up** by industry **as released**

Pros: More time available for consultation and ensuring requirements are appropriate; achieve partial benefits in the interim until fully implemented; planned uptake (also a 'con').

Cons: Extended transition phase, with partial benefits; potentially more costly and more resources required as constantly needing to amend systems and procedures; possibly multiple versions of data sets; there is a risk of confusion and a lack of stakeholder confidence in the process if changes are continually occurring.

***Option D*: Staged release of metadata requirements** by the Bureau **+ Staged uptake** by industry

Pros: Change occurs in smaller, possibly more manageable steps; opportunity to plan investment particularly if aware of the timing staged releases.

Cons: Extensive transition phase, with incremental benefits; potentially more costly and resources required as constantly needing to amend systems and procedures; potentially multiple versions of data sets; there is a risk of confusion and a lack of stakeholder confidence in the process if changes are continually occurring.

The preferred option would be the one that can deliver a balance between factors such as transition time, cost to industry and benefits to data users. Determining which option will provide optimal outcomes will require a detailed cost-benefit analysis once the extent of required changes is identified.

At this preliminary stage, the potential impacts on key issues under the different options have been estimated (Table 2) and are presented visually as a means to identify a preferred strategy.

Table 2 Summary of the implementation options showing the expected impacts on key issues from different strategies

			Key Issues					
	Strategies		Implementation		Data integrity			
Options	Release rate	Uptake rate	Transition phase	Cost to industry	Ability to collate data for reporting	Quality	Interoperability	Ability to assess if fit for purpose
A	Data set released all at once	As released						
B		Staged						
C	Data set released in stages	As released						
D		Staged						

Expected impacts

Least preferred ◄——————————► **Most preferred**

3.3 Transition period

The transition period refers to the time it takes to achieve the goal where all new data being provided to the Bureau have the level of integrity users need i.e. the point where users can assess the comparability, quality, and fitness-for-purpose of the data.

A lengthy transition phase may relieve the pressure on suppliers to make changes required, however, it will extend the period over which, at the national level, water quality data are incomparable and collectively have limited data integrity. The problems currently experienced regarding inconsistencies with historical data will persist, and therefore will continue to compromise the confidence users will have in the aggregated data.

In the interests of future demands for comprehensive and quality data, the transition phase should be minimised as much as practicable. Setting a short timeframe for uptake provides a new imperative to the industry, and will lend support to those putting forward a business case in their organisation or jurisdiction for the adoption of the new metadata requirements.

4 Facilitating change

Under current arrangements the Bureau states that 'if an organisation does not have the specified data in its possession, custody or control, it does not need to provide it' (BoM, 2010). Results of the benchmarking survey undertaken for this project showed that all participating organisations collected water quality metadata, however the extent and format varied, with no organisation currently collecting all of the metadata proposed in this project.

If the adoption of the proposed changes is voluntary, the time taken for at least a significant portion of industry to change may be prolonged. Even though the benefits are known, and change is supported in principle, the imperative for implementing them could be overshadowed by other pressing needs or interests competing for limited internal resources.

There are a number of different approaches which the Bureau could use to facilitate a faster rate of uptake by industry. These approaches can be tailored to suit individual objectives and available resources. Each is discussed below.

4.1 Staged uptake

A staged approach to uptake of the new requirements is one whereby each year a number of 'self-nominated' organisations in various jurisdictions implement the full set of metadata. This would continue until all named persons conform to the guidelines. Organisations can time these activities to coincide with circumstances which best suit local investment schedules and business needs.

There are a number of organisations who are currently planning to redesign their data management systems, and have already expressed an interest in using the proposed NWQDS as a model. These organisations would be the 'early adopters' who could contribute to the process of 'socialising' the new standards by demonstrating the resultant business benefits and associated incentives of sharing a common management system architecture.

4.2 'Road testing' changes

A second approach is to develop strategies and systems to 'road test' the changes at a jurisdictional level with the support of the Bureau. An example of this approach is where the Bureau supported the NSW Office of Water (NOW) with reforms surrounding water monitoring and water information reporting by NSW agencies.

NOW had been involved with the M&E project 3QLD1.3 and planned to implement the recommended IMP. However, they found that existing data management products had limited capability to accommodate the full suite of water quality metadata. This required NOW to work with data management software company Kisters (see www.kisters.com.au/english/html/au/homepage.html) which resulted in the development of a product to meet their needs. This product is now also commercially available to other organisations.

The Bureau could play an important role in initiating and coordinating discussions with industry to (re)design and develop generic options to suit the new national data requirements that could be utilised across the sector. The resulting costs could then be spread across organisations.

4.3 Which end of the elephant to eat first?

Another option would be to invest in specific changes within the data 'supply chain'. Data held by the Bureau are at the end point of a supply chain which starts with the capturing of data in the field, and progresses onward through various channels and processes. The introduction of the requirement to include water quality metadata elements will impact on all points along this supply chain.

One issue raised at an industry forum run by GHD (2010) was about which part(s) of the data supply chain to focus on first. Opinions were divided: around one third of the representatives indicated that the priority focus should be on data collection/generation 'as all else stems from this'; 22% stated that the primary effort should concentrate on data management and; 21% preferred data transfer. The remainder nominated 'information products' or 'other' areas for the initial focus. However, all parts of the supply chain need to be considered together rather than individual parts considered in isolation.

Participants at the national water quality metadata workshop identified four critical links within the data supply chain which they regarded as strategically significant and in need of priority investment (Figure 1). These links were:

- organisational arrangements and capacity
- data collection
- storage and verification
- WDTF quality coding.

The cost of implementing changes in the first three points resides predominately within local and jurisdictional organisations. The application of some form of 'program logic' may assist in setting priorities and strategies for the extensive amount of change required throughout the data supply chain.

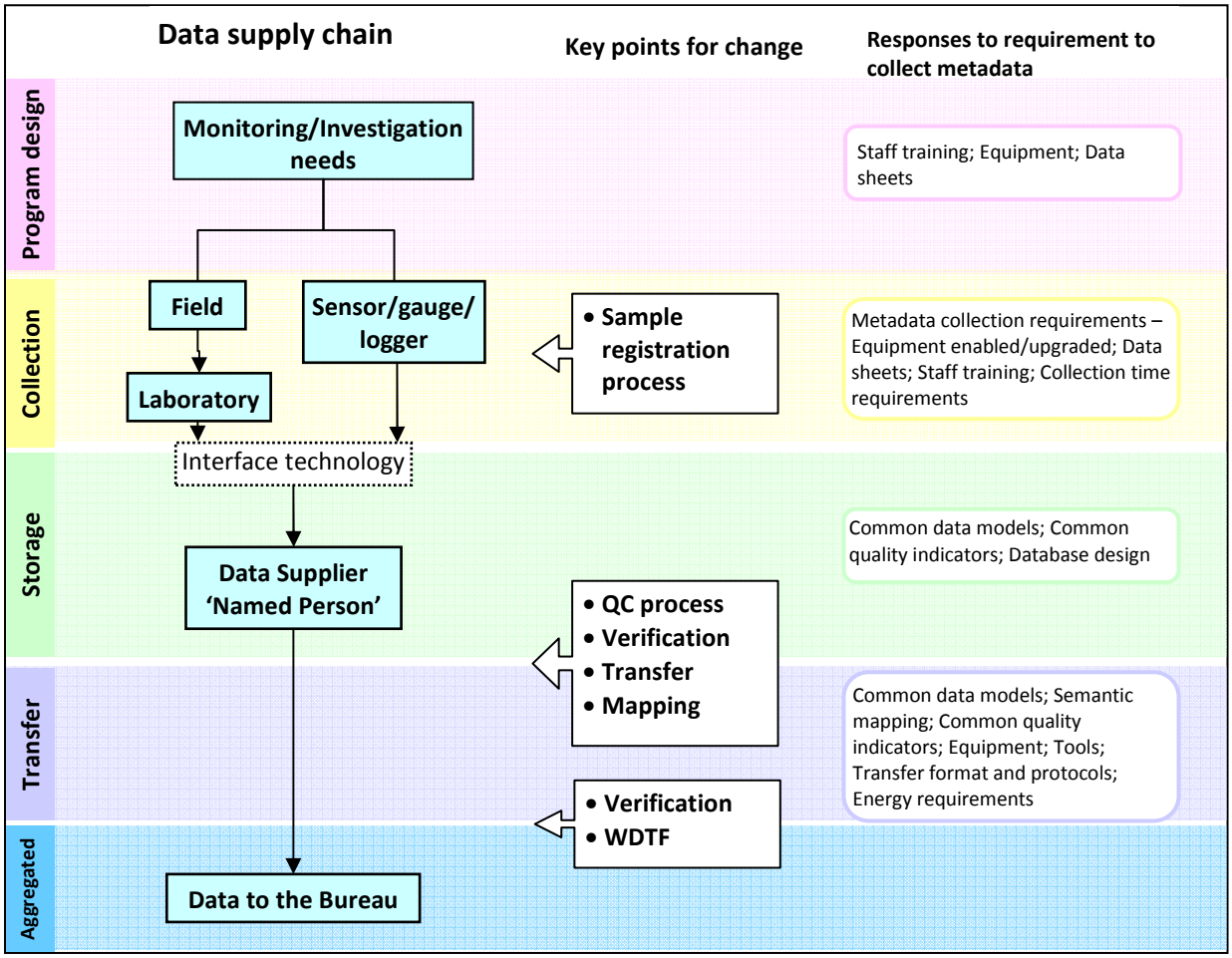


Figure 1 Data supply chain

4.4 Enabling changes

4.4.1 Capacity

A range of different business models exist within the water information sector, reflected in the variety of databases and systems currently in use. This includes both proprietary and customised systems, as well as supplementary systems that have been developed in-house. Many organisations may not have the structure and functionality in their WQ databases that can capture, and subsequently transfer, the additional water quality metadata to the Bureau.

The limited capacity of some organisations, particularly the smaller ones, to change their databases to accept additional metadata will be an obstacle to adopting the proposed NWQDS. Rather than requiring organisations to change their internal data management systems, an alternative approach is to offer them the opportunity and support to map their data structures to a national data model.

An additional consideration proposed during the industry consultation for this project was for laboratories to send both the results of the water quality sample data and the laboratory analysis methodology metadata to the Bureau. This would require the inclusion of a check box on the sample submission form where the authority lodging the sample gives permission for the laboratory to send the results directly to the Bureau. Implementing changes within the laboratories may be a less onerous option than modifying the data mangement systems of data suppliers. There are fewer laboratories involved with generating water quality data than there are organisations supplying the data to the Bureau. While this option would attract an additional cost for data suppliers, the outcome to achieve greater consistency of metadata codes is worthy of further attention.

4.4.2 Multiple data sources

Laboratories play a significant role in the data supply chain with the capacity of their information management systems to capture and communicate metadata being critical. The benchmarking survey undertaken for this project showed that using more than one laboratory for water quality data was the norm for most of the data suppliers. These could be in-house, commercial or university facilities, and could be chosen for particular analytical tasks for reasons such as facility location or accessibility, project arrangements (such as partnerships or collaborations), facility specialisation, reputation or accreditation. For a full list of the laboratories used by survey respondents see Report C, section 3.2.1.

Based on the survey there are at least 26 laboratories playing a significant role in the supply of data to the Bureau. They will be affected by changes in metadata requirements, and the Bureau will need to invest effort to include these facilities in its implementation management plans.

4.5 Resourcing change

Investment in water quality monitoring has historically taken a back seat to monitoring water quantity, where more effort has been focused on collecting data to support priority functions of water resource planning, allocation and management. Data suppliers will be looking to the Bureau for assistance in developing and implementing changes in the way they manage data. If viable, a new funding program similar to the existing M&E model, which was well received by stakeholders, could be introduced. This could enable software vendors to modify existing products to comply with the new protocols.

However, the likelihood of adequate external funding being made available is not a surety, and therefore other means of support will need to be sourced to enable successful implementation. For those data suppliers with limited capabilities to modify their systems, providing access to the necessary expertise is likely to be welcomed.

4.5.1 Capability

A range of initiatives was suggested by stakeholders to facilitate maximum and ongoing adoption of standards (GHD, 2010, p. vi):

- Support network – provision of a list of data management companies which could assist organisations with the upgrade/modification of their systems, similar to the network established by the Bureau to assist with the implementation of WDTF.
- Provide access to tools (e.g. metadata entry tools) to make transition and compliance as 'low-effort' as possible.
- Training in the use of guidelines or standards, and associated tools – initiatives previously in place (e.g. for the National WaterWatch community waterway monitoring network) or already employed under the current M&E program provide appropriate examples of training (e.g. road shows, technical workshops).

5 Challenges

There is any number of challenges and obstacles for organisations to change their existing data management systems to accommodate additional water quality attributes and metadata. Data suppliers who support the idea of providing the recommended water quality metadata have a number concerns over implementation such as their capacity to collect, store and transmit the additional data. These will need to be addressed in order for these organisations to supply the Bureau with the additional data requirements.

The priority issues to be addressed will include those that enable the industry to adopt the changes needed. This includes addressing problems encountered by some of the biggest stakeholders (e.g. lead agencies being assisted to develop or modify data collection protocols and work practices) which could result in a 'ripple' effect where solutions are shared with smaller organisations such as councils and natural resource management (NRM) groups.

There is an understanding that data accompanied by appropriate metadata will be of greater value than those data without, and therefore more likely to be used. Providing evidence that this is the case may be sufficient to persuade some data suppliers to adopt the necessary changes rather than potentially having their data disregarded.

5.1 Historical data

Historical data, especially from the more distant past, is the information which is perhaps of most value to those studying current water quality trends, patterns and changes. A considerable amount of historical data is held in different systems and formats (including paper records) that are not easily accessible, and have metadata that are inconsistent, inadequate, or non-existent. Data managers hold concerns over what will happen with the data they provide that do not have any, or all, required metadata, particularly if they are unable to rectify this situation in the near future.

The Bureau will need to allay concerns that historical data will be discarded because it does not have this additional information. Differential classifications could be introduced to reflect data with all, some or no metadata. One such classification is the modification to WDTF quality codes recommended in Report A – Water Quality Metadata Guidelines.

5.2 Multitude of systems/formats need changing

A certain level of expectation was held by some people during the engagement process that only one water data management system (Hydstra) needed to be modified, and hence only one provider (Kisters) needed to be consulted to enable metadata storage and management changes. However, there are a variety of data management systems, structures and formats that are currently being used for water quality data across Australia. Within many organisations, including most lead agencies, water quality data are managed using multiple packages, products and systems.

Of those surveyed recently, Kisters products (Hydstra and KiWQM), along with Microsoft products (Excel spreadsheets and Access databases) are commonly used (see Figure 2). The uniDap product WaterQ is used by regional natural resource management groups in Queensland and by some organisations in NSW, SA, WA and Tasmania. A range of other systems are reportedly also in use (such as Oracle, TimeStudio, Triton, and WIN).

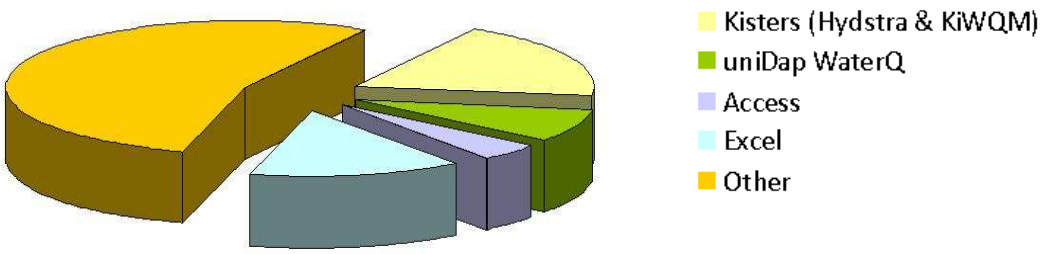


Figure 2 Summary of the most common systems used by organisations to manage water quality data (mostly lead water agencies) that participated in the Water Quality Metadata and Standards Survey (December 2010, Question 2.1)

Multiple systems are in use within individual organisations for continuous and non-continuous surface water data, and for continuous and non-continuous ground water data. This situation is the legacy of project and resource allocation decisions, organisational changes, restructuring and/or merger decisions; or because certain systems are better suited for particular functions such as interfacing with data sources. For example, in South East Queensland, Seqwater have annexed the water supply components of many local councils and subsequently inherited many of the councils' data sets. These are in various formats, the majority being in Microsoft Excel spreadsheets or paper files. This has caused considerable effort in incorporating these data sets into the Seqwater database.

As a result, the task of modifying or replacing systems to accommodate new metadata requirements will be more complex and costly than if there were just a few systems and/or providers. An impact analysis study would be needed in the first instance, to determine the potential effects the introduction of additional data fields will have on systems. Any changes are likely to affect database data structures, data migration and transfer, reports, input screens, system interfaces and instrument interfaces (e.g. ability of equipment such as those in laboratories to collect, store, or transmit the required data).

5.3 Data transfer

As well as multiple data systems, water quality data are currently transferred in a range of formats including XML, CSV, HyBoMexp, CSC, ASCII, and WDTF. The results of the project's benchmarking survey show that even within each organisation, particularly lead agencies, a number of different formats may be in use.

WDTF is yet to be developed for transferring water quality metadata. In the interim, the Bureau will receive data in multiple formats. The national water quality metadata workshop identified problems not only concerning the development of WDTF for water quality, but also those related to transferring data to the Bureau in general. This is one of the priority issues that would need to be addressed that is integral to the successful implementation of national metadata requirements (see Table 3).

Table 3 Data transfer issues identified at the national Water Quality Metadata Workshop (Brisbane 2011)

Data transfer issues	WDTF issue	General issues
Problems converting data to and from XML/WDTF format	•	
Compatibility issues		•
Can all this information be contained in the format?		•
Is WDTF flexible enough?	•	
Changes to format = cost for agency to implement		•
Hard to extract as time series		
Mandatory fields – what if you don't have them?		•
Staff – smaller agencies lack the manpower	•	•
Mapping of jurisdictional databases to the Bureau database – duplicate data sent	•	•
Corrupt files	•	•
XML files require huge processor power – greenhouse gas effect; hardware attrition; lengthy processing times; greater operating costs		•
Changed/deleted file/result at agency – what happens at the Bureau end?		•
Gateway busy at the Bureau's end		•
Security of data over Internet		•
Confirmation of receipt of data + verification		•
Misinterpretation of data at the Bureau's end (no local knowledge)		•
No process for additional codes	•	•
WDTF helpdesk	•	
Some agencies dependant on 3rd parties for data management → if 3rd party company goes defunct…		•
Intermediate layer and tools: Agency → Warehouse → (Bureau tool)→ WDTF (tracking?)		•
Test export tool	•	•

6 Final observations and recommendations

6.1 Ongoing stakeholder engagement

Whether standards should be mandatory, or offered as guidelines 'depends to a large extent on the level of buy in and adoption of at least the major data collection agencies in the water sector' (GHD, 2010). To date, there appears to be a high level of goodwill and support for M&E initiatives around water information. This has also been reflected in the strength of participation from jurisdictions to this water quality metadata project. One of the primary reasons for this could be due to the level of genuine engagement and consultation the Bureau has had with the industry.

It is important that these good relationships be maintained, particularly as the implementation phase may be more difficult and potentially fragmented than in previous phases.

The Bureau will also have an important role in engaging with commercial stakeholders on behalf of many data suppliers, especially the smaller organisations, to develop off-the-shelf solutions that support the new metadata requirements. Keeping these organisations (e.g. Kisters and uniDap; and laboratories) informed of what changes are imminent will also help them to proactively respond to the needs of their clients.

6.2 Implementation 'roadmap'

To implement the proposed changes required to achieve a standardised and sustained approach for water quality metadata, a number of steps are likely to be required by the Bureau. These steps include developing and drafting of ideas, ongoing stakeholder engagement, and implementation through to maintenance of the system. Potential steps are shown in Figure 3 which includes the progress on steps already undertaken.

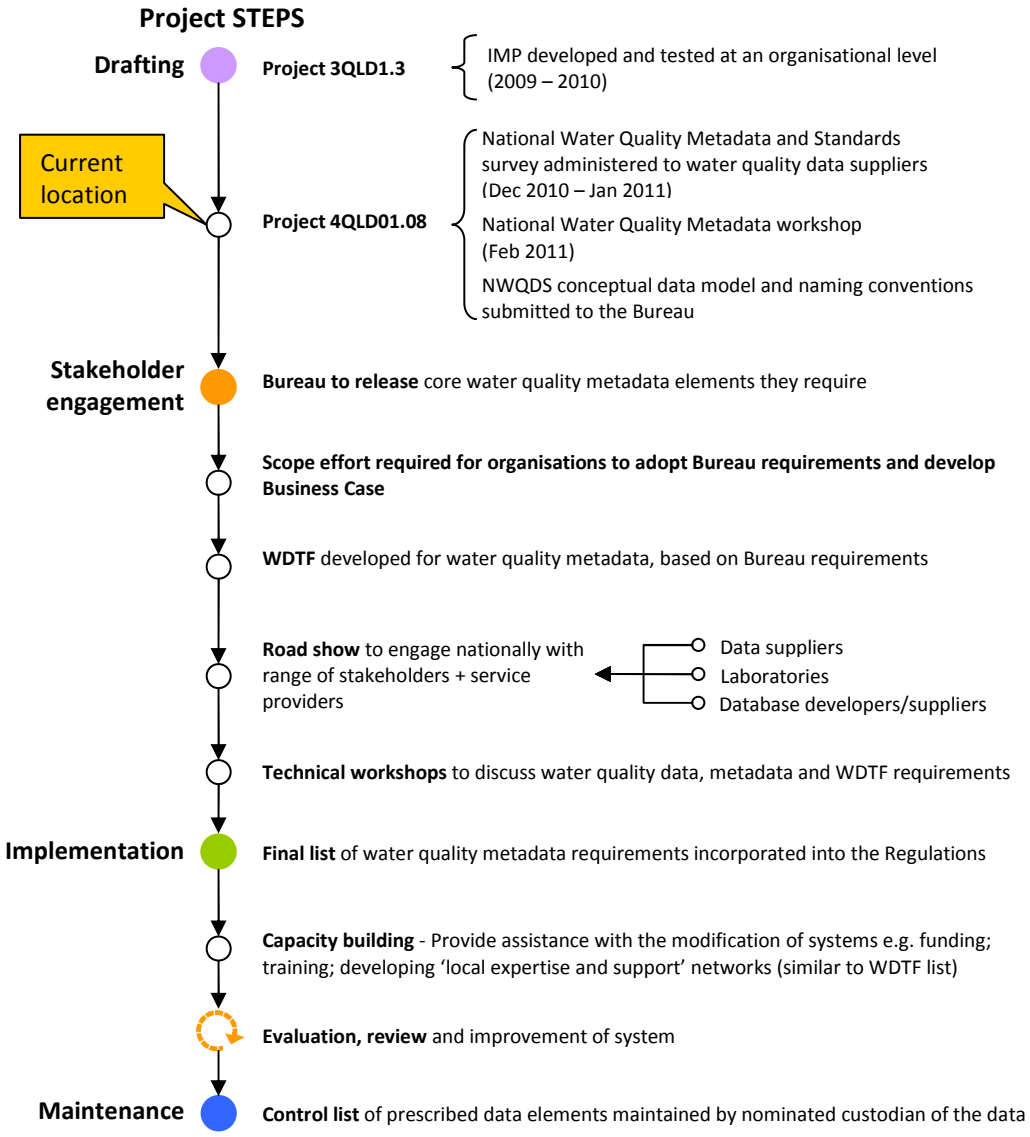


Figure 3 Implementation 'roadmap' for developing a standardised approach to water quality metadata

7 References

Bureau of Meteorology (2010), *Water information bulletin*, issue 7, Australian Government, Canberra, retrieved 17 May 2011, <www.bom.gov.au/water/about/publications/document/Water_Information_Bulletin_Issue_7_December_2010.pdf>

GHD (2010), *National water information standards development – an industry needs analysis*, final report for the Bureau of Meteorology, by GHD Pty Ltd, Sydney, September 2010, retrieved 5 April 2011, <http://www.bom.gov.au/water/standards/documents/nwis-final_report.pdf>

Appendix A List of Stakeholders Engaged

Jurisdiction	Organisation	Name and Position	Preliminary briefings	Survey	Workshop	Ongoing Feedback
C'wlth	Bureau of Meteorology (BoM)	Brendan Moran Manager, Standards & Regulations	X		X	X
		Malcolm Watson Supervising Hydrologist, Water Quality & Trends Unit			X	
		Linton Johnston Water Standards and Policy	X			
ACT	Department of Environment	Stewart Chapman SWIC ACT	X			X
NSW	NSW Office of Water (NOW)	David Malone SWIC NSW	X			X
		Grant Robinson Information Quality Coordinator	X	X	X	X
	Sydney Catchment Authority	Ramen Charan Senior Manager, Water Monitoring				X
	Sydney Water	Shafiqul Hassan Technical Specialist		X	X	
NT	Department of Environment & Resource Management	Julia Fortune SWIC NT	X			X
Qld	Department of Environment & Resource Management (DERM)	Donna Beattie SWIC Qld	X			X
		Ian White Principal Policy Officer	X	X		
		Ralph De Voil A/Project Officer			X	
		Ken Aitken Team Leader (Water Reporting), Water Accounting	X			
	Brisbane City Council	Charlotte Beresford Water Planning	X			
	Fitzroy Basin Association	Luke Ukkola Healthy Waterways Field Officer		X	X	
	Qld Health Forensic & Scientific Services (QHFSS)	Gary Prove Supervising Technical Officer			X	
	Qld Murray Darling Committee (QMDC)	Paul Webb Program Leader, Water & Wetlands	X	X	X	X
	qldwater	Regina Souter SWIM Program Manager			X	
		Rob Fearon Executive Director	X			
	Redland City Council	Katrina Udell Adviser, Waterways Management		X		
	SEQ Catchments	Joadie Hardy Water Quality Monitoring Manager	X	X	X	

Jurisdiction	Organisation	Name and Position	Preliminary briefings	Survey	Workshop	Ongoing Feedback
		Nathan Parker Water Quality Monitoring Officer			X	
	Seqwater	Ben Reynolds Environmental Systems Coordinator		X	X	
	SunWater Ltd	Petrina Douglas Water Accounting Manager	X	X		
	uniDap Solutions	Gavin Sigley Strategic Director & CEO	X		X	X
SA	Department for Water	John Barrett SWIC SA	X			X
		Simon Sherriff Manager, Surface Water Monitoring	X			
	Northern & Yorke NRM Board	Jennifer Munro NRM Water Officer	X	X		X
	SA EPA	Shaun Thomas Senior Scientific Officer (Water Quality)	X	X	X	
	SA Water	Damien Venema Water Information Coordinator	X	X		X
		Phil Thomas Laboratory Manager	X			
Tas	Department of Primary Industries, Parks, Water & Environment (DPIPWE)	David Thorp SWIC Tasmania	X		X	X
		Marty Jack Data Administrator	X	X	X	
	Ben Lomond Water	Peter Januba Data Manager	X			
	Cradle Mountain Water	Wouter vanderMerwe Data Manager	X			
	DPIPWE-EPA	Barry Windridge Data Management Specialist			X	X
		Celia Mackie Data Analyst	X	X		X
	Hydro Tasmania	Carolyn Maxwell Aquatic Scientist	X		X	X
		Ray Clark Technical Officer	X		X	
		Wayne Soutter Hydrographic Data Coordinator	X	X		
	NRM North	Toni Furlonge Monitoring and Improvement		X		

Jurisdiction	Organisation	Name and Position	Preliminary briefings	Survey	Workshop	Ongoing Feedback
	Southern Water	Donna Hollis Information Systems Administrator	X	X	X	
		Mark Abela Information Systems	X			
Vic	Department of Sustainability & Environment (DSE)	John Cameron SWIC Vic	X			X
		Brett Miller Manager, Water Information, IT	X		X	
		Sabine Schreiber Manager, Water Resource Monitoring	X	X	X	X
	Goulburn-Murray Water	Greg Smith Manager, Water Systems Health		X		
	Goulburn Valley Water	Jaclyn Bell Technical Administration Officer		X		
	Melbourne Water	Nick Crosbie Senior Risk Planner		X		
		Noel Miles Technical Specialist, Drinking Water Quality		X	X	X
		Graham Rooney Team Leader, Biodiversity & Information Systems		X		
WA	Aqwest – Bunbury Water Board	Mat Watson Coordinator, Water Treatment		X		
	Department of Agriculture & Food (DAF)	David Weaver Senior Research Officer/Project Manager		X		
		Paul Raper Hydrologist		X		
		Ben Cohen Senior Technical Officer	X			
	Department of Environment & Conservation (DEC)	Margaret Smith Hydrogeologist			X	X
		Ryan Vogwill Supervising Hydrologist/Hydrogeologist		X		
		Darren Farmer Senior Hydrologist		X		
	Department of Water (DOW)	Pauline Farrell SWIC WA	X			X

Jurisdiction	Organisation	Name and Position	Preliminary briefings	Survey	Workshop	Ongoing Feedback
		John Argus Team Leader, Water Information Provision		X	X	X
		John Patten Team Leader, Water Information Management	X			X
		Steve Fisher Team Leader, Estuarine Science			X	
	Water Corporation	Brad Fuller Asset Systems Analyst		X	X	X