Strategic Water Information and Monitoring Plan, Queensland

Prepared by the Department of Environment and Resource Management

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Acknowledgements

The Department of Environment and Resource Management thanks all the water information and water monitoring organisations in Queensland who have contributed to the development of the Queensland Strategic Water Information and Monitoring Plan (SWIMP).

A core group of DERM staff have been integral to the development of the SWIMP through provision of their knowledge and expertise in the different water information and monitoring activities, or through knowledge of policy and planning requirements.

An interagency working group of the key water monitoring stakeholders has been established in Queensland to progress issues relating to the reporting of data to the Bureau of Meteorology under the *Water Regulations 2008*. This group has provided valuable input to the identification and prioritisation of gaps. Their contribution and support has ensured that this plan presents the key gaps and issues relevant to the various types of monitoring organisations in the state. This working group is made up of representatives from the following organisations representing the interests of the majority of named persons in Queensland.

- Bureau of Meteorology (Queensland Office)
- Department of Environment and Resource Management
- Natural Resource Management bodies
- Queensland Bulk Water Supply Authority
- Queensland Water Commission
- Queensland Water Directorate (representing many water service providers)
- SunWater Limited

Foreword

The issue

In recent years water has become a pressing public policy issue for Australian society. As water demand increases and supply dwindles the strain on existing water supplies has reached new heights. Protracted drought and mounting evidence of climate change have added momentum behind a growing community and political will to see improvements in both our understanding of water resources and the way we manage them.

The challenge

Better management of water poses a national challenge, requiring a coordinated response. Our ability as a community to reach agreement on the tough issues relies on access to accurate, reliable water information that is freely available and of the highest standards. Key to making these decisions and arriving at sound policy is a definitive water data source that stands above reproach.

Australian Government response

Aligned with this need, the Australian Government assigned the Bureau of Meteorology (the Bureau) responsibilities under the *Water Act 2007* to compile and deliver comprehensive water information for the country. As part of the Australian Government's long term framework for water security, Water for the Future, $450 million was allocated to the Bureau over 10 years to deliver the Improving Water Information Program. This program includes development and maintenance of an integrated, national water information system which will be freely accessible to the public. Details of the full suite of Bureau objectives and deliverables can be found at www.bom.gov.au/water.

A partnership model…

Vital to the success of the Bureau's mission is the partnership and cooperation of all State and Territory Governments and all water data collecting organisations in each jurisdiction. One of the vehicles for effective collaboration is the Jurisdictional Reference Group for Water Information (JRGWI), established to provide regular input to the Bureau's activities, and bringing to the table the experience and wisdom of respected senior officials from across the water sector.

…and putting it into practice

The Modernisation and Extension of Hydrologic Monitoring Systems Program (the M&E Program) is an $80 million fund administered by the Bureau and available to organisations named under the Water Regulations. The M&E Program is aimed at improving technologies employed by those who collect water information, and enabling better approaches to data transfer and standardisation. Coordination activities are also supported through the M&E Program via funding for Strategic Water Information Coordinators (SWICs) in each State and Territory. SWICs have been tasked with bringing together key stakeholders in their jurisdiction to distil State/Territory priorities in water data collection, and to set these out in a series of Strategic Water Information and Monitoring Plans (SWIMPs).

Strategic

The SWIMPs provide a framework for describing where we are going and

plans… how we will get there. Each SWIMP has been produced with a whole of jurisdiction focus to encapsulate the current state of play in water information and monitoring, describe the gaps, issues and opportunities that exist, and articulate a series of priorities, strategies and actions that will bring us closer to the end vision of better water information for all.

…and how they contribute to the solution Through the M&E Program the Bureau is able to assist the States and Territories to get closer to our agreed view of what constitutes a fit-for-purpose hydrologic observing system in each jurisdiction. The Bureau looks to the SWIMPs to provide guidance on how best to invest M&E Program funds to achieve this goal. In this regard, the SWIMPs are a vital product.

In closing, the Bureau and the Department of Environment and Resource Management appreciate the energy and expertise that has been applied in the preparation of this SWIMP, and thank all of the officers that have participated in its development and review.

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Deputy Director (Climate and Water)
Bureau of Meteorology

July 2011

Ms Debbie Best
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July 2011

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Executive Summary

The Bureau of Meteorology (the Bureau) has sponsored the development of jurisdictional strategic water information and monitoring plans (SWIMPs) to describe current water monitoring and information activities in each jurisdiction and to identify and prioritise issues and gaps with those activities. These plans will assist the Bureau with investment through their Modernisation and Extension of Hydrologic Monitoring Systems Program (M&E Program).

The key water monitoring stakeholders in Queensland are the Department of Environment and Resource Management (DERM), SunWater Limited (SunWater), Queensland Bulk Water Supply Authority (Seqwater), local government and Natural Resource Management (NRM) bodies.

The fundamental drivers for water information and monitoring in Queensland can be grouped into four categories: assessment of water resources, assessment of water use, assessment of condition and trend and management and planning.

Water monitoring networks

There are over 5900 open sub-artesian monitoring bores in Queensland, of which 95 percent are maintained and monitored by DERM. The majority of the groundwater level networks are monitored quarterly, although in some areas with high levels of water demand and where enhanced management is required monitoring occurs monthly. Monitoring of water quality across organisations is infrequent; however, in areas where groundwater quality is a priority issue, such as saltwater intrusion in coastal aquifers, groundwater samples are taken on a bi-annual basis. More than 200 bores are equipped with automatic recorders monitoring water levels on a continuous basis.

There are over 900 sites measuring surface water level and flow belonging to those organisations reporting data to the Bureau under the federal *Water Regulations 2008*. Around 44 percent of these sites are managed by DERM. Monitoring sites exist for a range of purposes, such as assessment, management, storage monitoring, flood warning and water quality monitoring. Of the sites noted above 90 percent have telemetry systems in place. Recent events have emphasized the importance of timely and accurate water monitoring information.

The monitoring of major water storages in Queensland is primarily undertaken by SunWater, Seqwater, water boards, local government and other registered water service providers.

The flood warning network comprises more than 2000 stations which provide observations of rainfall or water level, or both rainfall and water level. Approximately 1500 stations provide rainfall data and 1200 stations provide water level data. The flood warning network integrates rainfall and water level data from stations owned and operated by the Bureau, DERM, SunWater, Seqwater and local government agencies.

Water quality parameters are monitored by a range of organisations including DERM, SunWater, Seqwater, local government and NRM regional bodies. Data collected supports a number of purposes, such as: water resource planning, modelling, condition and trend monitoring, resource operation plan compliance, ecological monitoring and the activities of regional NRM bodies.

Water accounting

DERM has approached the development of water accounting with a view to integrating it with existing reporting requirements. It is envisaged that it will enhance some aspects of current reporting such as the annual report for water resource plans (WRPs). Since 2006-07 Queensland has produced an annual water account for the Pioneer WRP area and water accounts have been produced for the Gold Coast, Logan and Moreton WRP areas since 2009-10. The water accounts for these four WRP areas appear in the annual report for WRPs. Data and information for the Gold Coast, Logan and Moreton WRP areas is forwarded to the Bureau as part of DERM's participation in the National Water Account.

Other stakeholders who maintain water accounting databases include the Queensland Water Commission (QWC) and the Queensland Water Directorate (*qldwater*).

Data management

Data management frameworks vary across and within monitoring organisations in Queensland. The majority of groundwater data is stored within the DERM groundwater database. Some councils store groundwater data in local data management systems, usually in Excel spreadsheets. The majority of surface water level and flow data and water quality data is collected and stored within the data management systems of DERM, Seqwater and SunWater; council data is stored in a number of differently-formatted Excel spreadsheets; NRM regional bodies now use the same product to store their data.

Water monitoring and data management gaps

Most water monitoring agencies in the state have identified similar gaps and issues such as spatial gaps in networks; the need for new or upgraded technology; the need to align sites to Australian Height Datum; a lack of appropriately skilled staff and insufficient resources.

In all sectors there is concern over a lack of standardisation of monitoring techniques and data management processes. There is a need for more collaboration between organisations undertaking similar monitoring to ensure that data is of a comparable standard. The key data management issue in Queensland at present centres on how to best manage the variety of collection and analysis methods in place, and the many data storage formats used, so as to optimise comparison of the different datasets.

A lack of good quality metadata attached to monitoring information is hampering the ability to determine the quality of the data itself.

A coordinated training and accreditation framework would assist in enhancing standardisation and uptake of any new processes developed for quality coding and metadata capture.

Further gaps relate to the need to better coordinate and format data stored by local councils and NRM bodies and the need to develop or enhance systems managing water accounting data.

Impact of M&E Program funding

Queensland organisations have received over $14 million in funding through the Bureau's M&E Program to date. This investment, discussed in detail in Section C, has enabled many

organisations to fully or partially close monitoring and data management gaps for their organisation, thereby improving the quantity, quality and format of data being delivered under the federal Water Regulations.

The key achievements from this investment include:

- New or enhanced data management systems for DERM, SunWater, Seqwater, almost all other named water service providers and all the named NRM regional bodies – for a total investment of over $4.9 million (35 percent of all funding received in Queensland).
- Installation of new monitoring sites and the upgrading of monitoring technology for key water monitoring stakeholders – for a total investment of over $2.9 million (21 percent of all funding received in Queensland).
- Funding of over $600,000 for strategic coordination has enabled improved communication between the Bureau and Queensland named persons as well as improved understanding and communication between named persons on water monitoring and information issues.

Recommendations

Appropriate data management and standardised approaches to data collection, storage, analysis and reporting are seen as critical issues for state and federal agencies as well as for most water information and monitoring organisations. Queensland organisations support the development of national standards or standardised coding of data, whichever is more appropriate. They also support more streamlined and integrated reporting frameworks for the reporting of data from state organisations to state and federal government agencies.

Recommendations to enhance standards and metadata include the development of standards for the use of new technologies, the development of rating curves and the digitisation of valuable historical data and metadata. Closely linked to the need for standardisation or standardised coding of data is the need to streamline reporting requirements and standardise terminology for similar water information from organisations within the state to state and federal government agencies.

The enhancement of data management systems is a priority for the state as the quality and availability of data are reliant on good data management processes. Subsequently a custodian framework is required for all DERM datasets, as key whole-of-government initiatives require a robust implementation of custodianship to ensure that roles and responsibilities are clearly understood and applied.

Recommendations to enhance monitoring networks and address modelling gaps include a range of activities such as expansion of the surface water monitoring networks in the Queensland Murray-Daring Basin, capture of high/medium flow ratings at certain gauging stations to get accurate discharge figures, bathymetric surveys of storages, expansion of the state ambient water quality monitoring network and enhancement of the state flood warning networks, where required.

Recommendations to address training and resources gaps include support for skills training for those smaller organisations in the state adopting data management systems to manage and deliver their data to the Bureau in the required format. It is also recommended that the Bureau lead the development of expert panel groups to encourage the development of

national standards through collaboration with all jurisdictions; opportunities for inter-jurisdictional collaboration on work practices have been limited to date and would significantly improve if facilitated by the Bureau.

1 Introduction

The Bureau of Meteorology (the Bureau) has sponsored the development of jurisdictional strategic water information and monitoring plans (SWIMPs) to describe current water monitoring activities in each jurisdiction and to identify and prioritise issues and gaps with those activities. The monitoring activities in scope for these plans are those that collect data required to be reported to the Bureau under the federal *Water Regulations 2008* (the Water Regulations). The focus is on freshwater data only.

This data includes the following:

- Category 1 - surface water level or flows
- Category 2 - groundwater levels or pressure
- Category 3 – water storage monitoring data
- Category 4 – rainfall and other meteorological monitoring parameters
- Category 5 – rural water use data
- Category 6 – data relating to the right to take, allocation and trading of water
- Category 7 – urban water management data
- Category 8 – water restriction notices
- Category 9 – certain physical chemical water quality parameters

Other water monitoring activities such as those undertaken to determine aquatic ecosystem health are not covered by this plan. The Department of Environment and Resource Management (DERM) is developing a version of the SWIMP that will include the aquatic ecosystem monitoring activities of the department.

These plans will assist the Bureau to make Modernisation and Extension of Hydrologic Monitoring Systems Program (M&E Program) investment decisions. The Queensland SWIMP is also a valuable document that informs state water monitoring management.

The Queensland SWIMP begins with an introduction to the characteristics that impact on water data collection and management and some background information on the key water information and monitoring sectors. The SWIMP is a snapshot of the situation in Queensland as at June 2011.

Section A briefly outlines the drivers for collecting water information – assessment and planning, legislation, policy and organisational drivers. These drivers determine the focus of water information and monitoring activities for individual organisations, resulting in activities that are ‘fit for purpose’. Appendix 1 presents more detail on legislative and policy drivers.

Section B describes the current monitoring of those organisations named in the Water Regulations to provide data to the Bureau. (These organisations are referred to in this plan as ‘named persons’). This section is sub-divided by activity type, such as groundwater monitoring or data management. This structure is maintained in Section C which highlights the gaps and issues faced by various organisations performing these activities. These gaps are subject to change over time as some gaps are addressed

and new ones emerge. The extent to which gaps have been addressed through Rounds 1-4 of the M&E Program are discussed at some length in Section C and in Appendix 4.

Section D outlines strategies for addressing some of the key gaps identified in Section C. This section also presents the methodology used to further prioritise these gaps. Gaps are arranged into groups according to the type of gap or issue they are – such as spatial gaps or data management gaps. These groupings of gaps are themselves ranked into three categories of priority. The prioritisation of issues and gaps is a complex process and every attempt has been made to obtain a balance between identifying issues for particular organisations and prioritising them from a whole-of-state perspective.

DERM monitoring, science, planning and regional staff have provided significant input to the SWIMP and their expertise has been critical to identifying and prioritising gaps and issues from a state perspective.

An interagency working group of key stakeholders exists to discuss issues relating to data reporting to the Bureau under the Water Regulations. DERM is grateful to this group for the ongoing and significant contribution made to the development of the SWIMP including the identification and prioritisation of gaps and issues. DERM would also like to thank the other individual organisations who have contributed to the development of the SWIMP either through identifying gaps and issues or by providing feedback on the direction of the SWIMP. This contribution has been integral to highlighting gaps across as many organisations as possible, thereby providing a more comprehensive view of Queensland issues.

The Australian Government, through the Bureau, is investing $80 million to assist those organisations named in the federal Water Regulations to improve the currency, quality and coverage of data being delivered to the Bureau. The M&E Program is being delivered over five years and is currently assessing project applications submitted under the fifth and final round of funding. The SWIMP presents, where known, the funding received by individual Queensland organisations under Rounds 1-4 and notes how this funding has helped to address priority gaps.

Queensland – state characteristics

Queensland's size, remoteness, population characteristics, variable climate and unreliable water availability ensure that the management of its water resources is a unique and enduring challenge.

The total land area of Queensland is 172.8 million hectares (1.7 million square kilometres), making it the second largest state or territory in Australia. The majority of Queensland's population lives near the coast. Conversely, centres in western catchments are typically small and isolated. Overall, Queensland is the most decentralised state in Australia with more than half the population living outside the capital city.

Whilst Queensland has around one fifth of the current national population, population growth in the state is substantially higher than the national average. This growth in population will lead to increasing pressure on the state's natural resources (DIP, 2009).

Queensland has enormous spatial and temporal variability in its climate. The state has five climate zones, high evaporation rates and a long history of severe droughts and major flooding. Although Queensland receives abundant rainfall, it is difficult to make effective use of it because most of the rain falls as storm-induced intense events during summer, covering a small area of the state. Only six percent of rainfall gets to inland river systems and most of the rain flows out to sea (EPA, 2003).

The amount of rain that falls from one season to another can vary significantly. Many of the northern and western river systems are seasonal. This stream flow variability is a direct result of rainfall variability, as precipitation is the dominant source of supply for Queensland river systems.

High potential evaporation rates have a significant impact on water resources in Queensland. Irregular and seasonal surface water availability and very high evaporation rates in western regions of the state have led to a dependence and overuse of groundwater resources.

Climate change is predicted to exacerbate the existing variability in Queensland's climate, likely causing:

- more frequent drought events
- increased variability in rainfall
- more intense rainfall events leading to more intense flooding
- higher temperatures leading to increased evaporation

In order to counteract high rainfall variability, Queensland has a storage capacity of around 3 megalitres (ML) per person (derived from Bureau of Rural Sciences, 2007). This is one of the highest storage capacities in the world. Around 80 percent of Queensland's total water storage capacity is contained in 45 'major' water storages - storages with a capacity of 20,000 ML or more. The combined total of these 45 storages is around 10.5 million ML. A map showing the location of these major storages is attached as Appendix 2.1.

Queensland has a hugely diverse ecosystem with 13 terrestrial and 14 marine bioregions. There are a number of environmental areas of international importance, including rainforests, wetlands, the Great Artesian Basin (GAB) and the Great Barrier Reef (GBR). These areas require extensive monitoring to ensure they are protected for future generations. Maps showing the location of the GAB and the GBR are attached as Appendix 2.2 and 2.3 respectively.

For water resource management purposes, much of Queensland is divided into water resource plan (WRP) areas. A WRP is subordinate legislation that provides a strategic blueprint for sustainable and efficient use of water. It establishes a framework for sharing water between human and environmental needs based on detailed technical and scientific assessment, as well as extensive community consultation. This process determines the right balance between competing requirements for water. It is the WRP that establishes tradable water allocations and the rules governing potential water trading.

A WRP nominates the water to which it applies. For the most part, WRPs initially apply to a catchment's surface water resources (rivers, lakes, overland flow). Some also

apply to groundwater and groundwater will increasingly be incorporated into existing WRPs upon review.

For most WRPs, a Resource Operations Plan (ROP) is developed to implement the outcomes and strategies specified in the WRP. ROPs detail the practical business of sharing and managing the water resources from day-to-day in a way that meets the WRP's objectives, and are also the instrument for establishing tradable water allocations and the rules governing potential water trading.

Over 91 percent of Queensland is covered by water resource planning activities, and over 90 percent of the state has an accompanying ROP in place. Water resource planning activities are not planned for about 7.5 percent (128,821 square kilometres) of Queensland at this time because these areas are relatively undeveloped.

Under Section 41 of the *Water Act 2000*, the Minister must establish a community reference panel when a water resource planning process begins. This panel must include representatives from cultural, economic and environmental interests in the plan area. Although the panel is not a decision-making body, it is a forum for consultation between the Minister, the department and the community on matters relating to the draft WRP.

Appendix 2.4 presents a map of the WRP areas in Queensland showing their relation to drainage basins.

Water information and monitoring

Significant sub-artesian groundwater resources are known to exist in numerous areas around the state, and are developed for agricultural, industrial and stock or domestic purposes, particularly along the eastern seaboard. Most of these areas are managed by the state government as either declared sub-artesian areas or groundwater management areas (GMAs). Outside these areas, groundwater availability is either limited or is not significantly developed.

Queensland is monitoring both water levels and the extractions from groundwater resources. In many aquifers in the state there has been a decline in the water level as the extraction has exceeded the average rainfall recharge. If not appropriately managed, declining levels will affect the reliability of the supply and subsequently influence the ecosystems dependent on the resource. In addition, the interaction between groundwater and surface water systems is vital in maintaining environmental flows and ensuring reliable supply for both groundwater and surface water users. The connectivity and relationship between surface water and groundwater systems can be affected by fluctuations in sub-artesian water levels.

The management of groundwater quality is also important in many sub-artesian systems. Groundwater quality can be affected by pollutants entering through recharge processes or by poor-quality water from adjoining strata entering aquifers of higher water quality. This can result from changes in water levels of overlying or adjacent aquifers, or from poor bore construction. Coastal groundwater systems are particularly vulnerable to seawater intrusion. This can be caused by an imbalance between the extraction of groundwater and inadequate volumes of freshwater recharge reaching the saltwater interface.

The state has a dedicated network of groundwater monitoring bores that measures water levels in all GMAs. As well as water level data, usage data are collected through metering and measurement of most non-stock or domestic water bores in GMAs. Monitoring and measurement data are periodically collated to assess the condition and trend of individual groundwater resources. (DERM 2010)

A number of sub-artesian areas have been declared under the *Water Act 2000*. Some have been declared within water resource plans, while most have been declared under the *Water Regulation 2002*, both of which are subordinate legislation to the Act. They become declared in order to preserve the quality and/or sustainability of the groundwater resource and in a declared area certain types of development must get approval from local and state government agencies.

The key players in water monitoring in Queensland and their water functions are briefly outlined below.

DERM

DERM is the lead water management agency in Queensland. As the lead water agency, DERM is the primary surface and groundwater monitoring agency in the state. The department has approximately 389 surface water gauging stations measuring a range of parameters related to water quantity and quality. In addition, groundwater quantity and quality is also monitored. The department operates and maintains approximately 5,700 open bores, including around 290 in the GAB.

DERM undertakes monitoring for the effectiveness of WRPs and for recommendations for replacement plans (as required under the *Water Act 2000*). This monitoring includes aquatic ecosystem monitoring of ecological assets and stream flow monitoring for model (and scenario) development. Monitoring is also undertaken for a range of other drivers relating to improving water and land management and conserving the environment.

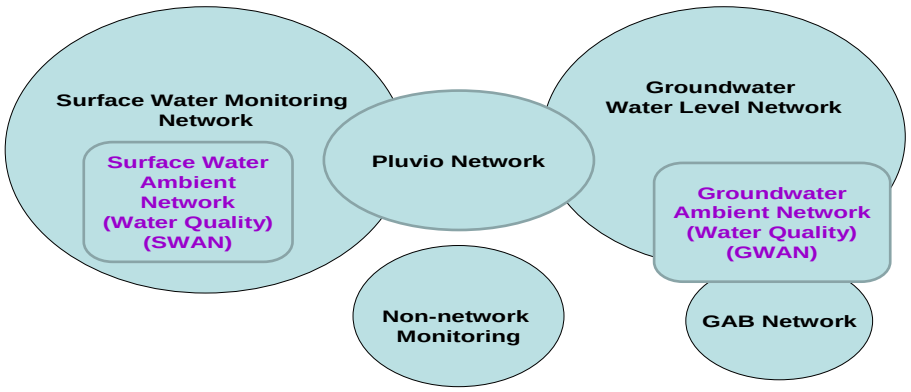


Figure 1 DERM ambient water monitoring activities

More information on DERM activities is available from the DERM website.

SunWater

SunWater is a government-owned corporation that provides a range of services including infrastructure ownership, water delivery, and operation and maintenance of infrastructure. SunWater has developed a regional network of water supply infrastructure throughout Queensland which supports irrigated agriculture, mining, power generation and urban growth. Examples of the water storage and distribution infrastructure owned and operated by SunWater include:

- 19 major dams
- 63 weirs and barrages
- 80 major pumping stations
- more than 2,500 kilometres of pipelines
- 730km of drains.

Overall, approximately 40 percent of the water used commercially in Queensland is supplied by SunWater via 23 water supply schemes.

SunWater collects and publishes water information for a variety of water monitoring parameters. Storage summaries provide data on storage and release volumes. Additionally, water level and stream flow data is supplied to DERM for the gauging stations owned and managed by SunWater.

More information on SunWater activities is available from the SunWater website.

Local government

In Queensland, unlike most other Australian states, the responsibilities of water extraction and storage for urban supply, water distribution and water reuse are mostly undertaken by local governments. The exception is in South East Queensland (SEQ) where recent reforms have shifted some of these responsibilities to water authorities (see below). The scope of water monitoring undertaken by local governments is usually limited to the quantity and quality of water involved in extraction, storage and release, distribution, and reuse, although some councils also undertake some ambient or receiving water environmental water quality monitoring and some meteorological monitoring. Many water service providers have sizable historical datasets, albeit in a range of data management systems from archaic to modern.

Local government amalgamations in April 2008 reduced the number of councils in Queensland from 157 to 73; a reduction of almost 45 percent. Of this number, 24 councils are currently named in the federal Water Regulations and are required to provide certain water monitoring information to the Bureau. Nine of these councils are in the SEQ corner of the state, with the rest spread from Dalby in the south to Cloncurry in the west and the Torres Strait Islands in the very north of the state.

Councils affected by amalgamation reforms have been focussing on how best to manage and merge multiple corporate systems, monitoring programs, data management systems and organisational cultures. Some have yet to identify all the monitoring programs and data stored by previous bodies and determine how best to integrate these programs and datasets. The impacts on councils has varied, depending

on the number of councils that have merged together (e.g. the new Toowoomba Regional Council is a merger of eight previous council bodies).

Water reform in SEQ

The Queensland Water Commission (QWC) was established as an independent statutory body in June 2006 under the *Water Act 2000*. The role of the QWC is to ensure sustainable water supplies within SEQ by developing long term water supply strategies, establishing a regional water grid, implementing water restrictions, managing water demand, providing advice to government and reforming the water industry.

The QWC initiated institutional reforms, approved by the Queensland Government, to align ownership and control of water assets with public accountabilities so that the Queensland Government is accountable for water supply security and in control of the water and assets to deliver that security. These reforms, introduced on 1 July 2008 changed the face of the SEQ water market. Pre 1 July 2008, councils were responsible for the bulk supply, bulk transport, distribution and retail of water to its customers. This translated to a water market consisting of more than 20 vertically integrated water businesses.

Post 1 July 2008, this structure was changed. The Queensland Bulk Water Supply Authority (Seqwater), Bulk Manufactured Water Authority (WaterSecure) and the Bulk Transport Authority (LinkWater) were created. The SEQ Water Grid Manager was also created to oversee the operation of the water grid.

Seqwater is a state owned statutory authority that provides bulk water storage and treatment services to SEQ. Seqwater has responsibility for managing 25 dams and 50 weirs across SEQ, including Wivenhoe, Somerset, North Pine, Hinze and Baroon Pocket dams. Seqwater also operates 47 water treatment plants and 14 bore fields.

Seqwater provides a range of services including:

- flood monitoring services
- catchment management services
- water quality research and investigation
- recreation services
- irrigation services to around 1,000 rural customers in five water supply schemes

LinkWater is a state owned statutory authority which moves water from dams and other water sources through bulk pipeline networks. The SEQ Water Grid Manager buys the services of LinkWater.

WaterSecure supplies water from the Gold Coast Desalination Plant to the water grid and supplies water from the Western Corridor Recycled Water Project to power stations and other customers. From 1 July 2011 WaterSecure will be merged into Seqwater.

Three council-owned retail entities were established on 1 July 2010 to provide water and waste services to end users; a function previously undertaken by local councils. The retail entities are Queensland Urban Utilities: servicing Brisbane, Ipswich, Scenic

Rim, Somerset and Lockyer Valley; Allconnex Water: servicing Gold Coast, Logan and Redlands; and Unitywater: servicing Sunshine Coast and Moreton. Proposed changes to the legislation establishing these entities were announced by the Queensland Premier in April 2011 allowing councils to withdraw from these entities if desired. Councils have till the end of June 2011 to make a decision to withdraw.

A map of the local government areas in Queensland is included as Appendix 2.5.

Natural Resource Management bodies

Queensland has fourteen Natural Resource Management (NRM) regional bodies. All of these bodies are listed in the Water Regulations and are required to report particular water information, if available. Between them, these bodies cover the entire state. The NRM bodies that currently have the largest water quality monitoring programs are:

- Fitzroy Basin Association
- NQ Dry Tropics
- Queensland Murray-Darling Committee
- Reef Catchments NRM
- SEQ Catchments
- South West NRM

Other regional bodies, such as Condamine Alliance and the Burnett Mary Regional Group, have previously undertaken sizeable monitoring programs recording benchmark data, but have no current program underway due to a lack of funding. If funding becomes available then they will recommence monitoring activities. NRM bodies largely rely on the attainment of federal and state funding to undertake monitoring activities. Their monitoring programs, therefore, are primarily project related with many spatial and temporal gaps. Lack of permanent funding also impacts significantly on the retainment of trained staff. Much of the water quality monitoring performed in regional NRM body areas is completed by community volunteers. This presents a number of issues for NRM bodies to manage, such as standardising collection and reporting techniques, centralised data management, high turnover of volunteers and the constant requirement for training.

Nevertheless, many NRM bodies possess valuable historical and ongoing water quality datasets. A range of water quality parameters are monitored including electrical conductivity (EC), potential of Hydrogen (pH) and turbidity. They collect, store and analyse this data and aim to make this information available to their respective communities in as short a timeframe as possible.

More information is available from the Regional Groups Collective website.

A map showing the location of NRM regions in Queensland is included as Appendix 2.6.

2 Section A

2.1 Queensland drivers for collecting water information

Section A lists the fundamental reasons for monitoring in Queensland, the key legislation in place that determines the framework for monitoring and a few of the many strategies and plans underway that direct the nature of the present monitoring networks in the state.

Drivers for monitoring include:

- the need to assess and manage the state's water resources and aquatic assets, their quality and availability and whether current water management practices are sustainable into the future
- legislation, both federal and state, that determines the rules of water development and use, and the need to monitor not only the quantity and quality of this precious resource, including as a public health resource (drinking water), but also the condition of the aquatic ecosystem it supports
- policy - federal, inter-state and state level strategies, plans and policies determine the development of specific monitoring activities
- organisational drivers - the need to monitor and analyse water assets to better understand and manage them

2.1.1 Assessment and management drivers

The assessment and management drivers for water monitoring in Queensland include:

A. Assessment of water resources

1. How much water is there and where is it?
2. What are the state's most important water resources and how effectively are they being managed?
3. What is the interaction between surface water and groundwater and what is happening to this over time?
4. Do current water supplies match historical trends?
5. How much water will be available for future generations?
6. What is the impact of land use on water resources and on aquatic ecosystems?
7. How will climate change impact on future water availability?
8. What new water sources are available?

B. Assessment of water use

9. How much of the state's water resources are being extracted, by whom and for what purpose?

10. Is this use efficient?
11. How much water is being traded and where?

C. Condition and trend

12. What is the quality of water resources and environmental assets (aquatic ecosystems) and potential uses?
13. Is water quality declining or improving over time? Is the water being supplied safe for its purpose?
14. What is the volume and impact of contaminant movement in the environment?
15. Are we protecting resources against salinisation?
16. Are we managing salt-water intrusion?

D. Management and planning

17. Are water extraction levels environmentally sustainable?
18. Are the objectives of state and federal policy being met?
19. Are water extraction and use levels economically sustainable?
20. Are our water and land management practices economically, environmentally and socially sustainable? If not, how should they be improved?
21. How well can future water availability be predicted?
22. Is the state planning for the water needs of future generations?
23. Are there known or unknown impacts on future water availability that are currently not being monitored?
24. Can the state adequately predict the arrival and impact of natural disasters such as floods and drought?

2.1.2 Legislation

The key federal legislation impacting on monitoring activities in Queensland includes the federal *Water Act 2007* and *Water Regulations 2008*. Key state legislation includes the *Water Act 2000*, the *Environmental Protection (Water) Policy 2009* and the *Water Supply (Safety and Reliability) Act 2008*. The *Right to Information Act 2009* has a significant impact on the access to the data collected by water monitoring organisations.

More details are available in Appendix 1.

2.1.3 Strategies, programs, plans

A number of federal and state strategies, programs and plans have a direct effect on the location and quantity of monitoring activities and in the state and on the management of water data. Federal strategies include the National Water Initiative, the Murray-Darling Basin Plan and the Sustainable Yields projects.

State strategies of note include water resource plans, water resource assessments, resource operations plans, the National Water Quality Management Strategy, the Reef

Water Quality Protection Plan and the South East Queensland Healthy Waterways Strategy. The Queensland Government Information Licensing Framework and its recommendation of Creative Commons licensing aims to enable easier access to water data.

More details are available in Appendix 1.

2.1.4 Organisational drivers

Individual organisations undertake monitoring programs to meet relevant legislative and policy requirements as well as to support operational management. Ensuring the sustainability of local water resources is of strategic importance to all organisations but especially to those who wish to continue supplying water to clients into the future.

Monitoring of local resources allows them to better understand the resource as well as to monitor condition and trends.

Many water service providers maintain flood warning programs to ensure the safety of their communities. For example, Seqwater has storages that are gated and can hold a volume of water over and above the nominated full supply level. During a major storm event real time data from the monitoring network (both upstream and downstream of the storage) is used to make informed decisions on the operation of the storages.

In addition, some agencies, such as NRM bodies, monitor to identify water resource issues, evaluate progress towards targets within regional NRM plans and communicate that information to their community.

3 Section B

Section B describes the current water monitoring and water data collection activities of named persons in Queensland. An attempt has been made to quantify the volume of monitoring activities in the surface, groundwater and water quality areas. Tables present figures as currently known and as they are subject to change they are to be regarded as indicative only. This section is sub-divided by type of activity, such as groundwater monitoring or data management.

3.1 Groundwater monitoring

3.1.1 Sub-artesian monitoring

3.1.1.1 DERM

There are over 5900 open bores in the Groundwater Water Level Network managed by DERM. These bores may be maintained and monitored on a regular basis, or as required. In addition, there are around 5600 closed bores that may or may not be serviceable. DERM regional staff are responsible for operational activities associated with measuring and maintaining this network. In some circumstances, DERM makes use of private bores to supplement gaps in the monitoring network.

Groundwater Water Level Network bores are present in all major sub-artesian aquifers in Queensland with varying levels of representation. DERM also operates some 90 telemetered groundwater data loggers, used to readily manage groundwater resources.

In 2007, a review of the state sub-artesian groundwater monitoring network was prepared by Environmental Hydrology Associates (EHA) on behalf of the then NRW. According to the EHA review, there are effectively four ‘styles’ of state groundwater monitoring networks:

- bore lines
- distributed monitoring bore network
- reconnaissance networks
- project oriented networks

The review proposed a number of rationales for groundwater monitoring by state government, including:

- groundwater units at, or likely to be at, risk of adverse groundwater impacts should receive greater monitoring effort
- groundwater resources of larger magnitude and higher value deserve greater expenditure of effort on assessment and monitoring
- areas with groundwater management plans in place require monitoring of key bores that underpin plans

- wherever possible dedicated groundwater monitoring bores should be used
- groundwater quality data should receive emphasis as well as groundwater levels

The review noted that state monitoring networks reflect historical funding and investigation effort, as well as monitoring effort imposed for specific projects (e.g. monitoring key irrigation areas or mines). Refinement of monitoring networks is the result of:

- in-fill drilling to assess resource condition in key areas of stress
- reactive ad hoc maintenance
- rationalisation, driven by funding limitations or reactions to specific data needs to support specific groundwater modelling efforts

Current monitoring is primarily focused on water resource planning and management to underpin sustainable use of the resource. Some of the key objectives include:

- determination of condition and trend
- system conceptualisation and resource assessment
- construction and calibration of groundwater models to assess system performance
- on-going assessment of the performance of water resource plans
- compliance action

There is a good coverage of monitoring bores within groundwater management unit boundaries. Outside these areas of groundwater interest, monitoring is not as intensive.

The majority of the Groundwater Water Level Network bores are monitored quarterly, although in some areas with high levels of water demand and where enhanced management is required monitoring occurs monthly. There are also a number of bores equipped with continuous monitoring technologies. Groundwater level records frequently span a period of twenty years or more, which enables trends to be observed through bore hydrographs.

Groundwater quality is much less frequently monitored and it is a much smaller subset of the overall Groundwater Water Level Network and its condition is predominately stable. In areas where groundwater quality is a priority issue, such as saltwater intrusion in coastal aquifers, groundwater quality samples are taken on a bi-annual or annual basis. In high risk areas, monitoring of EC is conducted monthly. In the Mackay and Bundaberg areas, dedicated seawater intrusion monitoring networks of around 160 bores have been established to monitor down-hole EC tracking movements in the seawater intrusion wedge over time.

3.1.1.2 National Action Plan Monitoring Network

Some 420 new monitoring bores have been established in sedimentary and fractured rock aquifers throughout Queensland, where dryland salinity was already developing or was likely to develop in future years due to rising water tables. The network was formed as part of the National Action Plan for Salinity and Water Quality (NAP) hydro-geological investigations project. Only limited monitoring of these bores has been undertaken since the conclusion of the NAP program, as no provision for ongoing operational costs was ever made.

3.1.1.3 Other stakeholders

SunWater has contracted DERM to undertake most of its bore level monitoring. Where SunWater has undertaken bore level measurements, it has been on a quarterly basis to fulfil their obligations under the interim Resource Operations Licences (IROLs). These bore levels are also used to determine the water availability for groundwater users in SunWater-operated water supply schemes where groundwater extractions are permitted. SunWater also undertakes monitoring of bores surrounding their storages for the purpose of monitoring and assessing seepage from those storages.

Seqwater owns a number of bore fields on North Stradbroke Island, Bribie Island, Oxley Creek (Brisbane Aquifers) and in the Central Lockyer Valley. There are 24 production bores on North Stradbroke Island as well as a number of monitoring bores. Bribie Island contains 18 production bores and associated monitoring bores. Both the Bribie Island and North Stradbroke Island bores are read manually by operations from the local water treatment plants.

Under the Brisbane Aquifer project Brisbane City Council installed around 20 bores in the Oxley Creek area. These bores are now the responsibility of Seqwater. Readings from these bores are monitored automatically and are fed into local water treatment plant Supervisory Control and Data Acquisition (SCADA) systems.

Seqwater owns approximately 61 monitoring bores in the Central Lockyer area that it inherited from SunWater following the amalgamation of water assets in SEQ. DERM monitors these bores on behalf of Seqwater, continuing an arrangement that DERM had with SunWater.

Toowoomba City has three surface water storages plus the availability of additional supply from a fourth surface water storage to supply its water requirements. The city continues to grow and these storages have reached their safe yield limits so new water sources are required. One of those sources is groundwater. Toowoomba Regional Council has a monitoring network of 42 bores established to measure the impact of increased groundwater take on aquifers, including the GAB.

There are no other named persons known to be maintaining any significant groundwater monitoring networks in Queensland.

3.1.2 Artesian monitoring

DERM has an artesian monitoring network of some 288 bores monitoring water levels and/or pressure in the GAB. There are 25 water management areas in the GAB that lie within Queensland. These are the areas covered by the GAB WRP and Resource Operations Plan (ROP).

The GAB WRP has recommended a Pressure Monitoring Network of artesian and sub-artesian bores be established and maintained. This network will consist of two sub-networks:

- System Monitoring Network – to assess pressure distribution across the whole or part of one or more management units
- Impact Monitoring Network – to assess local impacts of taking water in an area or on the flow of water to springs and base flow to watercourses.

Where practicable, the Pressure Monitoring Network is to use bores that have been monitored in the past to enable trend analysis. Parameters that may be recorded in this network include water pressure, water levels, flow, water temperature and EC.

The System Monitoring Network is required to be monitored once every three years. The purpose of this network is to establish baseline data away from heavily impacted areas to investigate long-term trends in aquifer condition, groundwater flow and the performance of aquifers at a basin or whole-of-aquifer scale, and to assist in hydro-geological characterisation. Parameters recorded may include discharge.

The Impact Monitoring Network is monitored as determined by the Chief Executive. The purpose of this network is to assess more localised positive or negative impacts of development at the management area or management unit scale. This may include areas of higher concentration of take of water, uncontrolled bores or recently capped bores, areas around springs and rivers, etc. Measurements may include pressure, water quality and discharge, focused on specific management units and areas.

Under the GAB ROP a Spring Monitoring Network is proposed, so as to enable the collection of data that can indicate trends in the flow of water to springs.

The following parameters may be monitored in this network:

- the extent of the wetted area of springs
- the flow of water from springs
- the flow of water in watercourses

Spring monitoring is proposed at least once in every three years. In 2009 DERM engaged the Queensland Herbarium to develop a spring wetland monitoring methodology to be utilised to fulfil the requirements for monitoring within the GAB ROP. From this work there have been six spring formations identified as being suitable to provide indication of basin health. In developing this method an assessment of the springs was undertaken. The adopted monitoring program is being implemented in June/July 2011.

In January 2007, the Australian Government committed to a third phase of the Great Artesian Basin Sustainability Initiative (GABSI). Under this commitment, money was allocated to establish a Whole of Basin Network to monitor the impacts of GABSI and

future management approaches on the GAB. Whilst monitoring of bores is currently undertaken by each jurisdiction, it is primarily to address jurisdictional water management issues and is of limited use for whole-of-basin monitoring. The main impediment is the inconsistency in the frequency and timing of measurement across the Basin. Of the 202 bores in this network, 130 will be located in Queensland.

Table 1 presents the number of open monitoring bores managed by named persons in Queensland based on information provided to date. Sites are listed according to whether data is monitored continuously or not and include both artesian and sub-artesian bores. Where bores are owned by one agency but managed and monitored by another they are counted with the latter. Seqwater owns 61 bores that are monitored by DERM and included in the DERM figure. The DERM figure reflects the status as at 1 May 2011.

Table 1 Number of bores managed by named persons in Queensland that monitor water level or pressure

Monitoring body	Number of monitoring bores, by currency		Total number of monitoring bores
	Continuous	Non-continuous	
DERM	146	5 478	5 624
Seqwater	21	49	70
SunWater	0	175	175
Toowoomba RC	42	0	42
Total	**209**	**5 702**	**5 911**

3.1.3 Groundwater monitoring technologies

3.1.3.1 Sub-artesian

One of the most significant recent achievements in practical groundwater science has been the development of reliable groundwater level, temperature and salinity probes connected to data loggers. In 2009 there were 115 DERM bores equipped with automatic recorders monitoring water levels on a continuous basis. With M&E Program funding a further 80 data loggers will be installed by the end of June 2011. A further 60 loggers will be installed with internal funding. By the end of 2012 DERM plans to have 255 bores with automatic loggers; an increase of 45 percent. This will enable monitoring for recharge assessment to be accelerated and more remote areas to be reliably monitored with lower frequencies of visitation.

A trial is currently being undertaken in the Bundaberg area using salinity data loggers to monitor conductivity trends in areas affected by seawater intrusion.

If this trial is successful, it will provide an opportunity to optimise our understanding of seawater intrusion processes, as well as to reduce our reliance on manual conductivity monitoring activities.

3.1.3.2 Artesian

Currently 12 sites in the recharge areas of the GAB are equipped with automatic recorders, recording water levels at all sites and rainfall at some. None of these use telemetry at this time. During implementation of the Whole of Basin Network, aging equipment will be replaced and further sites will be equipped with automatic loggers, bringing the total to 32 sites within the recharge areas of the GAB.

The Whole of Basin Network implementation includes funds to equip 18 artesian bores with automated pressure and temperature monitoring. The Bureau of Rural Sciences is currently assessing the viability of remote telemetry to monitor flow and pressure, to enable timelier monitoring. A telemetry trial was undertaken in New South Wales for some remote sites. The early findings were that the satellite technology used was very expensive and unreliable. Therefore, when distributing funds for the Whole of Basin Monitoring Network it was decided that equipping more sites with data loggers would provide better information on the viability of using automated flow, pressure and temperature recording on artesian bores than testing telemetry alternatives. Until this technology proves more cost-effective and technically reliable, there are no plans to install telemetry in the Queensland monitoring sites.

3.2 Surface water monitoring

3.2.1 State-wide monitoring

Queensland named persons manage over 900 sites measuring water level or flow. Further, there are around 700 sites that are currently closed or not operational. Around 44 percent of these open monitoring sites are managed by DERM. Sites may exist for a range of purposes, such as:

- resource modelling, assessment and management
- surface and groundwater interaction
- water quality assessment and reporting

Table 2 lists the number of open surface water monitoring sites managed by named persons in Queensland that measure flows or levels in watercourses. This table excludes sites that only monitor rainfall or water quality parameters, or are located at water storages. These figures are provided in later tables. Although rainfall monitoring is excluded many of these figures relate to ALERT station monitoring of water levels.

Table 2 Number of sites managed by named persons in Queensland that monitor water level or water flow, excluding sites at water storages

Monitoring Body	Number of surface water monitoring sites		Total surface water monitoring sites
	Continuous	Non-continuous	
Brisbane City Council	35	0	35
Burdekin Shire Council	21	0	21
Cairns RC	28	0	28
Cassowary Coast Regional Council	14	0	14
Cloncurry Shire Council	0	3	3
DERM[1]	400	0	400
Gladstone Area Water Board	0	2	2
Gold Coast City Council	28	0	28
Hinchinbrook Shire Council	12	0	12
Ipswich City Council	25	0	25
Logan City Council	11	0	11
Moreton Bay Regional Council	14	0	14
Pioneer River Improvement Trust	12	0	12
Scenic Rim Regional Council	18	0	18
Seqwater	47	0	47
Southern Downs Regional Council	7	0	7
Sunshine Coast Regional Council	40	0	40
SunWater	22	0	22
Toowoomba Regional Council	5	4	9
Townsville Regional Council	11	0	11
Western Downs Regional Council	4	2	6
Whitsunday Regional Council	4	0	4
Wide Bay Water Corporation	6	0	6
Total	**764**	**11**	**775**

Notes:

1. The DERM figure includes the department's gauging station network as well as 26 client sites managed by DERM; the data from these client sites is sent to the Bureau by DERM as per the Water Regulations requirements.

Around 70 percent of DERM sites are located in the North-East Coast drainage division – primarily in the Brisbane, Burnett, Burdekin and Fitzroy drainage basins. The drainage divisions least monitored are Bulloo-Bancannia and Lake Eyre (with a total of 3.5 percent of monitoring sites located within those divisions). The Murray-Darling division has around 14 percent of DERM sites and the Gulf of Carpentaria 11 percent.

A map showing the location of Queensland drainage basins is attached as Appendix 2.7.

DERM operates 389 streamflow gauging stations across Queensland which automatically collect and store information on streamflow depth which is converted to flow volumes. This flow information forms part of an extensive historical flow volume dataset that underpins infrastructure planning in Queensland including dam, bridge, road, rail and other major infrastructure design that may be impacted by streamflows. Streamflow information also supports the department's water resource planning and management activities. Activities include using data to build hydrology models, inform trend assessments, assess compliance with water resource plans and manage water user access to flows.

The gauging station network is maintained by appropriately qualified hydrographic officers and managed under a quality management Water Monitoring Business Framework (certified ISO9001 quality system). Gauging stations consist of a mixture of physical, mechanical and electronic components. They are located on the banks of streams and are subject to flood and climatic conditions. Consequently they are prone to breakdowns, ranging from instrument malfunction through to structural flood damage. The maintenance cycle for gauging stations varies based on the priority of the data collected and the ease of access to the site. Gauging stations in remote parts of the state might be inoperable for some time until maintenance can be undertaken. This doesn't present an issue for the department as data is used for water assessment and management purposes and is not normally required for real-time decision making.

Having remote access to gauging stations via telemetry assists the department to respond to non-functioning stations. However, the telemetry itself is subject to failure, either within the station or within the operations of the telecommunication service provider, such as Telstra. In these cases, the gauging station might be collecting and storing data which can be retrieved during the next maintenance cycle. Hence a telemetry failure does not necessarily imply a station failure. During periods of actual or potential flood flows, the department will immediately respond to station failures on request by the Bureau, where those stations are critical to the Bureau's flood warning role and it is safe for hydrographic officers to access the site.

Apart from watercourses and storages DERM also monitors wetlands. In Queensland the term wetland applies to six ecological systems, which are lacustrine (lakes), palustrine (swamps, bogs and fens), and estuarine, riverine, marine and underground wetlands. Long periods of drought in recent years have significantly impacted the extent and quality of some wetland habitats. It is too early to determine the impact of recent flooding on freshwater wetlands.

Wetlands are monitored for a range of reasons, such as to determine whether a wetland is increasing or decreasing in size or to identify changes to wetland nature or quality. In recent years Queensland has monitored the extent of wetlands by using state-wide mapping datasets and the results are reported in the Queensland SoE

report. Wetlands mapping has recently been updated and the new version should be released by 2011.

The condition of wetlands is monitored using a wetland assessment framework developed as part of the Queensland Wetlands Program. Pressure and condition indicators are included through a stressor based framework that allows pressures to be directly linked to condition to better enable the development of management actions.

Whilst there is no current broad-based monitoring of lacustrine and palustrine wetlands the stressor models which underpin the framework for monitoring these wetlands have been developed. Tools for monitoring these wetlands are currently being trialled in the MDB, Wide Bay and Fitzroy catchments. More information on the stressor models can be found on the DERM website.

A list of the other major current monitoring programs in Queensland wetlands is also available from the DERM website.

3.2.2 Water storage monitoring

Resource Operations Licence (ROL) holders and some holders of water licences for infrastructure not managed under a ROL are required to monitor a range of parameters at their water storages, as per the requirements of the water resource plan in their region. Generally this refers to inflows, releases and water levels, water quality and ecosystem health parameters. This information is delivered to the lead water agency through quarterly and annual reports. Aside from these legislative requirements to monitor, dam owners also monitor their storages for their own business needs.

The key ROL holders are SunWater, Seqwater, water boards and local government. SunWater, the major owner of water storage infrastructure in Queensland, has a network of 19 major dams and 63 weirs and barrages.

Seqwater owns and operates 24 dams in the SEQ region as well as 47 water treatment plants and is the single largest treated and bulk water service provider in the state. Aside from urban water they also supply around 1000 irrigators with water. See below for details of the technologies used in Seqwater's storage monitoring network.

Table 3 presents the number of open measuring points located at water storages managed by Queensland named persons. There can be multiple measuring points at any one water storage, therefore the number of storages where this monitoring takes place is also presented.

Table 3 Number of measuring points located at water storages managed by Queensland named persons

Monitoring body	Number of water storages where levels or releases are measured	Number of measuring points located at water storages				
		Continuous		Non-continuous		Total number of measuring points
		Levels	Releases	Levels	Releases	
Burdekin SC[1]	1	1	0	0	0	1
Cairns RC	1	1	1	0	0	2
Cloncurry SC[2]	1	0	0	1	0	1
DERM[3]	15	10	6	4	0	20
Gladstone Area Water Board	1	1	0	0	0	1
Rockhampton RC[4]	3	3	1	0	0	4
Seqwater	27	47	0	0	0	47
South Burnett RC	1	0	0	1	0	1
Southern Downs RC	1	1	1	0	0	2
Stanwell Corporation	2	1	1	0	0	2
SunWater[5]	47	47	24	1	0	72
Tarong Energy	2	0	0	1	1	2
Toowoomba RC	3	1	0	3	2	6
Torres SC	1	0	0	1	0	1
Townsville CC[6]	4	4	0	0	2	6
Wide Bay Water Corporation	6	5	2	1	1	9
TOTAL	**116**	**122**	**36**	**13**	**6**	**177**

Notes:

1. The monitoring site is at Burdekin Falls Dam owned by SunWater.
2. The monitoring site is at Corella Dam owned by DERM.
3. DERM has monitoring sites at a number of storages owned by other organisations.
4. Monitoring sites are managed by the Fitzroy River Water unit of council.

5. Of the total number of SunWater sites 47 monitor water levels only; 24 monitor both water levels and water releases – these are listed in the Releases column. In total however all 72 sites monitor water levels.
6. Monitoring sites are managed by NQ Water, a division of council.

3.2.3 Surface water monitoring technologies

Of the surface water monitoring sites listed in Tables 2 and 3 almost all are logged continuously and around 90 percent have telemetry systems in place; telemetry is used to transmit data on a near real-time basis to enable timely management of water user access to certain flow events and to remotely check on the continued operation of gauging stations. Some organisation telemetry systems are using IP enabled loggers. IP is an internet protocol for transferring data between locations.

DERM

Whilst DERM currently uses a mix of landline, NextG IP and satellite IP technologies the majority of sites are telemetered using NextG IP enabled loggers. IP technology enables real-time data transfer of time series data to an FTP site to be further utilised by the Water Accounting System (Hydstra).

Currently DERM is upgrading some seventy sites, having no or unreliable communications, to satellite IP technology. Satellite IP is the only option for telemetry at some sites due to their location. It is anticipated that by the end of 2011 all DERM gauging stations will be telemetered by satellite IP enabled loggers.

SunWater

Under Round 3 of M&E funding, all existing SunWater data loggers have been upgraded to the CR800 model and SD-12 output transducers for loggers and 4-20mA outputs for flood warning purposes. The new equipment enables SunWater to utilise the Next-G wireless IP Network to provide near real-time data and improves the currency of the water level, stream flow, meteorological and water storage data supply. There were also six new continuous monitoring stations erected to capture water level within storages and watercourses in the Murray-Darling Basin, Fitzroy, Pioneer and Burnett Basin catchments.

Seqwater

About 65 percent of Seqwater's monitoring network has sites that are radio telemetered and provide data via the ALERT network. The remaining stations are telephone telemetered and are interrogated via dial-up telephone.

Seqwater is currently upgrading its entire monitoring network as the majority of the network was comprised of hardware that was twenty years old and no longer supported by the supplier. Seqwater is doing this with the assistance of the Bureau through the M&E Program. This program has been instrumental in allowing this work to occur not only through the funding itself but also in providing direction for a relatively new entity.

Surface water monitoring at major and minor storages is being upgraded with highly accurate CR1000 loggers and new sensors, where applicable. For some of the major storages, stilling wells are being constructed to increase the accuracy and reliability of measurements. IP data transfer is also being trialled at two of our largest storages, Somerset and North Pine dams (still in trial phase and not yet available).

The remainder of Seqwater's remote surface water monitoring network is being upgraded with ELPRO field stations and new sensors, where applicable. Many of these stations were battery powered only but are now also being equipped with solar panels to make them more reliable. Data from all of the recent upgrades to Seqwater's network is available via the ALERT network.

3.3 Meteorological monitoring

3.3.1 Flood warning

The Bureau is responsible for issuing flood warnings and forecasts, including prediction of flood heights at many locations. The flood warning service in Queensland is operated in partnership with a number of agencies, especially local governments and Emergency Management Queensland, and is underpinned by a rainfall and water/river level monitoring network ('flood warning network') in most river basins/catchments in Queensland.

The flood warning network is comprised of around 2050 stations which provide observations of rainfall or water level (stream or river height, storage level, estuary or sea level, etc.). Approximately 1470 stations provide rainfall data and 1164 stations provide water level data. There is a degree of redundancy in the flood warning network, whereby some locations have more than one rainfall and/or water level observation to ensure operational robustness of the flood warning service.

The flood warning network integrates rainfall and water level data from stations owned and operated by the Bureau, local governments, DERM, SunWater, Seqwater and other water management agencies. In 2009 it was estimated by the Queensland Regional Office of the Bureau that roughly 55 percent of stations in the flood warning network were fully owned or partly owned by the Bureau. Of the 45 percent being owned by other agencies the Bureau either manages or has access to the data.

Details of the flood warning network in Queensland, including maps for each river basin showing the location of stations, are available from the Bureau website

DERM does not have any responsibility for flood alert/warning services but does provide Emergency Management Queensland and the Bureau of Meteorology with access to its near real-time streamflow gauging data. The department is a member of the Queensland Flood Warning Consultation Committee chaired by Emergency Management Queensland. Through this forum the operation of the department's gauging stations can be aligned, where possible, to best support flood alert and response activities. It is understood, however, that for most of the Bureau's flood alert activities the department's data would only be utilised if the Bureau's primary alert system was unavailable.

DERM has been installing Campbell CR1000 loggers at selected bore sites across the state. At some sites where no Bureau rain data is available a pluviograph has been

added as an enhancement to the installation. Locations are dependent on representative aquifer conditions suitable for recording time series data. This data helps provide information on the state of the aquifer through analysis of the ratio between rainfall and the rise of the aquifer. It can also provide information on the relationship between nearby streams and bore levels.

Queensland Floods 2010-11

Significant flooding occurred in many areas of Queensland during late December 2010 and early January 2011, with three quarters of the state declared a disaster zone. Queensland was affected by extensive flooding; further localised flood events were experienced in February and March 2011.

An independent Commission of Inquiry (COI) with all the powers of a Royal Commission has been established to examine the unprecedented flood disaster. The terms of reference for this COI include:

- The preparation and planning by federal, state and local governments; emergency services and the community for the 2010-11 floods in Queensland
- All aspects of the response to the flood events, particularly measures taken to inform the community and measures to protect life and private and public property
- Adequacy of forecasts and early warning systems, particularly as they related to the flood events in Toowoomba and the Lockyer and Brisbane valleys
- Implementation of the systems operation plans for dams across the state and in particular the Wivenhoe and Somerset release strategy and an assessment of compliance with, and the suitability of, the operational procedures relating to flood mitigation and dam safety

The COI is due to present an interim report to the Premier of Queensland by 1 August 2011, on matters associated with flood preparedness to enable early recommendations to be implemented before the 2011-12 wet season, and a final report by 24 February 2012.

The Natural Disaster Resilience Program is the primary funding program to address replacement costs due to recent flood events.

3.3.2 Other meteorological monitoring

The Bureau is the primary monitoring agency in Queensland for meteorological parameters other than rainfall. The Department of Employment, Economic Development and Innovation (DEEDI) measures certain weather conditions as part of project work at one site in Queensland. This data is not extensive but is being delivered to the Bureau.

DERM has an air quality monitoring program that is delivering data to the Bureau under the Water Regulations. The Air Quality Sciences Section collects global solar irradiance data on a continuous basis at two sites; wind speed and wind direction, dry-bulb air temperature, air pressure and relative humidity on a continuous basis at a number of sites in Queensland.

Measurements of wind speed and direction, temperature, humidity, rainfall and solar radiation are taken to further understand the chemical reactions that occur in the atmosphere. Meteorological monitoring is used to predict air pollution events such as inversions, high pollutant concentration days and to simulate and predict air quality using computer models.

DERM produces air quality forecasts for SEQ. This information is delivered to the Queensland office of the Bureau twice per day. The Bureau publishes this information along with their weather forecasts.

More information on the work of the Air Sciences Section can be found on the DERM website.

Seqwater maintains a handful of weather stations that collectively monitor a number of meteorological parameters including rainfall, wind speed, solar irradiance, temperature and humidity.

3.3.3 Meteorological monitoring technologies

DERM uses the latest equipment to monitor meteorological parameters. Wind speed is measured using an anemometer – either a 'cup wheel' anemometer which is turned by the wind generating an electric current that is a measure of wind speed, or a sonic anemometer which uses sound waves to calculate wind speed. Wind direction is measured with wind vanes or sonic anemonmeters. Pressure, temperature and humidity measurements are determined by the change in capacitance of silicon, ceramic or thin film polymer sensors respectively. Platinum resistance thermometers are used for temperature measurement at some monitoring sites. Rainfall is measured by precipitation sensors comprising a piezoelectrical sensor mounted under a steel cover. The precipitation sensor detects the impact of individual raindrops, with the impact signal being proportional to the volume of the drops. Solar irradiance data is collected using pyranometers, which generate a voltage output proportional to the incoming radiation.

Technologies used in flood warning stations include both manual observations (which rely on a person) and automatic stations providing data via telephone or radio telemetry, or more recently, directly to the Bureau's computing systems (via File Transfer Protocol (FTP) files) from the water agency computer systems. The main types of rainfall and water level flood warning stations are typically categorised as:

- Remote observer terminal (ROT): manual stations which report rainfall and/or water level via an ROT connected to a normal telephone line, or increasingly via the internet
- Synoptic stations (SYNOP): manual stations that provide a range of meteorological observations (temperature, pressure, etc.) as well as rainfall observations, typically several times per day at 3-hourly intervals
- Automatic weather station (AWS): AWS provide rainfall reports, typically via telephone, satellite or radio communications at regular (e.g. hourly or 10 minute) intervals
- TELEMETER: automatic stations reporting via telephone (landline, mobile, satellite). Data is typically polled from a logger at daily or more frequent intervals

during floods, although an emerging trend is towards “push’ communications based on pre-determined ‘event’ or time triggers

- Automated Local Evaluation in Real Time (ALERT): automatic rainfall and water level stations which provide event reports in real-time via VHF radio. These stations are a part of an ALERT system generally operated by the Bureau, in partnership with a local government or water agency.

The numbers of stations providing rainfall and water level data for each of these technologies is shown below.

Table 4 Number of stations in the Queensland flood warning network, by technology type

Type of Station	Rainfall	Water Level
ROT[1] (manual)	440	295
SYNOP[2] (manual)	45	0
AWS[3]	70	0
TELEMETER[4]	410	555
ALERT[5]	600	375
Total	**1565**	**1225**

Notes:
1. ROT: Remote Observer Terminal
2. SYNOP: Synoptic Stations
3. AWS: Automatic Weather Station
4. TELEMETER: Automatic stations reporting via telephone.
5. ALERT: Automated Local Evaluation in Real Time

3.4 Water quality monitoring

3.4.1 State-wide monitoring

DERM collects, manages and delivers water quality data by monitoring surface water and groundwater through its network of gauging stations and bores. DERM has automated systems in established infrastructure recording time series data and event data. DERM also undertakes point sampling at specific locations, measuring ambient flows and/or event flows. This data supports a number of purposes such as water resource planning, modelling, condition and trend monitoring, ROP compliance, ecological monitoring, development of water guidelines and objectives and the activities of regional NRM bodies.

SunWater maintains a water quality monitoring program based on ROP or IROL requirements, and undertakes this monitoring according to the Water Monitoring Data

Collection Standards issued by DERM. Monitoring is undertaken to assess physical, chemical and biological parameters.

SunWater does not collect time series water quality data. The purpose of their water quality monitoring program is to assess the impact of storages and release management strategies on water quality. Monitoring occurs monthly or quarterly depending on the storage and the location of the storage.

Queensland has 14 NRM regional bodies with many monitoring and assessing water quality on a project by project basis. Water quality is assessed by measuring physical, chemical and biological indicators of rivers and water bodies within their catchments, which are then compared with national and state guidelines and regional water quality targets, where available. The information is collected for a range of purposes, such as developing baseline understanding, prioritising and evaluating catchment management initiatives, and community engagement.

Local governments have a variety of responsibilities and different water quality objectives for different water uses. A domestic water supply for human consumption needs to be of a higher quality than water used for livestock. Recreational activities such as swimming require water to be of a much higher quality than water used for cooling machinery in industrial processes. Maintenance of high water quality depends on the effectiveness of managing water supply catchments, storage dynamics, treatment processes and distribution systems.

A variety of water quality data is collected within natural and constructed waterways by local councils, including pH, EC and turbidity.

3.4.2 State and federal government programs

There are a number or state and federal water quality monitoring programs that impact on current water quality data collection and management in Queensland. These include the following programs.

- Queensland Integrated Waterway Monitoring Framework – has been developed and is being implemented to ensure that all state government programs are integrated and the data available for use by multiple applications.
- Surface Water Ambient Network (SWAN) – collects data to report on condition and trend and to support state-wide investigations into water quality and risks to aquatic health.
- Stream and Estuary Assessment Program (SEAP) – a state-wide program designed to report on aquatic ecosystem condition and trends, integrate monitoring and assessment activities and improve current understanding of processes and components of the aquatic ecosystem that relate to condition.
- Paddock to Reef Program – this program is monitoring nutrient and sediment loads at approximately 35 sites across the Great Barrier Reef catchments. Intensive monitoring conducted through the program is used to assist the development and calibration of robust catchment models.
- Assessment for prioritising an integrated waterway monitoring program in Queensland – this program is collating information on policy and land drivers for

improved waterways quality monitoring and developing a methodology for prioritising geographic areas based on environmental risk.

- DERM water assessment program – assessing and managing the state's available water resources; data collected is also supporting other water quality monitoring programs.
- DERM wetlands assessment program – whilst there is no current broad-based risk or condition monitoring program for lacustrine and palustrine wetlands a set of tools have been developed to assess the risk to and condition of freshwater wetlands.
- DERM water quality monitoring programs – ambient and event monitoring programs are conducted as required.
- Ecosystem Health Monitoring Program - provides a detailed regional overview of the ecosystem health of the non-tidal reaches of rivers and streams throughout SEQ. The program measures waterway health using a broad range of biological, physical and chemical indicators of ecosystem health
- Sustainable Rivers Audit - an initiative of the former Murray-Darling Basin Commission designed to measure the health of the rivers at Basin scale.
- Lake Eyre Basin Rivers Assessment - designed to assess the condition of watercourses and catchments within the Lake Eyre Basin Agreement Area.

More detailed information on the above programs is presented in Appendix 3.

Organisations that maintain water quality sites tend to monitor a wide range of physical-chemical and aquatic health parameters. Only a subset of those physical-chemical parameters is required to be reported to the Bureau under the federal Water Regulations – category 9 parameters.

Table 5 presents the number of measuring points managed by named persons in Queensland that are located in watercourses and that monitor category 9 water quality parameters. Table 6 presents the number of water storages where category 9 water quality parameters are measured by named persons in Queensland. Table 7 presents the number of bores managed by named persons in Queensland that monitor electrical conductivity (EC), the only groundwater parameter listed in category 9 of the Water Regulations. All three tables identify how much of the monitoring is continuous or non-continuous.

Table 5 Number of measuring points managed by named persons in Queensland that are located in watercourses and monitor category 9 water quality parameters

Monitoring body	Number of measuring points in watercourses measuring water quality parameters, by currency		Total number of measuring points in watercourses measuring water quality parameters
	Continuous	Non-continuous	
Brisbane City Council	0	48	48
DERM	250	14	264
Fitzroy Basin Association	14	25	39
Mackay Regional Council	0	38	38
NQ Dry Tropics	0	79	79
Queensland Murray-Darling Committee	0	85	85
Redland City Council	6	0	6
Reef Catchments Mackay Whitsunday	0	21	21
SEQ Catchments Ltd	0	211	211
Seqwater[1]	23	66	89
South West NRM Ltd	4	37	41
Toowoomba Regional Council	0	1	1
Townsville City Council	0	51	51
Whitsunday Regional Council	8	0	8
Wide Bay Water Corporation	4	0	4
Total	**309**	**676**	**985**

Notes:

1. All Seqwater figures include water treatment plant (WTP) sites. The continuous surface water figure of 23 is all WTP sites; the non-continuous surface water site includes 17 WTP sites.

Table 6 Number of water storages where category 9 water quality parameters are monitored by named persons in Queensland

Monitoring body	Number of water storages where category 9 water quality parameters are monitored, by currency		Total number of water storages where category 9 water quality parameters are monitored
	Continuous	Non-continuous	
NQ Dry Tropics	0	1	1
Seqwater[1]	23	45	68
SunWater	50	0	50
Total	**73**	**46**	**119**

Note:

1. All Seqwater figures include water treatment plant (WTP) sites. The continuous storage figure of 23 includes 17 WTP sites; the non-continuous figure of 45 includes 20 WTP sites.

Table 7 Number of bores managed by named persons in Queensland that monitor category 9 water quality parameters

Monitoring body	Number of bores monitoring electrical conductivity, by currency		Total number of bores monitoring electrical conductivity
	Continuous	Non-continuous	
DERM	0	484	484
Toowoomba Regional Council	0	9	9
Total	**0**	**493**	**493**

3.5 Water management and accounting

3.5.1 Supplemented water resources

A supplemented water supply is one which is made more reliable by release and distribution of stored water, purified recycled water or desalinated water to watercourses, pipelines and/or channels. Supplemented supplies are managed by water service providers and water authorities. Supplemented water was historically referred to as regulated water.

A service provider can be a water service provider or a sewerage service provider. The *Water Act 2000* defines large, medium and small service providers as:

- large service provider – a service provider primarily providing bulk water services; or for a retail water service or sewerage service, a service provider with more than 25 000 connections to a registered service
- medium service provider – for a retail water service or sewerage service, a service provider with more than 1000 but not more than 25 000 connections to a registered service
- small service provider – for a retail water service or sewerage service, a service provider with 1000 or fewer connections to a registered service

Water authorities have rights to manage specific water activities, as per the definition in Schedule 4 of the *Water Act 2000* - including water conservation, water supply, irrigation, drainage, flood prevention, floodwater control, underground water supply improvement or replenishment and sewerage. A water authority can also become involved in certain other activities, such as, riverine protection, soil erosion control and land degradation treatment.

The measurement of urban water extraction and distribution is undertaken by urban water service providers to fulfil organisational and reporting objectives. The category 7 data parameters required by the Bureau include urban water extraction and distribution data.

The management of water supplies in SEQ differs from the rest of the state due to the introduction of water reforms described on page 22. The SEQ Water Grid is a network of two-way pipes connecting major water supplies in SEQ allowing the transport of water from an area of water surplus to an area with a water shortfall. This allows the risk to be managed at a regional level rather than at a storage level.

Since their establishment on 1 July 2010 the three new bulk distribution/retailer entities (Queensland Urban Utilities, Allconnex Water and Unitywater) have been responsible for the sale and distribution of potable water to end users, and the maintenance and service provision of the sewerage network. These functions were previously undertaken by individual local councils. These entities have recently been added to the list of named persons in the Water Regulations and are currently establishing mechanisms to deliver this data to the Bureau. It is expected that most of the information will continue to be delivered to the Bureau in WDTF through the SWIM data management system as has been happening to date.

Whilst these bulk retail entities also have some reporting responsibilities to the QWC, not all data required by the Bureau will be required by the QWC. Therefore if the WaterHub system was chosen to deliver SEQ data to the Bureau it would require further enhancements to allow for the ingestion of this additional data. At present the WaterHub system is delivering certain data from QWC that relates to the activities of the other bulk entities in SEQ, such as WaterSecure and certain data from Seqwater.

SunWater is a significant water service provider holding several ROLs and interim ROLs. These licences allow it to interfere with the flow of water to the extent necessary to operate infrastructure for supplying supplemented water to its customers. Licence

conditions require SunWater, and others holding similar licences to provide specified monitoring data to the department to specified standards.

3.5.2 Unsupplemented water resources

An unsupplemented water supply is one which is not augmented. Unsupplemented water supplies are managed by DERM and have historically been referred to as unregulated water.

To access unsupplemented water, a person must have a water entitlement, water permit or a statutory right to take water without an entitlement (e.g. for domestic purposes and stock watering on the land adjacent to a watercourse, lake or spring). Unsupplemented water includes water taken from groundwater, watercourses, lakes or springs and water harvested from flood flow and overland flow.

The measurement of unsupplemented rural water extraction is limited. Some measurement by individual entitlement holders is reported to DERM for compliance purposes and for billing for water harvesting. The category 5 data parameters required by the Bureau are in this category.

3.5.2.1 Water Metering Program

DERM is provided with the power to meter water extractions under the *Water Act 2000*. This power is supported by the *Water Regulation 2002* which provides for the specifics of the metering process, such as conditions of entry, site and works assessment, and charges applying to metered entitlements.

The Metering Water Extractions Policy was developed by the department to provide a framework for metering in rural Queensland. The metering policy specifies the types of situations that require metering to be implemented. The metering policy applies to all extractions in supplemented areas (areas managed by water service providers), while extractions that trigger the policy in unsupplemented areas will become ‘metered entitlements’. Extractions that do not meet the policy triggers, such as water taken for stock and domestic use will not be metered.

Meters will be introduced as ROPs are implemented, however other factors may also trigger meter rollouts. Under the policy the triggers for metering include:

- implementation of a ROP in a water planning area
- extracting water from supplemented systems operated by SunWater or other dam operators
- extracting unsupplemented water from supplemented systems operated by SunWater or other dam operators
- extractions located in ‘at risk’ areas where evident environmental damage or water depletion is occurring
- creation of transferable water allocations
- conversion of existing area-based licences to volumetric limits

- issuing new water licences (depending on local circumstances)
- extractions that contribute to growth in overland flow diversions
- involvement of entitlement holders in disputes over water 'stealing'

The metering policy also establishes that either DERM or a third party (but not the entitlement holder) will own all new meters in unsupplemented areas. All metering costs will be clearly identified by DERM and met by the entitlement holder. Metering charges will include the purchase, installation, maintenance and reading of the meter, as well as ongoing administration costs.

Metering water extractions provides water use information that allows DERM to:

- improve the outcomes of WRPs and ROPs
- collect data for catchment-wide modelling and planning purposes
- monitor water resource availability in 'at risk' areas
- ensure that entitlement holders take no more than their entitled share
- provide a fair and transparent basis for water use billing and charges
- facilitate water trading and temporary water allocation transfers
- assist entitlement holders in improving on-farm water use efficiency.

The metering program aims to install around 10,000 new meters throughout the state over the next few years.

3.5.3 Water rights, allocations and trades

The right to take water is regulated by the lead water agency. Water entitlements are issued by DERM, as the lead water agency. The right to trade water is determined through the water planning process; water trading dealing certificates are approved and issued by DERM and trades are registered on the Water Allocations Register (WAR) also managed by DERM.

3.5.3.1 Water sharing rules

Water sharing rules establish a framework for water use accounting and as such provide an accountable and auditable trail for the movement of water use within and between water entitlements. These rules also ensure that arrangements for access to water and water use accounting within a water management area are clearly articulated to water entitlement holders, to provide them with a stable water use accounting regime.

3.5.3.2 Water authorisations

A water authorisation is a general term for water entitlements, water-related permits, development permits and other water-related notifications and certificates.

A water entitlement can be a water licence, water allocation or interim water allocation. Water licences exist in regions that have a ROP in force and also in regions that do not. They can be volumetric or area-based licences. Water allocations exist in regions that have a ROP in force. They are all intended to be volumetric based entitlements. Current area-based licences are being converted to volumetric allocations as ROPs come into force although some exceptions to this still exist. There are currently almost 41,500 active authorisations in Queensland, over ninety percent of which are water entitlements. Volumetric allocations or licences manage over 5,700 gigalitres of water; area licences cover more than 111,000 hectares of land.

A water-related development approval may be required to develop works that take or interfere with water in a watercourse, lake, spring aquifer, or from overland flow. Such works may include but are not limited to pumps, diversion channels, weirs, dams, or bores. Approvals for water-related development are covered under the *Sustainable Planning Act 2009*. Development approvals are issued by the Department of Infrastructure and Planning.

3.5.3.3 Water trading

Water trading is the buying and selling of water separate to the sale of land. This enables users to buy water to expand their operations, or sell water they do not need. Trading is voluntary, and prices are set by the market. In Queensland the types of water trading include:

- permanent trading of water allocations
- leasing of water allocations
- seasonal assignment (or temporary trade) of water available under a water licence, interim water allocation or water allocation
- permanent transfer of interim water allocations in certain parts of the state

Note that a water allocation is equivalent to a water access entitlement.

There are currently markets for surface water only, but markets for underground water will be developed in the future.

Water trading is currently available in areas where ROPs have approved the establishment of water allocations and in the Mary River water supply scheme where water allocations have not yet been established but demand is high.

Registered attributes of water allocations are recorded on the WAR. The WAR is an accurate and secure register that centrally records the holders of, and other information on water allocations. To have effect the trade of a water allocation must be recorded on the register.

A water allocation title records a range of attributes for that allocation such as: details on the allocation holder, dealings, encumbrances and a range of resource-related attributes. Resource-related attributes include details on location, purpose, conditions, nominal volume, extraction rate, flow conditions and volumetric limits.

The register is managed by the Registrar of Land Titles and Water Allocations (within DERM) and is publicly searchable on a fee-for-service basis. DERM's water management system has access to certain information on dealings lodged and registered in the WAR. It is from this system that this information is being delivered to the Bureau.

National Water Market System

In November 2008 the Council of Australian Governments (COAG) agreed to the development of a national water market system (NWMS) to be operational by 2011-12. The Commonwealth Government is currently scoping the development of a NWMS and the Queensland component of this project involves enhancements to its existing registry system (i.e. the WAR and DERM's water management system).

The key objectives of the NWMS are to:

- ensure each jurisdiction has a sound register that records property rights and supports water accounting and resource management
- ensure that the transaction times for trades and other dealings is not limited by register processes
- ensure inter-operability between relevant water registers to improve the efficiency of interstate trading

Queensland is assisting this process through the delivery of category 6 Water Regulations information to the Bureau.

3.5.4 Water accounting

Under the NWI, the governments of Australia are now focused on enhancing Australia's water accounting capabilities, with a particular focus on putting in place a consistent approach to water accounting across the nation.

Water accounting is the application of a consistent and structured approach to identifying, measuring, recording and reporting information about water.

The NWADP envisages that water accounting in Australia will involve the regular preparation of general purpose water accounting reports relating to water entities by water organisations, in accordance with Australian water accounting standards (AWAS).

The Bureau will also be drawing on water accounting information to produce a NWA, as required by the NWI and the *Water Act 2007*.

DERM has approached the development of water accounting with a view to integrating it with existing reporting requirements. It is envisaged that it will enhance some aspects of current reporting, such as the annual report for WRPs.

Queensland undertook the Pioneer Valley pilot project to trial a comprehensive approach to water accounting at a WRP level as part of the NWADP. Since the pilot a Pioneer Valley water account has been produced annually in the report for WRPs. The Pioneer Valley water accounts provide volumetric information on the supply and use of

water in the Pioneer Valley catchment. Supplemented surface water is supplied through a distribution network of dams, weirs, channels and pipes. In the Pioneer Valley, access is also provided to un-supplemented surface water and groundwater.

A number of water related 'events' were identified within the Pioneer Valley catchment. These were used to develop the debit and credit transactions which formed the underlying information for preparation of the chart of accounts and general purpose water accounting reports. Transactions for water resources in the Pioneer Valley, based on the chart of accounts, have been undertaken for 3 years commencing in the 2005-06 water year. Data sources and quality associated with these transactions were identified.

The Statement of Water Assets and Liabilities (balance sheet), the Statement of Changes in Water Assets and Liabilities (profit and loss statement) and the Statement of Physical Water Flows are the three general purpose reports used to report on water resources in the Pioneer Valley. A contextual statement and disclosure notes are also produced as part of the annual account.

Resources, data, catchment characteristics, governance and water budget issues associated with implementing water accounting across Queensland were identified in the pilot project. Generally it was found that DERM would have to invest in the enhancement of existing Information Technology (IT) systems and work practices as well as develop new IT systems and work practices to enable the supply of water accounts across Queensland on a regular basis. The development of a Water Accounting Reporting System (WARS) is required to make data gathering, storage, management, analysis and collation more streamlined for water account preparation and reporting.

Water accounts have been produced for the Gold Coast, Logan and Moreton WRP areas since 2009-10. The water accounts for these four WRP areas also appear in the annual report for WRPs.

Data and information for the Gold Coast, Logan and Moreton WRP areas are forwarded to the Bureau as part of DERM's participation in the National Water Account.

QWC has developed a data management system (WaterHub) which collects water resource data for South East Queensland.

qldwater has developed the SWIM system to collect data compatible with NPR data, and has received Bureau funding to further enhance its functionality for provision of data to the Bureau.

3.6 Data management

3.6.1 Data standards

3.6.1.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)

These guidelines provide an authoritative guide for setting water quality objectives required to sustain current or likely future, environmental values for

natural and semi-natural water resources in Australia and New Zealand. They are not mandatory but provide water managers with recommendations they can use to guide practice and formulate policy, taking into account local conditions and associated costs and benefits.

More information is available online.

3.6.1.2 Queensland Water Quality Guidelines 2009

The Queensland Water Quality Guidelines 2009 were developed to produce a greater regional focus than the national guidelines for water quality. They address the need to protect aquatic ecosystems and human uses of waters by determining the water quality guidelines for an environmental value for water and the indicators for an environmental value for water.

More information is available from the DERM website.

3.6.1.3 Monitoring and Sampling Manual 2009

The Monitoring and Sampling Manual 2009 provides the common techniques, methods and standards for sample collection, handling, quality assurance and control, custodianship and data management for use by Queensland Government agencies, relevant persons and other organisations.

The manual is part of an integrated monitoring framework to decide the priorities, indicator selection, data storage, data analysis and reporting.

The Monitoring and Sampling Manual 2009 will facilitate consistency and increased scientific rigour of monitoring data available to all stakeholders. The data will support assessment of the condition and trend of Queensland waters so that the aquatic environment can be managed for sustainable development and aquatic ecosystem health.

The Monitoring and Sampling Manual 2009 is the primary document to determine the protocols where monitoring is required under legislation.

More information is available from the DERM website.

3.6.1.4 Water Monitoring Data Collection Standards

In order to ensure public confidence in the acquired data, water planning and management programs of DERM, a certified Quality Management System (QMS) is enforced. The Water Monitoring Data Collection Standards (NRW 2001, version 3.1) maintain a minimum standard of accuracy necessary to measure or derive data relating to surface water, groundwater and riverine ecosystem resources. The Water Monitoring Data Collection Standards apply to all water resource monitoring in Queensland that is required under the *Water Act 2000*, and any subordinate legislation (e.g. WRPs and their subsequent ROP) or departmental policy.

More information is available from the DERM website.

3.6.1.5 Groundwater work practices

Considerable effort has gone into the documentation of comprehensive operational work practices for groundwater monitoring that describe processes for key tasks including monitoring and maintenance procedures and data storage processes. Development of comprehensive training videos as companion tools to the work practice documents has proved effective in the training of new staff in groundwater monitoring procedures across Queensland. DERM reviewed a small number of these in conjunction with other jurisdictions, as part of a project funded by the Bureau in 2008-09.

3.6.1.6 DERM's Quality Management System/Framework

DERM has accreditation for its water monitoring functions under ISO 2001 guidelines. In support of the QMS, DERM has many water monitoring field and data collection work practices and procedures for both surface and groundwater functions.

3.6.2 Data management systems

3.6.2.1 Groundwater systems

DERM is the primary collector of bore monitoring data in the state and its groundwater data is stored in the Groundwater Database (GWDB). The GWDB is an Oracle-based system that is not publicly accessible through the internet. However, groundwater data is readily available from this database in a range of formats, such as hardcopy, spreadsheet, geographic information systems and text, by request to the department's Product Delivery unit. Data in the GWDB dates back to 1895 although most of the monitoring activities date from the mid 1940's. DERM GWDB managers have developed a tool to deliver data from the GWDB to the Bureau in WDTF. This means that the vast majority of groundwater monitoring data in Queensland will soon be delivered to the Bureau in the preferred format.

SunWater's bore level information is stored in their SWIMS R1 database where this information is collected by SunWater. The information collected on their behalf by DERM is stored in the DERM GWDB. The data from bores measuring seepage around their storages is not stored in a central repository system.

Groundwater monitoring data held by Toowoomba Regional Council is stored in Excel spreadsheets.

3.6.2.2 Surface water systems

The majority of surface water level and flow data in the state is collected and stored within the data management systems of DERM, SunWater, Seqwater and local governments. Surface water data in DERM is stored in the Water Accounting System (WAS) which is a Kisters (Hydstra) system. Hydstra is able to manage large amounts of time-series data. It is a collection of

database management tools and hydrologic software packages that allows users to store and organize historical data, graphically analyse and edit hydrologic data, store and access digital photos, maps and other documents associated with stream files. Hydstra also offers various output formats, both graphical and tabular, to share stream data with others. DERM has been investigating the potential of the Hydstra Web function to improve public access to its stream flow data; web access to this data will commence in June 2011. DERM is undertaking a trial of a WDTF tool for the Hydstra system, similar to the trial undertaken by the New South Wales Office of Water. It is hoped that in the near future data will be delivered from all Hydstra users to the Bureau in WDTF. DERM also uses another Kisters product, Soda, to manage its telemetry network.

With Round 4 M&E Program funding Seqwater has contracted Kisters Pty Ltd to install the WISKI system to centrally manage their data, and to develop a tool to enable the transfer of data from WISKI to the Bureau in WDTF. This tool will become available for other WISKI users to adopt. Data at SunWater is currently stored in TimeStudio but they too will soon adopt the WISKI system to replace TimeStudio. Like Hydstra, WISKI is a Kisters product that is able to manage large amounts of time-series data and a range of data types – surface water, groundwater, dam safety etc. WISKI is a scalable three tier data management system; the data tier where the time-series data is stored is a relational database such as Oracle or an SQL server.

The DERM Water Management System (WMS) is a web-based application that provides decision supported workflow and various security-driven navigator controls. The WMS application is delivered via an application framework that incorporates process integrity and common behaviour. WMS delivers the licensing, water use and billing needs for the department.

WMS was commissioned on the 31 March 2009 and contains approximately 20 years of records. Data quality from the early period has a confidence level of approximately 85 percent. However, moving forward this is anticipated to be much higher.

SunWater undertakes manual readings from gauge boards which is stored in their SWIMS R1 data management system. This SAP-based system is used to store non-continuous storage level and volume data, information about releases from storages and diversions to irrigation areas and other bulk users and water quality data.

SunWater also collects other data via a SCADA network. The data collected via SCADA systems are mainly related to information on balancing storages, operation of channel systems, etc. This information is not stored in a central repository system.

Seqwater currently has no central data management system and is looking at adopting a system such as WISKI to bring their data into the one system and be able to deliver data to the Bureau in the preferred Water Data Transfer Format (WDTF).

The majority of large councils use SCADA systems to get data from the field into their offices. However councils may use a number of differently-formatted

Excel spreadsheets to store this data, making it extremely difficult to automatically upload this information into other external data management systems. Smaller councils not using SCADA systems tend to store their data in Excel spreadsheets in a number of local systems.

This situation has been exacerbated by the local body amalgamation process, as councils now have to manage with an even wider variety of formatted information. Fraser Coast Regional Council has been funded under round 2 funding from the Bureau to develop the SWIM system, on behalf of the majority of named councils in Queensland, to incorporate the reporting requirements of the federal Water Regulations. *qldwater* is managing the SWIM project. Through the SWIM system, *qldwater* will collect the required information from councils, reformat into WDTF and report this information to the Bureau on behalf of councils.

Toowoomba Regional Council is an example of the impact of local body amalgamations on council data management. Toowoomba Regional Council was formed from the merger of Toowoomba City Council with seven smaller councils. Some level of central reporting has commenced. As the water information collection and monitoring that occurs through the new council region is undertaken at different levels, the amount of data stored in SCADA also varies. There is currently no single SCADA point of access to analyse/report all Toowoomba Regional Council data and information.

The QWC has developed its own in-house data management system – WaterHub. This system stores, analyses and provides secure access to SEQ water-related information in support of effective analysis, planning and reporting by the QWC. As at the end of January 2010 it comprises of six key storage and analysis components. These six key areas are:

- Volumetric Point Measurement Module – collects stores and extracts bulk volumetric flow volumes.
- Production Analysis Module – analyses consumption
- Consumption Analysis Module – analyses retail billing data
- Demand Forecasting Module – online modelling tool
- Reporting Facilitation Module – data ingestion and delivery tool
- Business Intelligence Module – provides dynamic reporting capability.

Data management systems used by a variety of organisations for both surface water and groundwater do not necessarily have the functionality to adequately describe or manage the various parameters measured whilst undertaking water monitoring activities.

3.6.2.3 Meteorological data management systems

Data from the flood warning network is stored in various Bureau computer systems, mostly in Oracle databases. Only a portion of the rainfall data (derived from daily totals) is transferred to the Bureau's climate archive. Most of the historical high-resolution rainfall data (from the TELEMETER and

ALERT stations) and water level data is only stored in legacy databases within the Queensland office.

Data from the Queensland flood warning network is not consistently quality-controlled, nor transferred to water-industry standard systems (e.g. Hydstra), although it is available to do so at some future time, perhaps to the Bureau's Australian Water Resources Information System (AWRIS) under development as a component of the national water information role.

3.6.2.4 Water quality data management systems`

Accessing water quality data has historically been a major challenge. This is primarily due to the differing file formats adopted by the many organisations involved with water quality monitoring. Additionally, the ability to compare data of a particular parameter is difficult due to differing terminology and analysis methods used across testing laboratories. Many organisations throughout Queensland, both government and non-government, maintain large volumes of data stored in various file formats.

Water quality data on all bodies of water must be collected, managed and evaluated, and both qualitative and quantitative data must be combined in the analysis to provide a meaningful dataset. DERM uses Hydstra as the standard data management package for water processes, measuring quantity as well as quality.

Hydstra is part of the Water Accounting System (WAS) which stores and enables analysis of:

- Time-series data – both height and flow
- Water quality data – Hydstra also supports management of time-series water quality data, including EC, temperature, pH and turbidity, as well as point water quality data where samples are sent away to a laboratory for analysis. Field handheld readings are also stored in the database.

DERM's GWDB stores all water quality sample analysis results associated with the groundwater monitoring network – including EC, pH and temperature.

DERM stores the majority of discrete water quality sample analysis in WAS. However to enable sound data management, the analysis results are kept in different data stores within the Hydstra system. Ongoing data is stored in the Surface Water Database data store and project data is stored in the Project Science Database. Some information is also stored locally.

This can pose challenges for accessing all this information and for delivery of the information to the Bureau. Potentially the delivery of discrete water quality data through Hydstra will be managed more effectively following a recent upgrade to Hydstra version 10 - undertaken in early 2011.

Those Queensland NRM bodies with current water quality monitoring programs in their catchments are investing in a uniDap Solutions product, uniDap WaterQ (WaterQ), to manage their water quality data. This system enables the development of database applications on a universal core

architecture which consists of 40 core tables in a unique, innovative and abstracted pattern, thereby making the system highly flexible and cost-efficient.

This data system enables NRM bodies to manage their data in one system, where previously it was stored in a range of spreadsheets in a variety of formats. This system allows them to input their data, have it approved and ready for community access over the internet in a very short time frame. There are currently 17 catchment groups from across Australia that have adopted WaterQ to manage and report their water quality data.

3.6.3 Metadata

When considering overall data sharing/collation and management issues that arise when data is provided by several sources, there is no bigger issue than having appropriate metadata available. Appropriate descriptors are required for the full range of water monitoring data that is collected, and also for subsequent water quality analysis coding. Similarly, data quality coding needs appropriate methodologies for determining and then applying relevant quality codes.

Many of the water monitoring sites throughout the state need to have location details added into the various management systems and/or have those details validated.

SunWater stores appropriate metadata, such as gauging station details, flow rating curves and storage level to volume relationships in their Time Studio or SWIMS R1 data management systems.

3.6.4 Spatial data

The Australian Hydrological Geospatial Fabric (Geofabric) is being developed as the geospatial framework to underpin AWRIS. It will hold key spatial data layers within a single, consistent, national geospatial framework for hydrological features. The Geofabric will contain a consistent representation of water features, and their connectivity, in the Australian water system. The Bureau is leading the Geofabric project, in partnership with Geoscience Australia (GA), the Australian National University, CSIRO and state jurisdictions. The partnership provides a collaborative mechanism for obtaining foundation hydrological data and upgrading this data through an enduring maintenance framework.

A national data audit was undertaken by GA which delivered a number of investment recommendations to the Bureau. These recommendations included the need for each state to undertake a project aimed at integrating individual agency mapping into a single point of truth surface hydrology database and significant revision of key spatial datasets – in Queensland the nominated areas are the SEQ, Burdekin and Murray-Darling catchments.

3.6.5 Data availability

3.6.5.1 Strategic coordination of water data

There is no one entity in Queensland that manages the state's water data; a number of named persons and other entities are involved in the collection and management of different types of water data to meet a range of organisational outcomes. To date there has been no attempt to centralise or centrally publish water data at a state level that would cover all the different water sectors identified in the Water Regulations. Historically, whilst some data relating to water supply and water quality is required to be reported under some form of legislation, water data is requested from other organisations by the state government on a voluntary basis and for specific reporting outcomes only. There is little data sharing between organisations.

Whilst the Bureau can require this information to be delivered under the Water Regulations there has been a need for some level of strategic coordination to ensure named persons understand their requirements and have the opportunity to identify issues with meeting their requirements and gaps in their data collection and monitoring activities. The Bureau has funded strategic coordination under Rounds 1-4 of the M&E Program through the lead water agency. Whilst all named persons are delivering data directly to the Bureau, or through a third party, DERM has coordinated input from the major water data providers into relevant Bureau activities including the development of this report. An interagency working group has been formed to speed up the delivery of communication between named persons and the Bureau. This working group has agreed to meet on an as needs basis post M&E Program funding to act as a communication conduit only.

3.6.5.2 Groundwater data availability

Data sharing agreements are developed between DERM and stakeholders on request for the purposes of particular projects only.

External access to data is made available using the following business rules:

- Small requests are free of charge but each organisation that requests data is allowed only 5 free requests per year.
- After 5 requests, regardless of the size of the query, a cost is incurred.
- A large data request (more than 5000 bores) incurs a cost.

Data is provided under a range of licence conditions – single supply licence (one-off supply), short form licence (multiple supply) or long form licence (when a royalty payable in arrears is required).

3.6.5.3 Surface water data availability

The data from many of the DERM gauging stations is available in near real-time to allow for improved operational use of the network. Data for the previous 14 days is available via the department's website as unverified

telemetry data. Having this information available publicly means that it may be used for a range of purposes. The data collected from the gauging station network is stored in the department's Water Accounting System (WAS) Hydstra proprietary database. The data goes through a process of validation by the department's hydrographic officers and is quality coded accordingly. Data may be accessed either via the department's website or via formal request. Should a data request take an excessive amount of time to process some labour charges may be incurred. DERM does not supply 'value added' analysis of data, i.e. flood recurrence intervals. More information is available from the DERM website

DERM has a number of data sharing agreements with water service providers, NRM bodies and local government. DERM and SunWater have recently committed to the sharing of stream flow data under a CC Licensing arrangement. This will significantly improve the flow of data between these two key organisations.

ROL holders report data to DERM as per their licence conditions. This data forms part of their quarterly reporting requirements and is sent in Excel spreadsheets or as part of written reports. ROL holders include local governments, water boards and other water service providers.

Apart from regulatory reporting to the state government and the sharing of data with the Bureau for flood warning purposes, there is limited organised sharing of surface water data by non-government agencies in Queensland.

Data from water service providers is provided to DERM for National Performance Reporting on a voluntary basis only and it is therefore hard to establish ongoing datasets for analysis.

Data from DERM's metering project is currently stored locally but is intended to be stored in Hydstra at some point in the near future to enable easier access to this water use information.

Wetlands mapping and inventory data is available online through DERM's first-stop-shop for wetlands information Wetland*Info*.

3.6.5.4 Impact of floods on access to data

Access to data during extensive flood events is critical. As a result of the flooding across Queensland in 2010-11, near real-time flow data was not available from a small number of DERM's gauging stations. Following requests from the Queensland Regional Office of the Bureau the department's regional hydrographic officers, coordinated by central office personnel, undertook repairs to those stations where it was safe to do so, as a priority to support the Bureau's activities.

During the SEQ Floods in January 2011 the Brisbane Central Business District (CBD) was closed due to power failure; affecting Mineral House where DERM's WAS server is located. The Disaster Recovery server located at another Brisbane location was brought on line, as per the departments WAS Business Continuity Plan, and subsequently used to manage the gauging station data. After working through communication issues resulting from the

loss of power to the CBD, access to all gauging station data was enabled again. The gauging station development server housed at Rocklea, which is used to trial new communication technologies, was moved off-site to ensure continuity of this service as the Rocklea office was inundated. After some technological issues relating to the change in location were resolved the server was operational and data could again be accessed on the department's website.

To ensure the timely preliminary repair of the gauging station network to meet both departmental and Bureau immediate priorities additional staff were re-assigned to assist with these activities. A Flood Recovery Plan to repair the gauging station network was developed as part of the Synchronised Queensland Reconstruction Road Map. This plan aimed to identify the activities required to ensure the long term repair and restoration of the network and the continual improvement of the management, systems, work practices and plans for its operations.

DERM has received many requests to provide streamflow data from flood affected areas and has allocated additional resources for this activity. These data are being provided on a priority basis in accordance with standard processes undertaken in DERM for data supply. To assist in the provision of streamflow data from the floods across Queensland the department has created a CD of all state gauging station data. Hydrographic officers are validating the relevant telemetry data as a priority. All streamflow data provided by the department has a user license, with the quality of the data clearly identified.

3.6.5.5 Water storage data availability

The water monitoring data of SunWater is currently shared in the following manner:

- current and historical storage level, volume and stream flow data from their gauging stations is available from their website
- data from gauging stations is shared with DERM under a data share agreement
- all other data not publicly available may be accessed through a licence agreement, where applicable

There is currently no cost for this access.

3.6.5.6 Meteorological data availability

DERM – the department makes a range of meteorological monitoring information available from its website, including hourly figures of air quality data.

Bureau - In addition to bulletins of information issued by fax, email, etc. to those agencies involved directly in the flood warning system, the Bureau continuously updates the rainfall and water level data on their website.

Depending on the station, processed data for the past several days is available on the website as a part of the flood warning service. The data is also supplied in response to requests for data from a large range of government agencies, organisations (engineering and environmental consultancy companies, insurance companies, primary producers, mining companies, etc.) and the public.

3.6.5.7 Water quality data availability

Through negotiated agreements, Australian, state and local governments and NRM bodies provide support, technical advice and training in monitoring to interested groups as well as to the general public. They also provide assistance in data management and interpretation. Water quality data is available from DERM under the access conditions as per surface and groundwater data. NRM regional body data is available over the internet to registered members of each regional body community.

4 Section C

This section presents analysis of the gaps and issues relating to the collection and management of freshwater data in Queensland. Preceding the gap analysis is a summary of a review of the impact of M&E Program funding on the closure of the gaps that were identified in the Queensland SWIMP 2010. Stakeholder investment in closing gaps is also acknowledged where this is known. Gaps that have received M&E Program funding and that have been fully closed are also acknowledged. New gaps that have arisen are included in the gap analysis. All figures used in this publication are GST exclusive.

4.1 Review of the impact of M&E Program funding

The objective of the $80 million M&E Program is to assist water data providers to modernise and extend their water monitoring or data management systems. This investment is enhancing the capacity of data providers to deliver data to the Bureau that has a wider coverage; is more frequent, current and accurate; and can be delivered to the Bureau in a standardised format. There have been 4 rounds of funding completed to date with the fifth and final round to be completed by the end of June 2012.

By the end of Round 4 in June 2011 Queensland named persons will have received funding of over $14 million. What impact has this funding had on their water data collection and monitoring activities?

Presented below are tables and graphs outlining some overall benefits from this funding; more detailed descriptions of the impact on specific gaps are presented throughout Section C. Appendix 4 presents further summary analysis of the impacts of M&E Program funding.

As this analysis was prepared prior to the completion of Round 4 projects two assumptions have been made:

- All Round 4 projects will be completed as per project plans.
- All funding allocated to Round 4 projects will be received.

Assessing the closure of gaps from a state perspective is complex. Not all monitoring stakeholders have been eligible for funding from this program as it is only available to those organisations that are named in the Water Regulations. For example there are many water service providers collecting water data who do not provide this information to the Bureau. Also, not all named persons have identified what their gaps are; therefore the analysis looks at the closure of gaps for particular organisations only. For example, following a network review, it was identified that DERM requires 179 new gauging stations. With M&E Program funding DERM is installing ten new gauging stations, therefore this gap has only been closed for DERM by 6 percent with 94 percent of the gap still outstanding.

Table 8 presents the number of gaps that have been partially or fully closed for particular organisations. For example, DERM has fully closed five gaps with M&E Program funding, three-quarters closed a further ten gaps and half closed a further six gaps. With a total of 25 DERM projects funded during rounds one to four of the M&E

Program this represents an excellent return on federal investment in the lead water agency.

Table 9 presents the number of projects funded to address individual gaps. Gaps are presented by funding theme. It also presents the level of closure for each funded organisation for each gap. For example, six projects were funded to upgrade or install telemetry at water storages; this funding fully closed this gap for four organisations. The funding therefore has had a significant impact on the capacity of these organisations to deliver data that is more frequent and reliable from their water storages.

Table 8 Number of gaps identified in the Queensland SWIMP 2010 that have been closed, by named person

Person category	organisation name	**Total Number of funded projects**	Total number of project applications submitted	Number of gaps addressed through M&E funding			
				Number of gaps, 100% addressed	Number of gaps, 75% addressed	Number of gaps, 50% addressed	Number of gaps, <50% addressed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
A, D, H	Department of Environment and Resource Management	25	29	5	10	6	4
H	Burdekin Shire Council	1	5		1		
H	Hinchinbrook Shire Council	1	1	1			
H, F	Ipswich City Council	1	15				1
H, F	Brisbane City Council	1	4				1
G	SEQ Catchments Ltd	3	8		1	2	
G	South West Natural Resource Management Ltd	2	6	2			
F, H	Wide Bay Water Corporation	4	4	1	2	1	
F	Queensland Water Commission	1	1	1			
D, H	Southern Downs Regional Council	1	1		1		
D, F, H	Queensland Bulk Water Supply Authority (Seqwater)	9	10	4	1	1	3
D, F, H	Townsville City Council	1	6		1		
D, F	Gladstone Area Water Board	1	3	1			
D, F	Rockhampton Regional Council	4	4	4			
E, F, H, D	SunWater	5	6	4	1		

Table 9 Number of projects undertaken per gap and the number of gaps closed

Theme 1. Improving the accuracy of existing water storage measurement, stream flow, groundwater, meteorological, and water quality networks								
				Number of M&E funded projects				
Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed	
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	
16	A lack of appropriately trained staff and adequate operational resources are emerging issues across agencies.	4	4					
19	Upgrades to gauging equipment are required for some organisations managing flood warning systems.	3	6					
12	Enhanced ratings of gauging stations and storages are required to improve the accuracy of data collected.	2	3					
13	Bathymetric surveys of storages are required to confirm storage capacities.	1	1					
2	The installation of data loggers on bores would result in data better able to characterise recharge events and water level depletion.	1	1					
32	There is a need for enhanced modelling capacity, particularly in the south east and south west regions.	0	1					
8	Resourcing for monitoring operations and for training to increase monitoring staff skill levels are emerging issues across all groundwater networks.	0	0					
21	There is a specific need for improved rain and water level monitoring in catchments above large storages.	0	0					
22	Stage-discharge ratings relationships for new and existing gauging and flood warning stations are required to provide data to assist predictions of critical flood heights at key towns and rural areas, and to assist water resource objectives.	0	0					
23	A major review is required for all gauging and ratings in the QMDB rivers and in other rivers where this would assist the collection of data for both flood warning and water resource assessment purposes.	0	0					
24	Technical and institutional support is required for local governments and regional bodies operating monitoring networks, especially rainfall and river height monitoring for the purposes of flood warning.	0	0					
25	A lack of skilled operators is a critical issue in obtaining enhanced ratings at flood warning sites.	0	0					

Theme 2. Installation of Telemetry							
				Number of M&E funded projects			
Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
17	There is a need to upgrade to automatic systems and install telemetry for instantaneous recording of storage levels.	6	10				
10	A number of existing gauging station data loggers require upgrading to improve data currency and to minimise data loss.	4	7				
3	A number of existing data loggers attached to bores require upgrading to improve data currency and to minimise data loss.	0	0				

Theme 3. Extending the coverage of the monitoring network to address critical information gaps.							
Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of M&E funded projects			
				Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
18	Gaps exist in spatial and temporal monitoring in flood warning networks, including in the high resolution ALERT-type networks and for inland towns and regions, particularly in south west Queensland and in the catchments of major storages.	3	29				
9	Spatial and temporal gaps exist in state surface water monitoring networks.	2	5				
26	Spatial and temporal gaps exist in the water quality monitoring networks of the lead water agency, NRM bodies and local governments.	2	8				
1	Spatial and temporal gaps exist in all bore networks, but particularly in the north, south east and south west regions.	1	2				
15	Additional data collection is required to reduce uncertainty in river modelling – issues particularly noted in the QMDB and the northern North-East Coast catchments.	0	1				
28	Frequency of sampling for some parameters, such as sediments and nutrients needs to be increased.	0	1				
7	A lack of sufficient bore monitoring data, particularly in high risk areas, impacts on the development of accurate models.	0	0				
20	Flood warning networks for inland towns and regions and in south west Queensland need to be further developed.	0	0				
27	More data loggers and probes are required to obtain real-time water quality datasets.	0	0				
29	Further monitoring of salinity, nutrients and pollutant loads is required, especially in the QMDB and SEQ.	0	0				

Theme 4. Improving water data (and metadata) management procedures.

Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of M&E funded projects: Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
54	Data management systems of many monitoring organisations require enhancement.	5	10				
46	The uniDap WaterQ system needs further enhancement to incorporate standardised metadata coding, as being developed in Queensland and New South Wales.	3	4				
50	Further enhancements to the SWIM data management system are required to ensure sustainable reporting of urban water data to the Bureau in WDTF – including enhancement of the QA/QC module, capture and translation of historical data and metadata into WDTF a	3	3				
45	Seqwater requires a new centralised data management system that will better manage the data from their extensive water monitoring networks. Upgrading to WISKI would also make their data compatible with SunWater and DERM systems. A tool to convert data in	1	1				
56	The data sharing capacity of water data collectors should be improved to allow wider access to relevant water data.	1	1				
47	There is a need for a method to easily integrate data from different SCADA systems.	0	1				
35	Enhancements to DERM and SunWater data management systems may be required once specifications for water allocation and trading data are available.	0	0				
44	SunWater requires upgrading of its TimeStudio system to the new WISKI system to ensure reliable storage and reporting of SunWater time-series data. A tool to convert data in WISKI into WDTF for delivery to the Bureau is required.	0	0				
48	Data validation is required for data in DERM's surface and groundwater databases.	0	0				

Theme 5. Recovery or rescue of water information, including metadata.

Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of M&E funded projects: Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
49	Many organisations have valuable data that should be digitised to expand datasets and assist with trend analysis and to better understand the quality of data.	0	1				

Theme 6. Improving the Australian Hydrologic Geospatial Fabric's (AHGF) national surface water foundation data set.

Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of M&E funded projects: Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
4	Bore locations should be aligned to a known datum to improve the quality of data collected and to support development of a national geofabric dataset.	2	2				
51	The surface hydrology spatial dataset requires cleaning, segmenting, networking, direction, edge matching, editing and attribution to improve the quality of data and maximise benefits for water managers and data users.	1	1				
5	There is a lack of measured data relating to connected groundwater systems and base flows (surface water-groundwater connectivity).	0	0				
11	Gauging stations and storage gauges should be aligned to a known datum to improve the quality of data collected and to support development of a national geofabric dataset.	0	0				

Theme 7. Improving the Australian Hydrologic Geospatial Fabric's (AHGF) national foundation groundwater data set.

Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of M&E funded projects: Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
52	Mechanisms need to be developed to transfer data into the National Groundwater Information Service data model being developed by the Bureau.	2	2				

Theme 8. Participating in the cooperative planning and production of the National Water Account (NWA).

Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of M&E funded projects: Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
37	Enhanced information systems to better collect, manage, and deliver NWA and AWAS compliant data and information are required.	2	2				
36	There is a wide range of data that is currently unavailable for inclusion in the National Water Account due to inadequacies in data collection processes and systems, incomplete data measurement and recording, or is currently not required to be measured or	1	1				

Theme 9. Engagement of Strategic Water Information Coordinators.

Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of M&E funded projects: Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
55	Strategic coordination is required to assist named persons with their data reporting to BOM.	4	4				

Theme 10. Development and application of best practice guides or standards for the collection, monitoring and storage of water information and or metadata.							
Gap ref. #	Gap	**Total Number of funded projects**	Total number of project applications submitted	Number of M&E funded projects			
				Number of projects which fully addressed gap for the funded organisation(s), ie 100% closed	Number of projects which **part** addressed gap for the funded organisation(s), 75% closed	Number of projects which **part** addressed gap for the funded organisation(s), 50% closed	Number of projects which **part** addressed gap for the funded organisation(s), <50% closed
				1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
38	Standardised approaches to data processing, management and quality coding are required across all monitoring organisations.	4	5	1	1		2
39	Standards for the use of Doppler technology and for the development of ratings curves are high priorities for the larger monitoring organisations.	1	1	1			
53	A coordinated training and accreditation framework would assist in enhancing standardisation in monitoring techniques and processes for quality coding and metadata capture.	1	1	1			
6	The analysis, evaluation and reporting of bore monitoring data is inconsistent.	0	0				
14	There is a recognised need to standardise analysis techniques used for surface water monitoring.	0	0				
30	Inconsistent methodology for determining sediment, nutrient and pollutant loads from event monitoring impacts on data quality.	0	0				
31	Better analytical methods of historical and real-time water quality data are required, especially for data poor areas.	0	0				
33	Multiple reporting requirements of federal agencies for water trading information are an issue for state organisations.	0	0				
34	Aggregating state water trading information up to a national level is complex and requires significant collaboration between state and federal agencies.	0	0				
40	Further review work and inter-jurisdictional collaboration is required on a range of field and operational work practices with a view to creating Australian standards.	0	0				
41	Defined quality coding and metadata and appropriate enhancements to data management systems are required to ensure integration of data is possible.	0	0				
42	Alignment of data reporting standards and formats between state and federal agencies such as the Bureau is required.	0	0				
43	Development of a national framework for water quality metadata is required.	0	0				

Applications to the M&E Program had to meet the criteria of funding themes that differed slightly from one funding round to the next, with key themes remaining constant. Funding for activities to extend or improve the accuracy or currency of water monitoring has been available in all funding rounds along with funding for activities to coordinate water information at a strategic level. Funding for water accounting activities has been available in most rounds; funding for the rescue of strategic data, the development of water information standards and improvements to the Geospatial Fabric has become available in later rounds of funding.

The funding themes used for this analysis are numbered as they were presented in the funding guidelines for Round 4 of the M&E Program, 2010-11. They are:

Theme 1: Improving the accuracy of water monitoring

Theme 2: Installation of telemetry

Theme 3: Extending the coverage of monitoring networks

Theme 4: Improving data management and transfer

Theme 5: Rescue of strategic data

Theme 6: Improving the Australian Hydrologic Geospatial Fabric (surface water)

Theme 7: Improving the Australian Hydrologic Geospatial Fabric (groundwater)

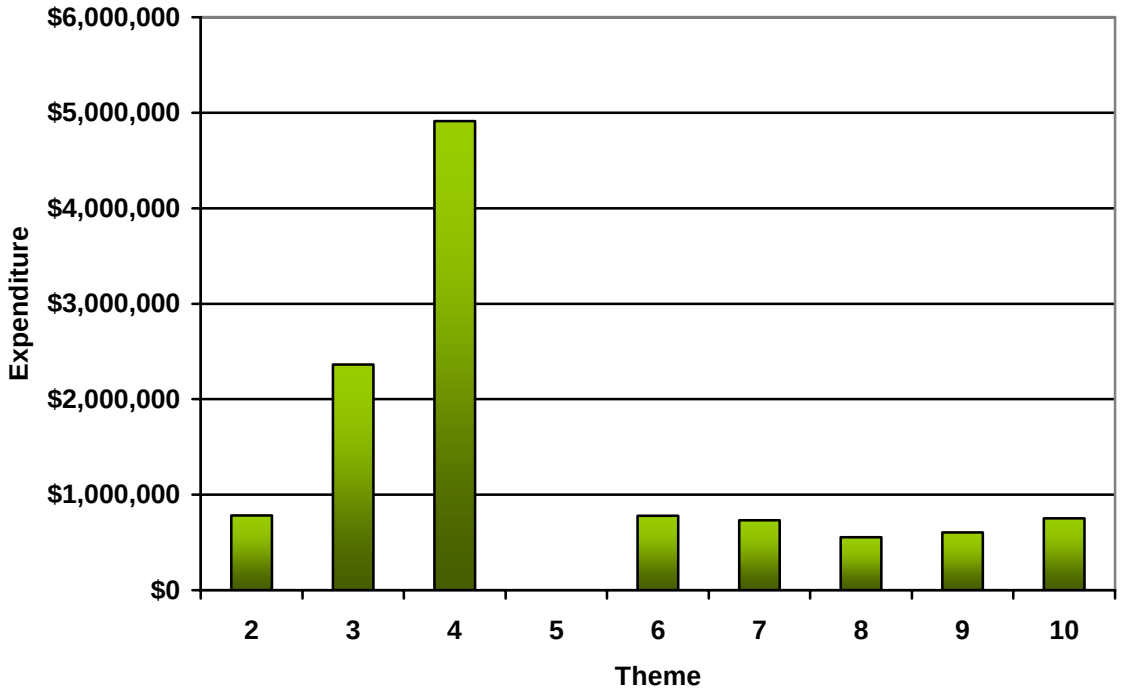
Theme 8: Improving the National Water Account

Theme 9: Strategic water information coordination

Theme 10: Water information standards

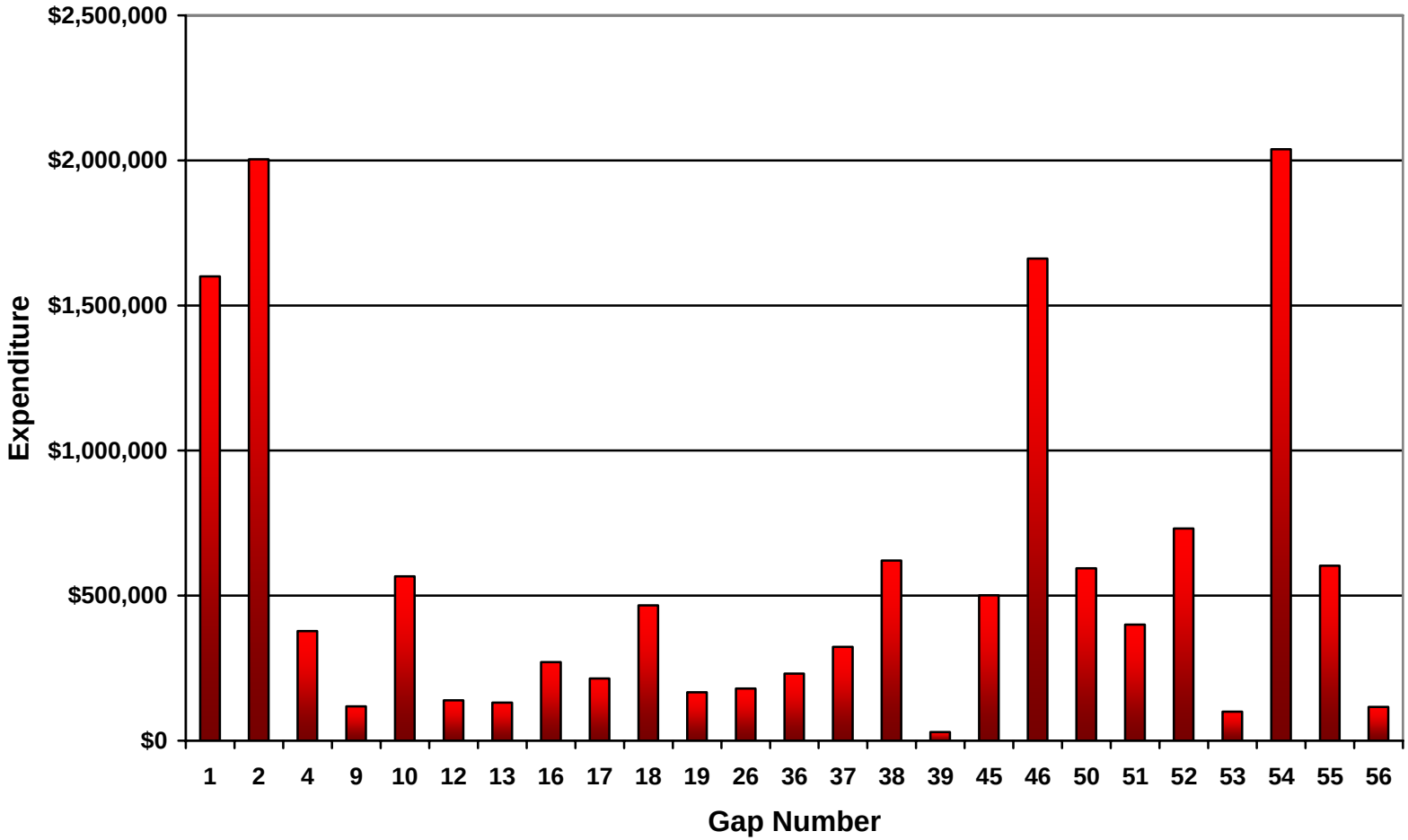
Most of the funding received by Queensland named persons was allocated to improve their data management and data transfer capacity; the second most funded activity was for the installation of new monitoring sites. This is evident in the following graphs which present different perspectives of the funding received in Queensland during Rounds 1-4 of the M&E Program. Graph 1 presents the funding received, by funding theme. Graph 2 presents the funding received, by identified gap. Graph 3 presents the percentage of funding received by each category of gap. Graph 4 presents the percentage of funding received by the different priorities of gaps.

Graph 1 Funding received by Queensland named persons, by funding theme



Graph 2 presents the amount of funding received for each gap identified in the Queensland SWIMP 2010. These gaps are listed in Appendix 4.

Graph 2 Funding received by Queensland named persons, by identified gap



Graph 3 presents the percentage of funding received by groups of gaps. In the Queensland SWIMP 2010 gaps were collated into groups according to the type of gap and then categorised by priority with Category One being the highest priority and Category Three being the lowest priority. These groups and categories are:

Category One Priority:

- Standards
- Metadata
- Data management systems
- Data reporting and analysis

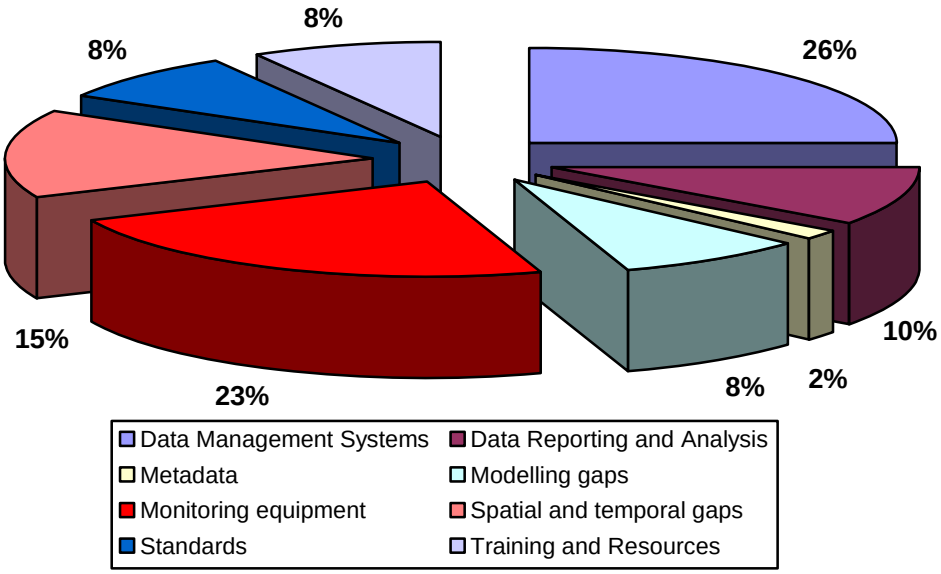
Category Two Priority:

- Spatial and temporal gaps
- Monitoring equipment
- Modelling gaps

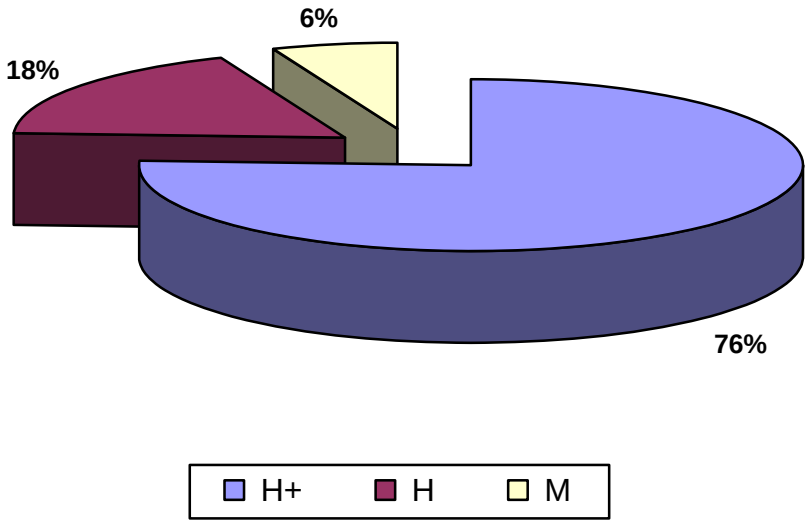
Category Three Priority:

- Training and resources

Graph 3 Percentage of projects received by Queensland named persons, by type of gap



Graph 4 Percentage of funding received by priority of gap



Most of the gaps identified in the Queensland SWIMP 2010 relate to a number of organisations, however where appropriate, certain gaps identify a significant requirement for a key stakeholder or a small group of stakeholders. Only these gaps can be understood to be fully addressed through M&E Program funding. For example Gap 45 concerns the need for Seqwater to centralise their important but fragmented data into one system; a system also capable of delivering data to the Bureau in WDTF. Seqwater was successful with a bid for funding under Round 4 and by the end of June 2011 this gap will be fully closed.

On the other hand Gap 10 concerns the need to upgrade existing gauging station data loggers. The quantum of this gap for all water monitoring organisations in the state is not yet known. Despite the funding of four projects to address this gap it cannot be assessed how much of this gap has been closed from a state perspective; only from the perspective of the organisations that received funding. The two recipients were Seqwater and SunWater. Seqwater believes this gap has now been three quarters closed; SunWater has fully closed this gap for their organisation. The value to the state of M&E funding to close this gap exists in the significant value of the datasets of these two organisations.

M&E Program funding has been of immense value to the named persons in Queensland. This is demonstrated by a number of key achievements including:

- A number of named persons were able to fully close category one data management gaps for their organisation.
- Many organisations that have not yet fully closed their data management gaps have come a long way towards that goal. For example, water service providers delivering data through SWIM and NRM bodies delivering data

through WaterQ (around 55 percent of all named persons currently delivering data) have significantly enhanced data management systems as a result of M&E Program funding. DERM, SunWater and Seqwater have all received considerable assistance to address data management gaps – the three largest surface and groundwater monitoring organisations in the state.

- A number of named persons were able to fully close or significantly close gaps for their organisation concerning the need to upgrade equipment. These organisations included councils closing flood warning gaps and SunWater completing upgrades to streamflow and storage monitoring stations.

See Appendix 4 for more analysis on the overall impacts of M&E Program funding; the following gap analysis in each monitoring sector includes details of funded projects and how they have addressed sector gaps.

4.2 Groundwater gaps

Across all groundwater monitoring networks there are spatial and temporal gaps in the data being collected.

Monitoring frequency is currently at minimum requirement levels at best and the installation of loggers would allow for increased levels of monitoring to better characterise aquifer recharge events and water level depletion. Upgrading of old logger technology is also required to improve the quality of data being collected.

Surface water-groundwater interaction and increasing salinity levels are key issues that require more intensive monitoring. This is of particular concern in the Queensland Murray-Darling Basin region. Water extraction levels and subsequent impacts on aquifer sustainability are other key issues requiring more focussed monitoring.

Many bores still require alignment to a known datum to improve the quality of the data being collected and to support development of a national geofabric dataset. Whilst previous funding has been received by DERM to address this issue there are more bores to be tied to AHD. Seqwater has also noted this as an issue.

More resources are required to increase the skill levels in a range of areas such as monitoring, data management, to enhance modelling capacity, to increase the level of analysis of the data being collected and to communicate data to the community.

4.2.1 Spatial and temporal gaps

EHA report (2007) –

- More monitoring is required to gather enough data to characterise groundwater areas.
- Water use data is often lacking, or of very poor quality. This is particularly an issue in non-declared areas where the gathering of this data is more difficult.
- There is a need to increase the frequency of monitoring. The quarterly monitoring of bores should be seen as an absolute minimum as the majority of aquifers react to recharge events much more quickly than a 3 month lag.
- More funding is required to support:

  - additional event-based monitoring and specialised monitoring
  - regular reviews of monitoring data
  - NAP network monitoring
  - Water quality monitoring for relevant parameters (e.g., temperature, EC, pH, biota and contaminants in high risk areas)
- If monitoring activities were required to be curtailed then the following areas could be regarded as being of the lowest risk: Daintree-Mossman; Farnborough; Stanwell; Boyne River; Fitzroy River; Theodore; Emerald; Fraser Island; Mooloola River; Biggenden and possibly Maryborough.

NAP Monitoring Network - Examination of the limited water level monitoring data which has been collected from the federally-funded NAP network bores since they were drilled indicates that significant rises in water tables have occurred in a number of areas throughout the state (up to 1 metre per year) through a period of the worst drought for a century. This trend highlights the need to undertake monitoring in these areas. To obtain reliable data, monitoring would be required for a minimum of at least 10 years.

However, only limited monitoring of these bores has been undertaken since the conclusion of the NAP program as no provision for ongoing operational costs was ever made. As these bores were drilled specifically to assess the potential for salinity problems they are not necessarily representative of aquifers, and therefore not considered part of the Water Level Monitoring Network.

DERM - areas that are not managed under state planning processes have a resultant lower density of monitoring bores, which are monitored infrequently. DERM's existing Groundwater Water Level Network was comprehensively reviewed in 2009. The primary purpose of the review was to define the network, identify spatial gaps and identify where new data loggers are required. A further key outcome of the review process has been the establishment of a methodology that can be applied to future reviews so that a degree of consistency can be maintained. The network review was completed at a regional office level as the state's bore water level network is essentially a compilation of regional networks. The review methodology uses a combination of tools including multi-criteria analysis, geographic information systems and local expert knowledge.

The steps undertaken included:

- defining the existing network and then:
  - mapping the network to individual aquifer units
  - determining the various types of monitoring being undertaken
- ranking the network according to its priority for assessment, using criterion such as:
  - recorded water level fluctuation
  - groundwater management area
  - multipurpose versus single use bore

  - influence on bore by external factors
  - distance to nearest groundwater level monitoring bore
  - monitoring bore data representative of aquifer
  - bore condition/access
- establishing optimum network and monitoring schedules to meet monitoring requirements - monitoring frequency may be determined by factors such as:
  - purpose of monitoring
  - need for long-term trend data
  - speed of recharge of the aquifer
- refining the network and schedule to align monitoring requirements and resource availability, using strategies such as:
  - sourcing additional monitoring resources
  - reducing the monitoring frequency
  - reducing the number of bores being monitored
- identifying bores requiring replacement – most common bore issues include:
  - bores on private property being damaged by farm equipment
  - bores with collapsed screens subject to sand or gravel intrusion
  - bores intersecting more than one aquifer
  - bores impacted by nearby production bores
  - shallow bores becoming permanently dry due to water level decline
- identifying sites for proposed new monitoring bores, taking into account:
  - expert advice
  - extent of the current network
  - a range of aquifer characteristics
  - areas of high levels of extractions
  - groundwater dependent ecosystems
  - suitability of locations
- identifying priority bores for equipping with continuous monitoring technologies

The full report on the groundwater monitoring network review is presented in Appendix 5.1. The following table presents the number of new bores the network review identified as being required in each DERM management region, as well as the number of new data loggers required.

Table 10 Outcomes of DERM sub-artesian groundwater monitoring network review

DERM management region	Number of new bores required	Number of new data loggers required
North	312	45
Central West	40	16
South East	173	38
South West	208	126
Total	**733**	**225**

Appendix 5.2 presents tables with more detail on these spatial gaps, including which aquifers require new bores and loggers, why they are needed, and whether they are a high priority or not. In general, spatial gaps impact on the capacity to monitor optimally for assessment, management, salinity, surface water-groundwater interaction and modelling purposes.

The most common reasons for assigning a priority of 'essential' to a gap area in the network review were:

- area is highly developed and resource is highly stressed
- limited or no current monitoring activity
- need for data on surface water-groundwater interaction
- required to help determine sustainable groundwater yield on which to base volumetric limits
- potential for future development

Under Round 4 of the M&E Program DERM has been allocated $1.6 million to construct 228 monitoring bores within ten water resource plan areas across Queensland to fill priority spatial gaps in the state groundwater monitoring network. This project will fill around one third of these spatial gaps, including 32 in the QMDB and 42 in North Queensland.

Therefore there are 484 priority spatial gaps that remain, as identified in the review of the DERM groundwater monitoring network. Funding will be allocated by the department to the construction of new bores on a priority needs basis. However, as a result of the financial implications associated with the recent floods in Queensland this is likely to occur in the medium to long term. Additional funding will be sought from external funding sources as opportunities present themselves.

DERM is responsible for implementing a monitoring program to assess any impacts on groundwater bores across the Surat Basin from Coal Seam Gas (CSG) activities as part of the LNG Enforcement Unit's Compliance Plan. The LNG Enforcement Unit was established in November 2010 to act as a one-stop shop to respond to safety, land

access and environmental concerns relating to CSG and Liquefied Natural Gas (LNG) activities. The Compliance Plan will entail 150 audits of established water bores by June 2011 and another 150 audits in the following six months. The program is not dependant on operational works to commission or build monitoring wells.

The program will establish water level and water quality for each of the potentially impacted aquifer systems before significant CSG production commences and will also be capable of detecting changes in water levels or pressure as a result of CSG activities.

4.2.2 Monitoring equipment and technologies

EHA Report (2007)

- The installation of data loggers on bores would result in data better able to characterise recharge events and water level depletion.
- Loggers could lead to significant cost savings in the Bundaberg region where visits to some bores are weekly and monthly, particularly if they could be set up for remote downloads.

DERM

The acquisition of new data loggers is seen as a high priority as they would significantly increase the accuracy of the data collected. Significant savings and better management of the resources can be made through increased automation of parts of the network.

The review of the groundwater network identified the need for 225 new data loggers. As part of a Round 4 $2 million M&E Program project to enhance its surface and groundwater monitoring networks DERM will be installing new data loggers on 80 bores. Sixty more bore loggers will be added to the network using departmental funding.

Once the funded activities above have been completed this gap will reduce significantly and the data from these continuous systems will be available to the public through the web in real time, enabling water users to monitor groundwater levels and improve decision making in relation to sustainable water use strategies.

Out of 126 new data loggers needed for bores in QMDB, 23 are being installed by the above project. This reduces the outstanding gap to 103 loggers.

It has been identified that all areas of monitoring would benefit from an increased accuracy and validity of data. The operational instrumentation such as Underwater Video System is used to assess the integrity of the bores and ensures that the data gathered is reflective of the aquifer status. A down-hole video inspection camera would be particularly useful given the many hundreds of bores that have been inundated.

Inundation of groundwater sites has resulted in damage to infrastructure and instrumentation to some DERM bore sites with automatic loggers; the full extent of the damage is yet to be determined. An assessment is underway to identify damage and works required to repair the network and a similar timeframe to gauging station assessment is expected.

4.2.3 Alignment of bores to a known datum

EHA Report (2007) – the mapping of bores needs to be updated and bore location metadata collected.

Under Rounds 2 and 3 of the M&E Program DERM has received $510,000 to update bore and gauging station location metadata. At the completion of the Round 3 funded project around 30 percent of DERM monitoring bores had been tied to Australian Height Datum (AHD) and the improved site metadata added to the DERM and Bureau data management systems.

This is a significant improvement, however, around 70 percent of DERM bores still require site location details validated or upgraded. Improved site location data is a requirement for enhanced modelling capacity.

4.2.4 Modelling data

DERM - Many aquifer systems have undetermined yields; there is a real need to have assessments made of these systems.

The NASY Project was completed by CSIRO in mid 2009. Gaps in data, information and knowledge were identified for both surface and groundwater resources. However these gaps have a low priority for the state due to the limited water resource development opportunities in this region. Groundwater gaps include:

- Monitoring bores are sparsely located
- Groundwater information is locally available but large areas remain devoid of any quantitative groundwater data
- Monitoring and models are vital to help constrain levels of extraction

Groundwater data are very sparse for most aquifers across the project area and there are large uncertainties regarding the volumes that might safely be extracted.

The Murray-Darling Basin Sustainable Yields Project was formed in 2006 at the Murray-Darling Basin Water Summit. CSIRO was commissioned to progressively report on sustainable yields of surface and groundwater systems within the Murray-Darling Basin, including an examination of assumptions about sustainable yields in light of changes in climate and other issues. CSIRO was further contracted by the NWC to conduct a water assessment on current and future water availability in the Murray-Darling Basin until 2030. CSIRO has prepared regional reports on the surface and groundwater systems across the Murray-Darling Basin, including five regions that fall within Queensland.

More information can be downloaded from the CSIRO website.

Outcomes from these projects for groundwater monitoring in the QMDB include the following:

- A greater understanding of groundwater impacts, particularly in the headwater catchments connected to the GAB, is required within the Warrego monitoring network.

- More information on groundwater influences is required, particularly in terms of the impact of extractions on surface water and the substitution of surface water with groundwater.
- Data is not of consistent quality.
- There is a lack of detailed assessment of groundwater flows, recharge or other water balance components.
- Surface–groundwater interactions are likely to be important in the Coolmunda system (Van Dijk et al., 2008).

Cross Region and Agency Monitoring and Evaluation Review

A cross region and agency group has been formed to address the need for consistency and efficiency of monitoring between regional bodies and state agencies in the QMDB. In 2007, this group compiled a review document to assist members of the Cross Region and Agency Monitoring and Evaluation Review (CRAMER) group to analyse the suitability of current monitoring programs for meeting state government and regional body business and reporting requirements (CRAMER 2007, unpublished).

Outcomes from this review for groundwater monitoring in the QMDB include the following:

- Insufficient numbers of bores are present in some areas at high risk of salinity, including the Border Rivers floodplains and Warwick.
- The analysis, evaluation and reporting of monitoring data is inconsistent.
- With the exception of the Condamine catchment, representative-type bores and salinised areas have not been evaluated and selected for monitoring and reporting purposes.
- There is no measured data relating to connected groundwater systems and base flows.

4.2.5 Standards in groundwater monitoring

EHA Report (2007) –

- A risk assessment should be carried out on the adequacy of bores and bore related information in particularly high risk and water usage areas (similar to the risk assessment recently carried out for surface waters). There is also a need to consider risks from contamination.
- Operational procedures are available for most aspects of monitoring. Whilst most procedures are in place and in practice, database enhancements are required to facilitate data validation.

DERM has recently identified the need to develop 10 years comprehensive bore maintenance program to ensure that maintenance to its network is planned rather than undertaken on an as needs basis only. Initial requirements include an assessment of bore maintenance requirements and prioritisation of maintenance issues.

4.2.6 Resourcing

DERM –

- Resourcing for groundwater monitoring operations and for training to increase staff skill levels are emerging issues in the operation and maintenance of this large water level network.
- More skilled staff are also required to develop groundwater models and assess groundwater and groundwater water quality data for adequacy and condition and trend.

CRAMER Review - Community groups need access to relevant equipment and support for training in order to adequately monitor shallow groundwater depths.

4.2.7 Other gaps

GAB

The existing GAB monitoring network is under review to ensure it aligns with the new monitoring framework prescribed in the GAB WRP. The current GAB monitoring network has a number of issues with its design and operation, including the following:

- current network was designed for a different purpose
- non-uniform representation of aquifers
- bores tapping multiple aquifers
- it is not a dedicated network – all bores are privately owned and operated
- lack of elevation data, resulting in an inability to construct pressure surfaces
- significant skills and training shortages for monitoring artesian pressure levels
- current resourcing is unable to support the existing network

The review of the GAB monitoring network includes a review of each water management unit to assess their monitoring requirements, and a review of each bore in the network to assess their suitability for monitoring WRP parameters.

These reviews used some guiding principles, including the following:

- use existing bores where possible
- recognise resource limitation
- recognise it is not necessary to monitor every management unit
- focus resourcing on those management units that are likely to show the impact of water resource development and management

Management units were ranked with regard to their need for monitoring. This process also helped to identify those units that would be adequately covered by system monitoring and those that required impact monitoring.

The 25 management units in the GAB were ranked in regard to:

- level of current development
- potential for water use change
- future demand
- existence of groundwater dependent ecosystems and extent of recharge areas
- trends in water levels or pressures

A set of criteria for monitoring bore suitability was developed, with each criteria ranked against the desirability of that criterion. Each monitoring bore was assigned a suitability ranking according to the sum of these criteria. Information required to score each monitoring bore was derived using a number of criteria and from analysis of existing data from the GWDB.

Outcomes of this study led to recommendations for each bore that included whether the bore was suitable to be maintained as is, or if it needed repairing. Bores unsuitable for ongoing monitoring were identified as either needing replacement or were simply removed from the network.

The review assessed all 288 bores in the Pressure Monitoring Network. Of these bores, 64 (22 percent) have been recommended for removal from the network. Of the remaining bores, 40 percent either need to be replaced or repaired.

This review is yet to be finalised and the assessment outcomes are not yet ready for publication. In general, the review indicates that the existing network of bores provides good coverage in the most heavily used artesian areas within the GAB. However, there is not adequate coverage in some of the sub-artesian areas where more extensive monitoring is required due to large demands on the resource. DERM is currently looking for suitable bores to use for monitoring in areas that require enhanced monitoring.

Priority gaps for groundwater monitoring networks in Queensland in 2011

1. Spatial and temporal gaps exist in many bore networks.
2. The installation of data loggers on bores would result in data better able to characterise recharge events and water level depletion.
3. A number of existing data loggers attached to bores require upgrading to improve data currency and to minimise data loss.
4. Bore locations should be aligned to a known datum to improve the quality of data collected and to support development of a national geofabric dataset.
5. There is a lack of measured data relating to connected groundwater systems and base flows (surface water-groundwater connectivity).
6. A lack of sufficient bore monitoring data, particularly in high risk areas, impacts on the development of accurate models.
7. A lack of appropriately trained staff and adequate operational resources are emerging issues across groundwater monitoring agencies.

4.3 Surface water monitoring gaps

The largest organisations in Queensland monitoring surface water levels and flow are DERM, SunWater and Seqwater. DERM primarily monitors in watercourses; SunWater and Seqwater primarily monitor in water storages although SunWater does monitor in a number of watercourses in their water supply scheme areas. There are a range of other organisations that collect localised monitoring data for a variety of purposes and uses. The key issues in surface water monitoring and activities to resolve these issues are discussed below. Note that stream flow monitoring for the purpose of flood warning is discussed in the “Meteorological monitoring gaps” section.

In many cases the most critical issues for surface water monitoring organisations relate to data management; these issues are discussed later in the Data Management Gaps section. The exception to this is the QMDB where a lack of stations, equipment and skilled operators are more critical issues than data management.

4.3.1 Spatial and temporal gaps

Spatial and temporal gaps in surface water monitoring networks exist in most regions of the state. In remote regions gauging stations can be particularly sparsely located, thereby limiting the potential to monitor the impact of seasonal flows on ecological systems and assess the resource availability.

DERM

DERM has recently undertaken a review of the adequacy of its gauging station network for a range of state needs, such as: assessment; management; modelling and surface water-groundwater interaction. The assessment methodology used in this process is attached as Appendix 5.4. Drainage basins were selected, analysed and set criteria applied to determine if any new gauging stations were required. The review identified 179 new monitoring sites that are required for assessment purposes, to adequately determine the state’s water resources.

With Round 4 M&E Program funding DERM is installing ten new gauging stations across the state. Although DERM is the primary body monitoring the assessment of watercourses in the state the department has only applied for funding for new gauging stations under the fourth round of the M&E Program as prior to this funding round there were no available DERM resources to cover the ongoing maintenance and depreciation costs of any new assets.

Due to the impact of severe flooding across Queensland the installation of these new gauging stations will not be completed until the end of 2011. Once they are installed there will remain a significant number of spatial gaps in DERM’s surface water assessment network (169 sites).

Appendix 5.5 presents tables outlining further information on the surface water monitoring network review. A summary of the new surface water monitoring sites required in Queensland, as identified by the review, is presented in the table below.

Table 11 Spatial gaps in the DERM surface water monitoring network, by region

DERM management region	Number of new sites required
North	81
Central West	23
South East	4
South West	61
Total	**169**

More recently DERM has identified the need for a number of pluviographs to assist with early alert to carry out stream gauging activities. Pluviographs will also assist in water resource assessment and modelling and in some cases may fill identified gaps in the gauging station network.

SunWater

SunWater currently has no known spatial gaps in its surface water monitoring network, however it does have one gauging station that needs to be reconfigured or moved to an alternative location to improve the accuracy of the data collected.

Queensland Murray-Darling Basin

The CRAMER Review and a CSIRO Sustainable Yields Project identified that various major tributaries in the QMDB are not gauged or are sparsely gauged and that hydrological data pertaining to the Border Rivers, Moonie, Condamine-Balonne, Warrego and Paroo catchments in particular have both spatial and temporal gaps.

Under Rounds 1 and 2 M&E Program funding South West NRM was allocated almost $180,000 to purchase and install mobile water sampling units to measure both water quantity and water quality at four remote sites in the Warrego, Paroo and Bulloo catchments. These units will improve the reliability of data sampled during runoff events and enhance understanding of the regions waterways.

DERM has 69 open gauging stations monitoring flow and water quality in the QMDB. All these stations are aligned to AHD. In 2009 a review of the DERM surface water monitoring network identified a need for 42 more gauging stations in this region; two of the ten new gauging stations DERM is installing with Round 4 M&E Program funding are in this region bringing the total number of gauging stations in the QMDB up to 71 by late 2011.

North Queensland

Gauging stations are sparsely located in north Queensland. Data is especially sparse in floodplain regions where maintenance of recording equipment is difficult. Under

Round 4 of the M&E Program DERM is building three new sites located on Flinders River, Rankin Creek and Liverpool Creek.

4.3.2 Monitoring equipment and technologies

Many existing data loggers need upgrading to newer technology to improve data currency and to minimise data loss. Recent record floods have highlighted the need to have pressure transducers/sensors with sufficient range to measure the full change in river stage. A significant number of sites will have to have higher range sensors installed. There is a need for increased use of in-situ Doppler's to assist with rating curve development.

DERM

The review of the DERM surface water network identified over 200 DERM data loggers for upgrading. New technology is needed to enable operations staff to assess whether there has been equipment failure so timely maintenance can reduce any potential data loss.

Over the past couple of years DERM has had limited resources to improve the coverage and currency of its surface water monitoring network. The focus has been on prioritising expenditure and improving the efficiency of existing resources. In 2009 the reprioritisation of telemetry systems and the launching of IP telemetry services has resulted in significant cost savings and increased efficiencies in data handling. The application of satellite broadband for remote areas will further enhance data availability.

As a result of the severe flooding across the central west, south west and south east regions of Queensland between November 2010 and February 2011 some DERM gauging stations were damaged and require rebuilding. In some areas instruments were inundated and the structures may have to be relocated to higher ground. Quite a number of sites had capillary lines ripped out (temporary repairs made) and four sites had severe bank slumping. Repairs are expected to be completed prior to the 2011/12 wet season. DERM is seeking financial assistance to reconstruct and repair damaged water monitoring infrastructure under the National Disaster Relief and Recovery Assistance (NDRRA) program.

The main impact of flooding on DERM telemetry systems was the loss of a number of landlines that failed after inundation; some in areas with no mobile phone coverage as an alternative. Communication issues were also experienced in the northern region as a result of Cyclone Yasi, with the status of a number of stations uncertain after parts of Telstra's network failed. Regional staff, with the support of the Hydrographic Support Unit at Rocklea, have been undertaking preliminary assessment and, where possible, temporary repairs to the network. Due to the access issues and the general remoteness of much of the network, it is anticipated that the full extent of the damage will not be known until mid 2011.

SunWater

Under the M&E Program SunWater has been able to address a number of gaps relating to the installation of new equipment. Under Round 3 funding SunWater was granted $212,000 to upgrade all existing data loggers to the CR800 model and SD-12

output transducers. The new equipment enables SunWater to utilise the Next-G wireless IP network to provide near real-time data and improves the currency of water level and streamflow data.

A further $122,000 was allocated to purchase modern flow measurement equipment to improve the accuracy of the rated flow and rainfall data. Every measurement that improves the definition of a rating table ensures better use of the resource. The equipment purchased included three SonTek flow trackers, two SonTek river surveyors and three rugged Personal Data Assistants. The acoustic velocity meters purchased as part of this project provide excellent QA processes enabling gauging collection by non hydrographical staff which reduces the cost of gauging collection. This project also allowed for the calibration of rainfall gauges which is improving the accuracy of data being provided to the Bureau.

SunWater was also allocated $142,000 to install new sensors and transducers to improve the quality and consistency of data from monitoring in watercourses and storages. This also benefits the data being collected for flood warning purposes as the new sensors will ensure water level data is captured over the full range of events. Accuracy of data in the upper ranges is being improved by installation of new equipment that can be calibrated to provide reliable data over the full sensor range. The new shaft encoders will ensure water level settings are not lost during a power failure and accurate data will be available as soon as power is restored.

4.3.3 Water storage monitoring

The key water storage monitoring gaps relate to the alignment of gauges to a known datum; enhancement of ratings; application of bathymetric surveys to determine correct storage capacities and the need to upgrade equipment to automatic systems. The two largest water supply storage monitoring organisations in Queensland are SunWater and Seqwater. SunWater monitors across all regions with the exception of SEQ where Seqwater owns the major water supply storage infrastructure. With M&E Program funding SunWater and Seqwater have made significant investments in their water storage monitoring networks.

SunWater

With around $80,000 of M&E Program funding SunWater has installed a number of new continuous monitoring stations for water level measurement within storages and watercourses at critical locations within the QMDB, Fitzroy, Pioneer and Burnett Basin catchments. They also installed a measurement device to measure tail water flow at Fairbairn Dam, the second largest dam in Queensland. Releases from Fairbairn Dam are made through several conduits which made it a complicated process to capture the total volume of flows.

These new sites are equipped with Campbell CR800 data loggers with OTT CBS units to provide greater accuracy and Next G Wireless IP network telemetry technology.

Seqwater

Seqwater has upgraded its entire monitoring network, previously comprised of hardware that was twenty years old and no longer supported by the supplier, with the

assistance of the Bureau through three rounds of the M&E Program. This program has been instrumental in allowing this work to occur not only through the funding of over $300,000 itself but also in providing direction for a relatively new entity.

Upgraded surface water monitoring stations at major and minor storages are now fitted with highly accurate CR1000 loggers and new sensors, where applicable. For some of the major storages, stilling wells are being constructed to increase the accuracy and reliability of measurements. IP data transfer is also being trialled at two of Seqwater's largest storages, Somerset and North Pine dams (still in trial phase).

Seqwater was also allocated $131,000 to undertake bathymetric surveys at four storages to provide a better understanding of the available storage capacity. The storages surveyed were Baroon Pocket, Lake MacDonald, Ewen Maddock and Leslie Harrison.

Information from previous surveys is often decades old, having been based on land surveys and undertaken during the dam design phase. Since then changes to the landscape, possible sedimentation and evolving technologies have provided the opportunity for more accurate surveys to be undertaken. There are a number of other smaller storages within SEQ where storage capacities are based on outdated information and resurveying would be beneficial. There are also a large number of weirs that have little or no capacity information.

Of benefit would be the refurbishment of manual staff gauges at storages and gauging stations. Staff gauges are relied upon to calibrate automated gauging systems, and to act as a back up when automated systems are not functioning. They also provide confidence in automated systems during significant event periods. Due to the differing maintenance programs of the previous asset owners not all staff gauges have been maintained to the same standards. This is something that Seqwater is seeking to standardise.

Rockhampton Regional Council

Under Round 2 funding Rockhampton Regional Council received over $100,000 to install new sensors and telemetry systems to improve the currency and quality of data coming from their storages. This funding has significantly improved the reliability of the water level data received.

4.3.4 Alignment of gauging stations to a known datum

Alignment of gauging stations in all networks to a known datum would help standardise and significantly improve the accuracy of data collected from these sites as well as support the development of a national geofabric dataset.

Under the M&E Program DERM was allocated funding to upgrade bore and gauging station location metadata. This enabled DERM to increase the number of gauging stations tied to AHD to around 80 percent. The remaining gauging stations should also be tied to AHD.

A number of gauging stations that Seqwater has inherited have not been converted to AHD and are instead based only on a local gauge height. This can lead to uncertainty, particularly when comparing to other known gauge heights, and is something that Seqwater is looking to address.

4.3.5 Modelling data

In undertaking a review of its surface water monitoring network DERM has identified that undefined flow ratings at many gauges are impacting on data quality and making it difficult to define the water resource.

The following gaps that impact on modelling capacity in the QMDB have been identified by the CRAMER Review and the CSIRO Sustainable Yields Project.

- Difficult-to-measure flow volumes exist outside gauged channels in the QMDB.
- There is a lack of sufficient data at a local scale.
- Metadata that assists in interpreting hydrological data is scarce.
- The quality of high stream flow gauging data (relating to breakout and bypass flows, for example), particularly towards the end of the river system, needs improvement.
- The simulation of low stream flow patterns in this region has been affected by problems estimating river losses.
- Additional data collection and research is required to reduce uncertainty in river modelling in this region.
- Runoff estimates for some regions are poor due to remoteness, intermittent river flows and a low number of rainfall stations, due to drier conditions.

The CSIRO Northern Australia Sustainable Yields (NASY) Project also identified a number of gaps relating to surface water monitoring, however they are of a low priority for the state due to the limited opportunity for water resource development in this region. The modelling gaps include:

- Paucity of data greatly inhibits the potential to assess the linkages between ecological systems and flow regimes
- Surface water modelling has had to rely heavily on stream flow data collected from the 1970s and 1980s. Only a few stations go back to the 1950s and many stations have closed in recent years.
- The ability to develop water availability assessments for catchments is reliant on the existence of river system models. Such models exist for the South-East Gulf, Mitchell and Flinders-Leichhardt regions but no such model exists for the northern North-East Coast drainage division.

Seqwater has identified the importance of the revision of ratings for weir and dam spillways and gauging stations. Recent rainfall has led to increased storage levels in SEQ, with many dams approaching full storage capacity for the first time in a number of years. This provides the opportunity to collect additional data and revise existing ratings. In addition to new data, there are a number of analytical techniques available that should be compared and contrasted when developing ratings.

One of the Rockhampton Regional Council projects under round 2 of M&E Program funding involved the production of accurate models of the flows released from the Barrage. Two components of the project covered the analysis of the Barrage data and the production of accurate flow models as well as integrating the modelling data into

the SCADA system. Advances in water modelling in the last thirty years are likely to be able to provide much more accurate estimates of flow through the Barrage and will increase the accuracy of the data transferred to the Bureau.

Mackay Regional Council has noted that there is limited information on stream flows in urbanised catchments to provide correlation between water quality and stream flow for creeks in GBR catchments.

4.3.6 Resourcing

Limited resources and the need for more training for staff are evident across all monitoring agencies. As an example, the monitoring of freshwater wetlands is restricted due to a lack of available funding.

DERM has identified staff resourcing, an ageing workforce and a need for training to increase skill levels as emerging issues in both the operation and maintenance of the gauging station networks. Reviews of monitoring in the GAB also identified staff skill levels as a critical issue.

During two rounds of the M&E Program DERM received over $140,000 to train staff in the use of Hydstra, acoustic Doppler meters and in the development and maintenance of rating curves. These training opportunities support the need for standardisation of monitoring and data management practices.

As a consequence of institutional reforms in 2008 Seqwater acquired ownership of all major water supply storage infrastructures as well as a number of production and monitoring bores in SEQ. This resulted in an urgent requirement to develop a new hydrographic unit within the organisation as well as a need to centralise and better manage the new datasets coming from these new assets. Round 3 M&E Program funding mentioned earlier assisted Seqwater to purchase the equipment needed to establish their new hydrographic unit.

The QMDC has stated that resourcing (lack of skilled staff and insufficient funding) is the key restriction on all forms of water monitoring in the QMDB. Further the CRAMER Review highlighted that community groups need access to relevant equipment and support for training in order to conduct nutrient monitoring.

4.3.7 Other gaps

The *Australian Water Resources 2005* reported on water balances for six priority water management areas: Brisbane, Pioneer, Burnett, Condamine-Balonne, Barron and Georgina-Diamantina catchments. This report identified that data relating to farm storages (including on-stream or off-stream farm dams that are filled either by local runoff, pumping from a nearby waterway or by flood harvesting) is strongly required across Queensland. It also noted the lack of recharge and runoff information.

Further data gaps highlighted by these water balances include:

- lack of gauging conducted in the downstream reaches of the Brisbane water supply area
- lack of data on losses from minor catchment dams, conveyance losses and seepage from streams to groundwater

- lack of data on evaporation from open water and wetlands

Wetlands

According to the Queensland State of the Environment Report 2007 (SOE 2007) the state continues to lose wetland area; between 1997 to 2003 more than 7000 ha/year were lost. However it is difficult to report on the overall extent of wetlands as there are gaps in the data on wetland condition. Ways are being sought to fill these gaps but, as previously noted, there is no broad-based ongoing program to monitor wetland extent in Queensland and the condition of lacustrine and palustrine wetlands. Essentially the tools to monitor these wetlands have been developed and assessments of wetland extent have been conducted in recent years but there are currently no resources allocated to implement an ongoing monitoring program. More information on these issues can be found on the SOE 2007 website.

Priority gaps across surface water monitoring networks

8. Spatial and temporal gaps exist in surface water monitoring networks measuring water levels and flows.
9. A number of existing gauging station data loggers require upgrading to improve data currency and to minimise data loss.
10. Upgrades to new technology flow sensors will improve the quality and quantity of river flow data collected.
11. Gauging stations and storage gauges should be aligned to a known datum to improve the quality of data collected and to support development of a national geofabric dataset.
12. Enhanced rating of gauging stations and storages is required to improve the accuracy of data collected.
13. Bathymetric surveys of storages are required to confirm storage capacities.
14. Additional data collection is required to reduce uncertainty in river modelling – issues particularly noted in the QMDB and the northern North-East Coast catchments.
15. A lack of appropriately trained staff and adequate operational resources are emerging issues across surface water monitoring agencies.
16. There is a need to upgrade to automatic systems and install telemetry for instantaneous recording of storage levels.
17. Insufficient monitoring of wetland extent changes and risk to and condition of wetlands.

4.4 Meteorological monitoring gaps

Most spatial and temporal gaps in flood warning networks are highlighted during and post flood events. The flooding in southwest Queensland in 2010 identified a number of specific gaps that are presented here. The more widespread flooding that occurred during the 2010-11 wet season, sometimes at historic levels, has also highlighted specific gaps; stakeholder analysis of these gaps is included where available.

An independent COI has been established to review the preparedness and management of these historic floods. An interim report from the Commission is due by 1 August 2011; this report may identify further issues with flood management in the state.

In general terms, flood warning networks for inland towns and regions need to be further developed. In particular there is a need for improved networks for rain and water level monitoring in catchments above large storages.

Further, there is a growing need to obtain data from ALERT stations to support other purposes such as water resource assessment and to obtain data at sub-daily levels. To meet these needs sites would require enhancement and far greater levels of maintenance and management.

As with other surface water monitoring sites there is now a real need for a review of ratings for high and low flows given additional data is available from the 2010/2012 flood events to assist with modelling and flood flow correlation.

A number of councils and other organisations have identified the need to upgrade equipment to telemetry or other automated systems. These organisations lack the resources to fully develop their ALERT networks and must seek external funding to enhance their systems.

The primary funding program for flood warning gaps is the Natural Disaster Resilience Program (NDRP). This disaster mitigation and community resilience competitive grant program is funded through shared contributions of the Australian Government, the Queensland Government and eligible applicants. NDRP priorities are to direct funding to Queensland's highest natural hazard risks; enhance community preparedness for natural events through community education and awareness raising and strategic targeting to increase resilience across sectors. For more information visit Emergency Management in Australia

Most of the gaps listed below were presented in the 2010 Queensland SWIMP; with the exception of gaps known to be resolved, they are presented again until more recent gaps are determined by stakeholders.

4.4.1 Spatial and temporal gaps

The spatial (and temporal) density of rainfall and water level data required for flood warning and prediction is generally significantly greater (an order of magnitude at least) than that required for other water information services. In addition, each flood season generally highlights a previously unknown requirement or demand for a more developed flood warning network for townships or regions affected by flooding. For example, floods in 2009-10 generated specific demands for additional flood warning

stations in the Emerald-Nogoa area, Belyando, upper Thomson and tributaries, Cape York rivers, Gulf rivers and elsewhere.

In general terms, flood warning networks for inland towns and regions need to be further developed. There is also a specific need for improved networks for rain and water level monitoring in catchments above large storages in Queensland.

Further, a trend exists whereby populated centres with automated flood warning systems (e.g. ALERT), previously considered as adequate for flood warning, are requiring additional rainfall and water level stations. This is to provide more detailed monitoring and datasets for their catchment areas for a range of purposes (including spatially detailed flood warning and response, water resources, drainage design and operation, etc). These additional objectives will require trained staff to operate and maintain the sites and to derive flow data.

Apart from existing flood warning ALERT and TELEMETER networks, there are significant gaps in sub-daily (e.g. hourly) rainfall and water level data which is required for adequate flood prediction and warning. In Queensland, rainfall is highly variable and runoff and flood generation is mostly at sub-catchment scale. There is an increasing demand for sub-daily rainfall and water level data for many other water-related or water-affected purposes.

The Queensland Office of the Bureau and DERM both identified the following specific spatial gaps in 2010, following flooding in the south west catchments of the state.

- Paroo River upstream from Eulo and below the Paroo River-Beechal Creek junction. DERM notes that the Paroo is not an easy channel to measure with many areas difficult to access. The Bureau site at Humeburn is not practical for an assessment gauging station. DERM has identified a potential assessment site some 10 kilometres downstream of Humeburn. No further investigation has been undertaken further downstream in the area in question. DERM also requires an assessment site at Yarronvale on the Paroo some 150 kilometres upstream of Beechal Creek.
- An additional gauging station in the Barrackdale/Warroo area above Beardmore Dam to measure/monitor inflows which are highly modified by natural storage below Weribone. DERM notes that the impact of the storage on in-channel flows would impact on any long-term viability of a site here for assessment purposes.
- The Bureau has noted that possible additional gauging stations on Condamine-Balonne-Maranoa tributaries, including Amby Creek, Muckadilla Creek, lower Dogwood Creek, Charleys Creek, Undulla Creek, Brigalow Creek and Wilkie Creek would be beneficial. DERM notes that some of these creeks have insufficient catchments to warrant assessment gauging stations in their own right. Lower Dogwood and Tchanning creeks have been identified for a site, particularly for management and use requirements, but the junction of these creeks is impacted by back up from the Condamine, hence the need for two sites about the Condamine-Surat Road. Wilkie Creek has been identified for an assessment site but does suffer from poor access and undefined flood plains.
- There is a need for a site above the junction of the Bungil and Balonne rivers and Dunkeld Road upstream of the Bureau's Garrabarra site.

Southern Downs Regional Council has previously identified the need to install ten new rain/river field stations; upgrade four existing sites; install three new repeater stations along with other technical upgrades. Under Round 2 of the M&E Program the council received funding of over $290,000 to install a number of new stations in the southern part of the region and is now able to remotely monitor storage levels and the amount of spill from Storm King Dam, Stanthorpe's only water supply. More coverage of rainfall records and earlier warning of flooding can now take place but there still some gaps remaining in the network for the northern and western parts of the Southern Downs Region.

Ipswich City Council has identified the need for new rain gauges in a number of catchments, including the Bremer River, Marburg and Rosewood basins and Ripley Valley. Round 4 of the Bureau funding granted over $100,000 to install or upgrade some of them.

Burdekin Shire Council has previously identified the need for a number of new flood warning stations along the Burdekin and Haughton rivers, at Brandon, Barratta Creek and Plantation Creek. Whilst these gaps did not receive any M&E Program funding they did receive funding through the NDRP; this funding supplemented by internal funding has enabled these gaps to be fully closed. Another gap identified was the need for a second ALERT repeater for the Haughton River flood warning network; funding under Round 3 of the M&E Program enabled them to close this gap and improve reliability of the network. Their only remaining gap is the need for a rainfall monitoring site at Yellow Gin Creek on the Bruce Highway, south of Home Hill. A preliminary estimate of the cost of closing this gap is $20,000.

Hinchinbrook Shire Council has previously identified the need for two new rainfall stations, the relocation of another station and the purchase of new testing equipment. These gaps have been closed as a result of Round 2 M&E Program funding of around $24,000. These improvements have enabled Council to better understand rainfall frequency and intensity in different areas of their network.

Mackay Regional Council has identified the need to improve the level of rainfall, river height and river flow monitoring in the Pioneer River, Bakers Creek, McCreadys Creek and Plane Creek catchments.

Sunshine Coast Regional Council has highlighted the need for the installation of rainfall and water level telemetry gauges within Kin Kin and Six Mile Creek catchments. This additional equipment would improve flood monitoring and warning capabilities for those areas.

Townsville City Council received $50,000 under Round 2 of the M&E Program to install five new rainfall monitoring stations; all of which were operational by March 2009. Council has since funded two new rainfall and water level gauging stations; operational in late 2010. A further two rainfall and water level gauging stations are being constructed under Natural Disaster Resilience Program funding; due to be commissioned by the end of June 2011.

The Gowrie Creek System Flood Risk and Mapping Study conducted in 2007 has recommended the installation of new flow gauges to collect survey levels in the Toowoomba local government region. Toowoomba Regional Council has proposed twelve sites that could support flood mitigation program and future land use planning.

4.4.2 Monitoring equipment and technologies

Reliability of real-time data supply in the south west region of the state could be enhanced with the upgrading of equipment in the region below St George and Fenton where landline communications failed in 2010 due to flooding. Real-time communication with these sites failed again in the 2010-11 wet season and Telstra was unable to access the area to repair landlines for a couple of months. These sites would require a satellite solution; DERM is upgrading one site in this location to SatIP. More details on the impact of the 2010-11 floods on DERM gauging stations, including stations from which the Bureau collect data to support the state flood warning network, can be found in the section on surface water monitoring gaps.

Under Round 3 M&E Program funding Seqwater has been allocated $50,000 to upgrade telephone telemetry systems at three stations and to install two new ALERT stations. This is resulting in improved currency and accuracy of data being delivered to the Bureau. Seqwater was also allocated $150,000 over two funding rounds to upgrade the electronic components at its rainfall monitoring stations. This represents a significant improvement in the incoming data

Whilst Hinchinbrook Shire Council has no outstanding spatial gaps in its flood warning network there is a need to secure infrastructure at certain locations. Damage by vandals has affected the reliability of some sites which was highlighted during recent flood events.

Toowoomba Regional Council operates 26 rain gauges, 9 of which currently use the Event Monitoring System (EMS) radio telemetry system. This system has now been superseded and is considered less reliable. Council has identified the need to upgrade these sites to the newer ELPRO Technologies radio telemetry system.

4.4.3 Modelling data

Both the Bureau and DERM have recognised the need for high stage gauging and a full review of rating tables at low flow and high flow extrapolations for key gauging stations and other strategic locations in Queensland.

In the Queensland SWIMP 2010 the Bureau noted that a major initiative is required to review all gaugings and ratings in QMDB rivers and in other rivers which would assist in high flood volume estimation, consistency of ratings from upstream to downstream through whole river systems, prediction of flood heights and river modelling including at low stage and high stage. This could potentially involve the collection of improved cross section and floodplain Digital Elevation Model (DEM) data, inundation or flood path modelling, hydrologic modelling and a full review of the consistency of ratings from systematic hydrologic modelling, such as the Bureau's flood forecast modelling or DERM's Integrated Quality and Quantity Model (IQQM). It is considered that LIDAR mapping would be a cost effective solution for terrain mapping on large scales.

As a result of a flood event in November 2008 and an assessment of the outcomes of the Australian Rainfall and Runoff Revision Project a number of gaps in the Ipswich City ALERT system were identified. Ipswich City Council has further recommended the development of the “Floodwise” system to improve prediction, record building, planning and analysis of effects of events.

4.4.4 Resourcing

Stakeholders have noted that a lack of skilled operators is a critical issue in obtaining enhanced ratings. In particular, if flood warning sites are to be developed to provide data for streamflow assessment then it is critical that training is given to water monitoring staff to be able to operate and maintain sites for the new objectives and to be able to accurately derive flow information at such an increased level of detail.

Local government monitoring organisations are still restructuring post local body amalgamations; new programs are restricted by limited resources. Similarly Seqwater has also been in development phase to rebuild appropriate resources following the acquisition of all major water storage infrastructures in SEQ.

DERM has identified the need to replace an ageing workforce.

Priority meteorological gaps

18. Gaps exist in spatial and temporal monitoring in flood warning networks, including in the high resolution ALERT-type networks, inland towns and regions and in the catchments of major storages.
19. Upgrades to gauging equipment are required for some organisations managing flood warning systems.
20. There is a specific need for improved rain and water level monitoring in catchments above large storages.
21. Stage-discharge ratings relationships for new and existing gauging and flood warning stations are required to provide data to assist predictions of critical flood heights at key towns and rural areas, and to assist water resource objectives.
22. A major review is required for all gauging and ratings in the QMDB rivers and in other rivers where this would assist the collection of data for both flood warning and water resource assessment purposes.
23. Technical and institutional support is required for local governments and regional bodies operating monitoring networks, especially rainfall and river height monitoring for the purposes of flood warning.
24. A lack of skilled operators is a critical issue in obtaining enhanced ratings at flood warning sites.

4.5 Water quality monitoring gaps

4.5.1 Spatial and temporal gaps

Spatial and temporal gaps exist in Queensland's surface and groundwater water quality monitoring networks. Limited funding to NRM bodies ensures spatial and temporal gap issues will continue to be ongoing for these organisations into the future.

DERM has undertaken water quality monitoring at approximately 3500 groundwater bores at some point. Currently however water quality monitoring from bores is limited with a much lesser number of bores monitored for salinity on a regular basis. DERM's Groundwater Water Quality Network is currently under review; however DERM has already identified sites which will be monitored to assess areas impacted by salt-water intrusion.

The EHA review of the Groundwater Water Level Network in 2007 reviewed water quality monitoring activities in this network. The review determined that whilst a good range of water quality parameters were being monitored by the lead water agency at the time of the review, with the exception of some high priority areas, the number of bores monitored for water quality were insufficient to characterize the aquifer systems they were meant to represent. The review also noted the need to improve the following:

- amount of background information for isotopes
- level of monitoring of groundwater salinity in areas potentially vulnerable to seawater intrusion – monitoring according to established priority rankings and agreed triggers
- level of monitoring nitrate in major agricultural areas
- more training of less experienced officers
- proper adoption of certain validation procedures (EHA 2007)

A review of the DERM Surface Water Ambient Network (SWAN) was completed late 2010. The review identified gaps in the network and documents the value of each gauging station for water quality information collection. This is a first step towards refining and enhancing DERM water quality monitoring activities.

To assess the characteristics and value that each gauging station could contribute towards supporting SWAN objectives, each station was assessed against a set of water quality criteria developed to categorise the spatial attributes thought necessary to meet SWAN objectives. The five criteria were:

1. End of system sites
2. Trend sites
3. Outflows of major tributaries
4. Representative sites
5. Focused monitoring sites

Each of the criteria represents a feature of gauging station characteristics influencing water quality monitoring. To standardise the relative importance of information from each gauging station, a methodology was developed to prioritise gauging stations

based on the water quality criteria and SWAN key objectives. Prioritising gauging stations based on criteria scores attempts to focus network design on identified departmental objectives. Documenting this process provides a transparent and accountable method that can be reviewed and adjusted as objectives and management practices change.

In the prioritisation process greater importance was placed on supporting the ability to report on broad scale condition and trend. Therefore sites representing larger catchment areas (end of system) with sufficient historic datasets to allow ten year trend analysis, or identified as reference sites, were considered to be of primary importance to SWAN objectives.

Gauging stations positioned to provide detailed information on specific environmental processes in upper catchments are not the intended focus of SWAN's broad objectives and thus prioritised lower, as tertiary sites. Stressor monitoring that is focused on specific environmental processes or location is conducted outside of the scope of the SWAN project.

Identifying regions excluded from water quality monitoring activities is a first step in highlighting gaps in the network. Recognising gauging stations or proposed gauging stations in unmonitored regions is an obvious step towards filling gaps in the network. The surface water monitoring network review proposed 179 new gauging stations for flow monitoring across Queensland.

Other possible gaps recognised by DERM include the following.

- Inconsistent methodology for determining sediment, nutrient and pollutant loads from event monitoring impacts on data quality.
- The frequency with which sampling is undertaken needs to be increased to allow for effective statistical analysis to be undertaken. For a period of two years commencing in July 2010 DERM has been monitoring 22 sites monthly to assess the benefits of more frequent monitoring.
- There is a need for better analysis of historical and real time sampling of water quality data.
- Early warning and 'incident' monitoring in relation to point source discharges is required, particularly in high risk catchments.
- Improved quality control procedures are necessary although electronic data entry is now progressing.

In future, consideration may also need to be given to emerging water quality issues, such as those related to climate change, endocrine disruptors and the synergistic effects of water quality pollutants.

An ecological risk assessment was conducted in 2009 by DERM as part of the development of the Queensland Integrated Waterway Monitoring Framework. The aim of this assessment was to identify catchments where waterways are potentially under the greatest threat from human activities. This will inform priority areas for water quality and ecosystem health monitoring across the state, such as the review of the surface water ambient network. Assets of interest to the project included ecosystem health values of riverine, non-riverine, estuarine and marine environments.

Spatial gaps noted by the CRAMER Review include the following.

- Data collection is predominately concentrated within the larger sub-catchments of the MDB.
- Significant gaps are present in regional monitoring data, particularly in regards to western catchments and the sampling of medium to high flow events.
- At end-of-valley gauging stations, time series turbidity probes are absent.

4.5.2 Monitoring equipment and technologies

There is a need for more real-time data loggers and probes measuring a range of water quality parameters to improve the currency and accuracy of the data being collected. The frequency of sampling also needs to be increased to improve statistical analysis.

South West NRM has noted the need for increased application of technology including remote sensing, telemetry and automated systems.

4.5.3 Modelling gaps

The collection of certain water quality parameters is insufficient, particularly in regards to salinity, nutrients and pollutant loads, with this being especially noted in the QMDB and SEQ regions.

The availability of historical and real-time data for modelling is lacking in many areas and there is a need for enhanced modelling capacity, particularly in the south east and south west regions.

There are a number of data quality issues of concern including the application of inconsistent methodology for determining sediment, nutrient and pollutant loads from event monitoring; a need for better analysis methods and programs; and a desire for increased application of standard methodologies and protocols. More issues relating to data management are presented in the Data Management section.

Modelling gaps noted by the CRAMER Review include the following.

- Aside from gauged sites, the collection of nutrient data is not conducted regularly. In addition, nutrient data from gauged sites is generally inconsistent and limited to no flow or low flow conditions.
- There is no sampling program committed to regularly monitoring stream water quality to determine end-of-valley loads, condition and trend.
- Accessibility to historical and current data records needs to be improved.

Modelling gaps noted by the Condamine Alliance include the following.

- confirmation of community water values (environmental values) for development of water quality objectives
- defined suite of promoted standard methodologies/measurement protocols from which to select (based on resources available and data quality required) to simplify decision-making and also allow for cross-regional data analysis

QMDC monitoring is currently on limited and unsecured funding, and is thus limited in QA/QC measures. However, within this limitation, data collection is likely to expand to include more sites and to integrate agency data as QA checks and then as additional data for condition and trend assessments.

Other gaps identified by QMDC include the following.

- Water and pollutant loads quantity and trend analysis is currently limited by the lack of flood event data.
- Flow data for events could be improved with additional flow measurements and the inclusion of change of stage weighted discharge calculations to match Australian standards in flow measurements.
- Pollutant load estimates require a sustained commitment to flood event sampling at strategic paddock, gully, creek and end of valley sites.
- An improvement in current model estimates for pollutant loads is desired.

South East Queensland Healthy Waterways - Data gaps affecting the water quality monitoring network in SEQ were highlighted in a report prepared by Ecowise Environmental Pty Ltd in association with the Healthy Waterways Partnership (formerly Moreton Bay Waterways and Catchments Partnership). They include the following gaps.

- Information regarding input loads of total suspended solids and nutrients for estuary and bay studies is lacking, as only modelled estimates are available.
- Data on catchment exports of sediment and nutrients to Pumicestone Passage is deficient, as only modelled estimates are available.
- The availability of data required for urban impact/ development modelling is not consistent across SEQ catchments.
- There is a lack of measured load data.
- Spatial patterns of sediment and nutrient export need to be determined for sediment network modelling software (SedNet) and Environmental Management Support System (EMSS) model validation.
- Very little event mean concentration data is available for EMSS modelling.
- The availability of data required for modelling is not consistent across SEQ.
- There is a requirement for enhanced modelling capacity.

4.5.4 Resources

Monitoring for water quality parameters is an expensive process as it involves laboratory analysis. Many NRM bodies struggle to maintain on-going monitoring programs due to the continual need to apply for external funding to keep these programs running. This cyclical funding issue also makes it difficult for them to retain staff with appropriate levels of skill and experience.

Priority water quality monitoring gaps

25. Spatial and temporal gaps exist in the water quality monitoring networks of the lead water agency, NRM bodies and local governments.
26. More data loggers and probes are required to obtain real-time water quality data sets.
27. The frequency of sampling for some parameters, such as sediments and nutrients needs to be increased, especially during flood events.
28. Inconsistent methodology for determining sediment, nutrient and pollutant loads from event monitoring impacts on data quality.
29. There is a need for enhanced modelling capacity, particularly in the south east and south west regions.

4.6 Water management and accounting gaps

The primary water management and accounting gaps relate to water trading data and the data required to support the development of a national water account. The limited availability of water use data is also of concern for the state.

4.6.1 Reporting of water trading data

Two key issues currently impacting water trading information in the state are:

- multiple reporting requirements to federal agencies and overlaps in the information requested
- complexity of aggregating water trading information at a national level due to differences in systems and product specification, and the resulting differences in terminology

The NWMS will be highlighting and addressing any gaps in water trading information. Part of this project will be the enhancement of existing water management systems in Queensland to allow more consistent information to be reported and accessed at the national level.

4.6.2 Collection and management of water accounting data

Water accounting is the application of a consistent and structured approach to identifying, measuring, recording and reporting information about water. A number of data and information gaps have been identified.

Gaps ‘first appear’ when state water accounting is undertaken or data/information is provided to the National Water Account (NWA) for a catchment. The gaps reduce as water accounting is repeated annually for each catchment as estimation methodologies are developed as required. However, when water accounting is undertaken in a new catchment, similar gaps ‘appear’ for that catchment. These gaps include, but are not limited to, the data/information requirements for:

- state water accounting, e.g., unmetered extraction

- the NWA
    - identifying available data (geographic and temporal scope) that fits with the Chart of Accounts
    - identifying and collecting new data required for the NWA (that are above and beyond what DERM currently reports)
- the Australian Water Accounting Standards (AWAS)
    - data available (geographic and temporal scope) that fits with AWAS requirements

Gaps due to voluntary reporting of data and information include the following.

- All local government water service providers are requested to provide data on a voluntary basis to the Local Government Association of Queensland (through their service body *qldwater*). As reporting is voluntary there are large gaps in data and information through non-participation and partial reporting.
- Urban and rural water service providers meeting the eligibility criteria for the National Performance Report are requested to provide data to DERM. This reporting is also on a voluntary basis in Queensland, therefore there are gaps in information through non-participation by eligible water service providers and partial reporting.

Specific gaps that have an impact on water accounting include the following issues.

- Groundwater gaps
    - Water extraction data is often lacking, or of very poor quality. This is particularly an issue in non-declared areas where gathering this data is more difficult
    - Monitoring frequency. The quarterly monitoring of bores should be seen as an absolute minimum. The majority of aquifers react to recharge events much more quickly than a three month lag
    - Installation of monitoring bore loggers, resulting in better quality data to better characterise recharge events and water level depletion, is required
    - Many aquifer systems have undetermined yields; there is a real need to assess these systems
    - A lack of enhanced modelling capacity
- Murray-Darling Basin Sustainable Yields Project
    - There is a lack of detailed assessment of groundwater flows, recharge or other water balance components
    - Adequacy of stream flow gauging generally appears to vary with the importance of river water resources and the complexity of the surface water system
    - Greater information is needed with regards in-stream storages

  - Quality of high stream flow gauging data (relating to breakout and bypass flows, for example), particularly towards the end of the river system, needs improvement
  - Simulation of low stream flow patterns in this region has been affected by problems estimating river losses
- The Northern Australia Sustainable Yields Project
  - Groundwater information is locally available but large areas remain devoid of any quantitative groundwater data
  - Monitoring and modelling are vital to help constrain levels of extraction
  - Groundwater data are very sparse for most aquifers across the project area and there are large uncertainties regarding the volumes that might safely be extracted
  - Gauging stations are sparsely located. Data is especially sparse in floodplain regions where maintenance of recording equipment is difficult
  - Level of confidence in low-flow records at many gauging stations is poor
  - Surface water modelling has had to rely heavily on stream flow data collected since the 1970s and 1980s. Only a few stations go back to the 1950s and many stations have closed in recent years
  - The ability to develop water availability assessments for catchments is reliant on the existence of river system models. Such models exist for the South-East Gulf, Mitchell and Flinders-Leichhardt regions but no such model exists for the Northern North-East Coast drainage division
- Surface water gaps
  - Undefined flow ratings at many gauges are impacting on data quality and make it difficult to define the water resource
- The Australian Water Resources 2005 report identified that data relating to farm storages (including on stream or off stream farm dams/ring tanks that are filled either by local runoff, pumping from a nearby waterway or by flood harvesting) is strongly required across Queensland. It also noted the lack of recharge and runoff information. Further data gaps highlighted include
  - Lack of gauging conducted in the downstream reaches of the Brisbane water supply area
  - Lack of data on losses from minor catchment dams, conveyance losses and seepage from streams to groundwater
  - Lack of data on evaporation from open water and wetlands.

4.6.3 Other gaps

By the end of June 2010 under the Metering Water Extractions Policy there will have been 2225 new meters installed to measure unsupplemented water take. There have also been upgrades undertaken to around 400 existing meters.

All new meters will have data loggers attached. Data from these loggers will be stored in DERM's WMS data management system. In the future this system will become web-enabled and landholders will be able to access the data from their meters, via the internet. This access will be password secured and a landholder will only have access to the meters on their own property. Metered use data from this system is being delivered to the Bureau but only aggregated data will be published.

There is no intention at this point in time to meter stock and domestic take. It is assumed that landholders take their full stock and domestic entitlement.

Priority water management gaps

30. Multiple reporting requirements of federal agencies for water trading information are an issue for state organisations.
31. Aggregating state water trading information up to a national level is complex and requires significant collaboration between state and federal agencies.
32. Enhancements to DERM and SunWater data management systems may be required once specifications for water allocation and trading data are available.
33. There is a wide range of data that is currently unavailable for inclusion in the National Water Account due to inadequacies in data collection processes and systems, incomplete data measurement and recording, or is currently not required to be measured or recorded but is required for the first NWA and for implementation of the AWAS across Queensland.
34. Enhanced information systems to better collect, manage, and deliver NWA and AWAS compliant data and information are required.

4.7 Data management gaps

The key data management gaps in Queensland include the following requirements:

- improved standardisation in all aspects of monitoring and data management
- more centralised or integrated data management within organisations
- enhanced data management systems
- more comprehensive and accessible metadata
- improved spatial datasets
- digitisation of historical data and metadata

4.7.1 Data standards

In all sectors there is concern over the lack of standardisation with monitoring techniques and data management processes. More collaboration between organisations undertaking similar monitoring would support the development of data that is of a comparable standard. In 2010 it was noted that standards were particularly required for:

- Doppler technology – this new technology is obtaining increasing rates of uptake and standardisation is needed to ensure the technology is used in a standard way to ensure compatibility of the data collected.
- Ratings development – ratings should be developed to a minimum standard to improve the compatibility and quality of data.

With Round 4 M&E Program funding of $30,000 DERM has developed standards for the collection of discharge measurements using Acoustic Doppler Current Profilers (ADCP). These standards have been developed in consultation with key stakeholders in all jurisdictions, with interest from New Zealand. The standards include a rating guide allowing ADCP measurements to be rated on a common scale thereby enabling cross jurisdictional comparisons of flow data quality.

With regards ratings development, over the past year DERM has reviewed and updated the ratings at a number of gauging stations in the south west region of the state. However there has been no activity to develop recommendations for minimum standards for all stakeholders.

As above, all sectors have varying methods of managing data and metadata. Guidelines are required for coding in order to be easily able to identify varying data as ‘fit for purpose’. There is a requirement for all databases to be able to capture parameter descriptors (using a standardised variable naming list), methods, and data purpose and quality codes to define accuracy. There is a need to have the capacity within the database to analyse for a number of various combinations of the parameter descriptors.

DERM conducts its monitoring under an accredited quality management framework, but this is not always present in other monitoring organisations.

With regards to groundwater monitoring, DERM has procedures on instrument calibration and use, the measurement of water levels, and the recording, downloading and validation of data. Whilst most of the procedures are in place and in practice, more effort could be made with the validation of data.

On request DERM supplies other organisations with copies of their work practices. A number of these work practices and procedures require review for both the surface water and groundwater disciplines. DERM received $150,000 under Round 2 funding to develop work practices for groundwater monitoring. The key outcome of this project was the completion and delivery of work practices that will provide a consistent approach to groundwater monitoring and assist with training and skilling components. These work practices were developed in consultation with regional staff and their input and increased understanding should ensure a high level of application. The work practices developed for Queensland are a starting point for the basis of Australian standards. However many more DERM work practices still need to be reviewed.

A coordinated training and accreditation framework would assist in enhancing standardisation in monitoring techniques and processes for quality coding and metadata capture. This has been identified across all water monitoring networks and also in the field of urban water data collection.

DERM received $100,000 to engage a consultant to ensure materials used for training and education purposes have up-to-date technological content.

DERM is using Round 4 funding ($145,000) to develop an integrated QA/QC framework for ambient and event based water quality monitoring in SEQ. DERM and the South East Queensland Healthy Waterways Partnership own and operate an automated event monitoring framework of 19 stations across SEQ. The program also accesses data from 49 event monitoring sites owned by other organisations such as local government, NRM bodies and Seqwater. This program will formalise the best practice procedures employed by DERM and enable adoption of these procedures by other participating organisations.

4.7.2 Data management systems

The key data management issue in Queensland at present centres on how to best manage the variety of collection and analysis methods in place and the many data storage formats used, so as to optimise comparison of the different datasets. The data monitored by each organisation is 'fit for purpose' and is monitored within organisational resource constraints. For whole of state and national water resource assessment and water accounting purposes, there is a need to collate data and allow the required analyses across different data sources. Improvements to data management systems and practices are necessary to ensure this integration is possible and that the data is comparable with defined quality coding or metadata.

4.7.2.1 Supplemented data management systems

Under Round 1 M&E Program funding SunWater received $825,000 to modernise their water data storage, management and transfer capabilities. This funding enabled the transfer of data from their in-house data management systems (SWIMS R1 and R2) to the Bureau in WDTF. SunWater stores time-series data in the Kisters product TimeStudio. The Bureau provided a transfer tool to enable delivery of data from TimeStudio in WDTF.

However, Kisters are no longer supporting the TimeStudio product and SunWater needs to adopt a new data management system to ensure reliable storage and reporting of time-series data. As SunWater is the second largest monitoring agency in Queensland the information stored in TimeStudio is an important dataset for the state and for federal water accounting purposes. SunWater has undertaken an analysis of the different systems available and has determined that the new Kisters product WISKI would best suit their requirements. The need for a new system to manage time-series data is currently SunWater’s most critical gap.

One of the key water organisations in SEQ is Seqwater, yet this organisation was only established in November 2007. In this short period of time Seqwater has inherited infrastructure and associated monitoring networks from all SEQ councils as well as infrastructure in SEQ that was owned by SunWater. Seqwater is currently working through a number of challenges regarding the understanding and integration of its new monitoring network. A key component of this is the centralised management of data from the network. This is being driven by an internal operational need as well as an external reporting requirement. Due to the geographic fragmentation of the inherited assets and their various conditions, data management was disparate and localised. Since

its establishment Seqwater has been upgrading its monitoring network, replacing aged hardware with standardised systems, and installing new monitoring where gaps have been identified.

The lack of a centralised data management application to collect, manage, store and report on data has been a critical issue for Seqwater but M&E Program funding in 2010-11 of around $500,000 has enabled Seqwater to install WISKI to centrally manage their data and to develop a WDTF tool that can be used by all WISKI clients to deliver data to the Bureau in the preferred format.

Under Round 3 M&E Program funding QWC was allocated almost $394,000 to enhance their WaterHub system to automate the collection, collation, formatting and generation of reports from SEQ Water Grid entities and transfer them to recipient entities using appropriate file transfer protocols. This has enabled data to be delivered to the Bureau in WDTF.

As outlined in Section B water reform processes in SEQ have led to the establishment of bulk distribution/retail entities. Three entities (Queensland Urban Utilities, Allconnex Water and Unitywater) are now responsible for the sale and distribution of potable water to end users, and the maintenance and service provision of the sewerage network.

These entities were legally established on 1 July 2010 and have recently been named in the Water Regulations. These entities have yet to confirm the mechanism they will adopt for delivering data to the Bureau however it appears likely that some will choose to deliver through the SWIM system managed by *qldwater*. However, on 7 April 2011 the Premier of Queensland announced that the legislation that created these entities will be repealed and that councils who wish to return to their previous structure may do so. It is yet unclear the impact this will have on the custodianship of the urban water data from SEQ.

The Bureau has funded the enhancement of the SWIM system under rounds 2-4 of the M&E Program, with an investment of almost $600,000. The SWIM system assists with the reporting of data from one quarter of the named persons in Queensland required to deliver data to the Bureau. Round 2 funding enabled the SWIM system to cater for parameters to be reported to the Bureau under the Water Regulations and for the delivery of that data from water service providers through SWIM, in the preferred WDTF. Round 3 funding was allocated to make the task of transferring data from water service providers to the Bureau, via SWIM, more manageable, thereby improving the accuracy and timeliness of reporting. Round 4 funding has enabled enhancement to the SWIM Quality Assurance Module to automate data checking arrangements; the capture of historical information and reformatting into WDTF; and the updating of the SWIM-WDTF programming codes to support submission of groundwater data and a small number of meteorological indicators that were not previously supported.

The most critical outstanding gap for the SWIM system involves the lack of centralised and synchronised data management across many water service providers impacting on the frequency and accuracy of data reporting. Most

water service providers store their data in a number of different formats and to report this on to the SWIM system they must manually collate the necessary data and then repackage it; manual processes such as this are prone to errors, omissions and delays.

4.7.2.2 Unsupplemented data management systems

DERM holds most of the water rights, allocations and trade information as well as unsupplemented rural water information. Historically this information has been stored in disparate information systems within DERM, however under Round 2 of the M&E Program DERM was allocated $750,000 to significantly update its data management system. With this funding the information is more secure and reliable and is centrally managed. The system now has the capacity to deliver information to the Bureau in WDTF. As clearer specifications of data requirements become available from the Bureau or other federal agencies, assessment of data management enhancements required will be undertaken.

SunWater has also recognised the need for enhancements of their system, or development of a new system, to manage the water allocations data being requested by federal agencies. As an example, SunWater's current data management system does not have the capacity to store all the data required by the COAG Service Standards. This information is presently captured in spreadsheet format.

4.7.2.3 Water quality data management systems

NRM bodies struggle with funding for monitoring activities therefore these organisations require a data management system that is low cost. Most of their monitoring is undertaken by volunteers who, historically, have stored data in a range of spreadsheets. This data management has needed to be centralised. As NRM bodies are committed to reporting back to their communities in as short a time as possible, they have required a data management system that allows that. The majority of NRM bodies have committed to invest in a web-based data management system, uniDap WaterQ, which is providing for their organisational data management needs. This system is also enabling efficiencies in data management and the delivery of data to the Bureau in one format, rather than a plethora of formats.

The Bureau has invested over $1.6 million to enhance the WaterQ data management system which benefits not only Queensland NRM bodies but a number of similar organisations in other jurisdictions that are also now using WaterQ to manage their data. This funding included a trial of a web portal that could be used by any named person to upload and then deliver their data to the Bureau in WDTF.

This investment significantly improved the efficiency with which stakeholders in the field, record and retrieve data. It has enabled the capture and storage of data in a standard structured form which supports dashboard reporting and analytical processing to produce meaningful insights from the data. It has enabled the aggregation and sharing of data from a common central

repository. As this system is being adopted by groups across Australia this will improve the comparability of data from these organisations. At the time of publication data from many of these organisations is being delivered to the Bureau in WDTF. The system now has capacity to manage data from any type of organisation not just water quality monitoring agencies.

Whilst this system is low-cost some of the smaller organisations will need to find external funding sources to ensure hosting of this system into the future. The system also needs enhancing to incorporate standardised metadata coding, as being developed by Bureau funded projects from Queensland and New South Wales. QA/QC processes for water quality data across participating regions also need to be developed to improve compatibility of data.

NRM bodies also require the input of paper historical data to WaterQ via an intelligent importer that has recently been designed. This data includes metadata and is of high value to NRM bodies and to the users of their data as it will enable trend analysis and a better understanding of current datasets.

Gladstone Area Water Board (GAWB) was allocated $45,000 in funding under Round 3 of the M&E Program to procure and implement a water quality data management system. Prior to this funding GAWB managed its water quality data in a range of Excel spreadsheets. This funding has enabled GAWB to improve the quality and accuracy of its water quality data through centralisation of the data and standardisation of metadata. This information is then delivered to the Bureau through *qldwater's* SWIM data management system.

4.7.2.4 Other data management system issues

Other data management issues include the following:

- Enhancement of DERM's Hydstra system is required to allow for better public access to flow and water quality information. DERM is investing in the Hydstra Web product and it is expected that web access to all its streamflow data will be available to the public by mid 2011.
- DERM's surface and groundwater databases require validation - in particular, groundwater levels and site validation details in both databases.
- Enhancement of the DERM Air Quality Monitoring Database is required to enable delivery of meteorological data to the Bureau in WDTF.
- Improved and standardised analysis techniques would add value across all water monitoring datasets.
- Many agency data management systems do not have the functionality to adequately store a variety of monitoring data, nor to code that data appropriately.
- As many monitoring organisations use Excel or in-house data management systems to store their data, it is difficult for them to

automate the delivery of data to the Bureau or to prepare their data in the preferred WDTF.

- Councils such as Toowoomba - that are still working through merger issues - require a single SCADA access point to gather, analyse and report all data from previous entities.
- SCADA systems need to be upgraded so that they have the ability to report to outside agencies, which could also include the reporting of data to the Bureau in the preferred WDTF.
- A data quality review of DERM surface and groundwater databases is desired.
- A data quality review of water affiliated bodies' surface and groundwater databases is desired.

4.7.3 Metadata

Within Queensland, there are a range of organisations that collect monitoring data for a variety of purposes and uses. The data is collected and managed according to organisational resource constraints. To optimise the investment in these monitoring activities, the data that is collected needs to be better managed, coded, and stored so that the purpose of monitoring, methods employed and the quality of the data are understood. There is a need to identify any particular dataset as being 'fit for purpose'.

There is a lack of good quality metadata attached to monitoring information, which hampers the ability to determine the quality of the data itself. Not only is there a need for comprehensive metadata, but the metadata needs to be available electronically. Often the metadata is unattached to the water data and overlooked.

Data management, variable/parameter descriptors and quality coding need standardisation. Appropriate methodologies to assess data quality need to be further developed and applied to the data, along with enhanced reporting and analysis tools associated with any newly defined methods for data storage.

Databases managing water data require enhancement and validation to ensure quality coding systems are in place. There is also a need for standardised training to overcome the ad hoc and uncoordinated interpretations of parameters.

DERM has been allocated around $340,000 under rounds 3 and 4 of the M&E Program to identify the water quality information being captured by the various agencies, government bodies, councils and water authorities across Australia and to propose a set of water quality data elements to form a National Water Quality Dataset. This dataset would then be incorporated as the water quality component of AWRIS. The water quality data considered in this process includes surface and groundwater values for both in-situ and lab-based results. Time-series values have not been included for consideration and are expected to be handled through other areas of AWRIS. A conceptual data model was developed in consultation with all jurisdictions in Australia, with interest shown from New Zealand.

DERM is also undertaking an ongoing project that is capturing water monitoring metadata for publication on Wetland*Info.* The 'Capture of water monitoring metadata for publication on Wetland*Info*' project is a component of the Integrated Waterways

Monitoring Framework. Metadata information for internal and external water quality, water quantity and aquatic ecosystem monitoring programs will be available in a spatially interactive mode via Wetland*Info*. This project will assist with a need for improved access to more comprehensive metadata on monitoring programs.

DERM has significant amounts of supporting documentation in paper format stored in files around the state that should optimally be scanned and stored online with the data. These files may contain, for example:

- photos of gauging station controls/river bed and banks/flooding/site instrumentation etc
- reports on rating curve development – both high and low flows
- reports on data estimation
- some general yearly assessment of station performance

This documentation would be invaluable for the users of that data to be able to interpret the quality of the data they are using.

Other organisations have valuable historical data in paper format that require digitisation to expand the dataset and assist with trend analysis. This data can include metadata such as the georeference data for sites. Currently there are limited resources available to digitise these datasets.

4.7.4 Spatial data

At the National Groundwater Data and Information Systems workshop held in December 2008 there was agreement on a number of priority actions. One of these was to investigate the feasibility of a nation-wide roll-out of the Arc-Hydro data model/ESRI geo-database, as presented at the workshop. Implementation models would be managed by the lead water agency in each state/territory and would be capable of being rolled-up into a synchronised national system maintained by the Bureau of Meteorology or Geosciences Australia. This would support the Bureau's water resource assessment, water accounting and water availability forecasting functions as well as deliver to the various business needs of agencies within each state and territory.

Under Round 3 of the M&E Program DERM was allocated $155,000 to undertake a pilot study in the Burnett catchment to trial the applicability of the Arc Hydro data model for Queensland. The Burnett catchment is a large region with a variable climate and important aquifers with multiple uses. It is hoped that this system will prove a useful tool to improve geo-data management in Queensland. Queensland has identified and mapped the Hydrogeological units within Queensland and is currently populating the Arc Hydro data model.

The Bureau is developing a National Groundwater Information Service (NGIS) data model. To support the development of the NGIS Queensland should:

- develop of mechanisms for transferring data into the NGIS data model
- report on the transfer issues including problems and issues encountered and recommendations on how the system can be improved

- provide a copy of a populated data model and associated metadata and documentation to the Bureau

DERM received around $700,000 in funding from the M&E Program to address these issues.

In order to provide better quality data to support the Bureau's development of a national foundation dataset for the Australian Hydrologic Geospatial Fabric, there is a need to define the elevations of gauging stations in surface water monitoring networks as well as define the elevations of bores not yet defined. The EHA review noted the need for a concerted effort to bring the mapping of bore locations up-to-date. As previously stated Bureau funding has given DERM the capacity to tie many gauging stations and bores to AHD, significantly addressing this important gap, as far as the state monitoring networks are concerned. Seqwater has identified the need to undertake similar activities for their sites.

Queensland is compiling a surface hydrology spatial dataset by combining the best available data into a single dataset which can be used in conjunction with related datasets such as wetland mapping and farm storage datasets. This surface hydrology dataset requires cleaning, segmenting, networking, direction, edge matching, editing and attribution to improve the quality of data and to maximise the benefits for water managers and other data users.

As noted in Section B, GA has undertaken a national data audit to support development of an Australian Hydrological Geospatial Fabric. The audit recommended certain activities be funded by the Bureau in order of priority – Tier 1 to Tier 4 activities. Queensland identified regional based activities which match the priorities outlined in the audit. In 2010-11 DERM was funded to complete the capture and revision of 1:25,000 watercourses and water body data in SEQ. Outstanding priority activities include:

- Great Barrier Reef and QMDB catchments: require similar enhancement activities, as noted above, involving two main components:
    - Integration of data such as man-made water bodies already captured through the National Topographic Information Coordination Initiative project and other sources with 1:100,000 water courses.
    - Transfer of data attributes from GA's 1:250,000 dataset to the 1:100,000 dataset being used for networking and stream ordering.
- Gulf region and western Queensland:
    - 1:100000 watercourse networking and direction
    - Transfer of data attributes from GA's 1:250,000 dataset to the 1:100,000 dataset being used for networking and stream ordering.

The completion of these activities will assist in the creation of a state wide point of truth dataset that can be used for future water management and planning.

4.7.5 Data availability

The key gaps relating to data availability concern the need for coordination at a state level, the myriad of data management systems in use by data providers and the need for improved data custodianship.

Under Rounds 1-4 of the M&E Program DERM has been funded to coordinate communication with named persons in the state on behalf of the Bureau. This level of strategic coordination has had significant benefits for the Bureau including improved communication enabling speedier dissemination of information from and back to the Bureau; more consensus from stakeholders on reporting issues; development of this report identifying state gaps and priorities; and increased promotion and understanding of the aim of the M&E Program itself. This strategic activity has also had significant benefits for the state including the opportunity for cross-industry networking and the improved understanding by state organisations of the gaps and issues faced by other sector organisations.

From the perspective of assisting the Bureau with matters relating to the Water Regulations it is currently difficult to assess the level of strategic coordination still required. It is likely, however, that strategic coordination requirements will be more project specific and short term.

Under Round 2 of the M&E Program DERM was allocated around $110,000 to develop a framework to enable simple and transparent management of information rights and to create an environment where the Bureau has the greatest possible scope for reuse and distribution of water information to water stakeholders. The outcomes for the Bureau include recommendations on how to manage water data from a license perspective. The project established that a CC framework was suitable for the water information being provided by data suppliers under the Water Regulations.

As part of the Strategic Water and Information Coordination project in Round 3 DERM was allocated $50,000 to communicate the benefits of CC licensing to Queensland named persons and to develop educational tools to sit on the Bureau's website to inform all water data providers of the impacts and benefits of this type of licensing system. This information has been available for all named persons to use to support a decision on how to license the data they deliver to the Bureau. This project also provided advice to the Bureau regarding the adoption of this licensing system for all their water data.

Access to water data is compromised by the myriad of data management systems in place in Queensland. Commercial sensitivities also prevent open sharing of data amongst certain organisations. Collecting data for whole of state or national water resource assessment and water accounting purposes can therefore be difficult.

Access to groundwater data needs enhancement to deliver web data.

Data and information resources are valuable assets. DERM Departmental Custodians hold a number of these assets on behalf of the State of Queensland. Custodians are accountable for the capture, maintenance, dissemination and preservation of these resources. The following criteria are considered in delegating custodianship responsibilities:

- Statutory responsibility for collecting and/or maintaining the data

- Significant policy/planning use or requirements for the data or ability to engage users of the data
- Existing responsibility for whole of state co-ordination and/or capture and maintenance of the data
- The best placed, or most accepted by users to manage the data
- Most capable and most willing to undertake the custodianship role

A lack of consistent application of data custodian principles over the diverse group of datasets contributes significantly to undermining the value of the data and is an area that can be enhanced.

Priority data management gaps:

35. Standardised approaches to data processing, management and quality coding are required across all monitoring organisations.
36. Standards for the development of rating curves are high priorities for monitoring organisations.
37. Further review work and inter-jurisdictional collaboration is required on a range of field and operational work practices with a view to creating Australian standards.
38. Development and adoption of defined quality coding and metadata as well as appropriate enhancements to data management systems are required to ensure successful integration of data is possible.
39. Alignment of data reporting standards and formats between state and federal agencies such as the Bureau is required.
40. Improved and standardised analysis techniques would add value across all water monitoring datasets.
41. Lack of centralised and synchronised data management across many water service providers is impacting on the frequency and accuracy of data reporting.
42. SunWater requires upgrading of its TimeStudio system to the new WISKI system to ensure reliable storage and reporting of SunWater time-series data.
43. Spatialisation of water consumption data is not currently possible due to limited appropriate metadata.
44. Updates to the data management systems of water data providers are necessary each time changes are made to the metadata coding required to be delivered under the *Water Regulations 2008*.
45. Further enhancement to the uniDap WaterQ system used by Queensland NRM bodies will be required if these bodies adopt the national water quality metadata coding system being developed.
46. Updates to the data management systems of water data providers are necessary each time changes are made to the water data transfer format preferred by the Bureau of Meteorology for data delivered under the *Water Regulations 2008.*

47. There is a need for a method to easily integrate data from different SCADA systems.
48. Validation of data and enhancement of metadata is required in DERM's surface and groundwater databases.
49. Many organisations have valuable data that should be digitised to expand datasets and assist with trend analysis and to better understand the quality of data.
50. The surface hydrology spatial dataset requires cleaning, segmenting, networking, direction, edge matching, editing and attribution to improve the quality of data and maximise benefits for water managers and data users.
51. Mechanisms need to be developed to transfer data into the National Groundwater Information Service data model being developed by the Bureau of Meteorology.
52. A coordinated training and accreditation framework would assist in enhancing standardisation in monitoring techniques and processes for quality coding and metadata capture.
53. Data management systems of many monitoring organisations require enhancement.

Table 12 presents the priority gaps across all data categories, in order of appearance.

- Gap numbers 1-7 are groundwater monitoring issues that are discussed on pages 75-83.
- Gap numbers 8-17 are surface water monitoring issues that are discussed on pages 84-91.
- Gap numbers 18-24 are meteorological issues that are discussed on pages 92-96.
- Gap numbers 25-29 are water quality monitoring issues that are discussed on pages 972-101.
- Gap numbers 30-34 are water management and accounting issues that are discussed on pages 101-104.
- Gap numbers 35-53 are data management issues that are discussed on pages 104-115.

Table 12 Priority gaps in Queensland across all water data categories, 2011

1	Spatial and temporal gaps exist in many bore networks.
2	The installation of data loggers on bores would result in data better able to characterise recharge events and water level depletion.
3	A number of existing data loggers attached to bores require upgrading to improve data currency and to minimise data loss.
4	Bore locations should be aligned to a known datum to improve the quality of data collected and to support development of a national geofabric dataset.
5	There is a lack of measured data relating to connected groundwater systems and base flows (surface water-groundwater connectivity).
6	A lack of sufficient bore monitoring data, particularly in high risk areas, impacts on the development of accurate models.
7	A lack of appropriately trained staff and adequate operational resources are emerging issues across groundwater monitoring agencies.
8	Spatial and temporal gaps exist in surface water monitoring networks measuring water levels and flows.
9	A number of existing monitoring sites require upgrading to improve data currency and to minimise data loss.
10	Upgrades to new technology flow sensors will improve the quality and quantity of river flow data collected.
11	Gauging stations and storage gauges should be aligned to a known datum to improve the quality of data collected and to support development of a national geofabric dataset.
12	Enhanced rating of gauging stations and storages is required to improve the accuracy of data collected.
13	Bathymetric surveys of storages are required to confirm storage capacities.
14	Additional data collection is required to reduce uncertainty in river modelling – issues particularly noted in the QMDB and the northern North-East Coast catchments.
15	A lack of appropriately trained staff and adequate operational resources are emerging issues across surface water monitoring agencies.
16	There is a need to upgrade to automatic systems and install telemetry for

	instantaneous recording of storage levels.
17	Insufficient monitoring of wetland extent changes and risk to and condition of wetlands.
18	Gaps exist in spatial and temporal monitoring in flood warning networks, including in the high resolution ALERT-type networks, inland towns and regions and in the catchments of major storages.
19	Upgrades to gauging equipment are required for some organisations managing flood warning systems.
20	There is a specific need for improved rain and water level monitoring in catchments above large storages.
21	Stage-discharge ratings relationships for new and existing gauging and flood warning stations are required to provide data to assist predictions of critical flood heights at key towns and rural areas, and to assist water resource objectives.
22	A major review is required for all gauging and ratings in the QMDB rivers and in other rivers where this would assist the collection of data for both flood warning and water resource assessment purposes.
23	Technical and institutional support is required for local governments and regional bodies operating monitoring networks, especially rainfall and river height monitoring for the purposes of flood warning.
24	A lack of skilled operators is a critical issue in obtaining enhanced ratings at flood warning sites.
25	Spatial and temporal gaps exist in the water quality monitoring networks of the lead water agency, NRM bodies and local governments.
26	More data loggers and probes are required to obtain real-time water quality data sets.
27	The frequency of sampling for some parameters, such as sediments and nutrients, needs to be increased, especially during flood events.
28	Inconsistent methodology for determining sediment, nutrient and pollutant loads from event monitoring impacts on data quality.
29	There is a need for enhanced modelling capacity, particularly in the south east and south west regions.
30	Multiple reporting requirements of federal agencies for water trading information are an issue for state organisations.

31	Aggregating state water trading information up to a national level is complex and requires significant collaboration between state and federal agencies.
32	Enhancements to DERM and SunWater data management systems may be required once specifications for water allocation and trading data are available.
33	There is a wide range of data that is currently unavailable for inclusion in the National Water Account due to inadequacies in data collection processes and systems, incomplete data measurement and recording, or is currently not required to be measured or recorded but is required for the first NWA and for implementation of the AWAS across Queensland.
34	Enhanced information systems to better collect, manage, and deliver NWA and AWAS compliant data and information are required.
35	Standardised approaches to data processing, management and quality coding are required across all monitoring organisations.
36	Standards for the development of rating curves are high priorities for monitoring organisations.
37	Further review work and inter-jurisdictional collaboration is required on a range of field and operational work practices with a view to creating Australian standards.
38	Development and adoption of defined quality coding and metadata as well as appropriate enhancements to data management systems are required to ensure successful integration of data is possible.
39	Alignment of data reporting standards and formats between state and federal agencies such as the Bureau is required.
40	Improved and standardised analysis techniques would add value across all water monitoring datasets.
41	Lack of centralised and synchronised data management across many water service providers is impacting on the frequency and accuracy of data reporting.
42	SunWater requires upgrading of its TimeStudio system to the new WISKI system to ensure reliable storage and reporting of SunWater time-series data.
43	Spatialisation of water consumption data is not currently possible due to limited appropriate metadata.
44	Updates to the data management systems of water data providers are necessary each time changes are made to the metadata coding required to

	be delivered under the *Water Regulations*.
45	Further enhancement to the uniDap WaterQ system used by Queensland NRM bodies will be required if these bodies adopt the national water quality metadata coding system being developed.
46	Updates to the data management systems of water data providers are necessary each time changes are made to the water data transfer format preferred by the Bureau of Meteorology for data delivered under the *Water Regulations*.
47	There is a need for a method to easily integrate data from different SCADA systems.
48	Validation of data and enhancement of metadata is required in DERM's surface and groundwater databases.
49	Many organisations have valuable data that should be digitised to expand datasets and assist with trend analysis and to better understand the quality of data.
50	The surface hydrology spatial dataset requires cleaning, segmenting, networking, direction, edge matching, editing and attribution to improve the quality of data and maximise benefits for water managers and data users.
51	Mechanisms need to be developed to transfer data into the National Groundwater Information Service data model being developed by the Bureau of Meteorology.
52	A coordinated training and accreditation framework would assist in enhancing standardisation in monitoring techniques and processes for quality coding and metadata capture.
53	Data management systems of many monitoring organisations require enhancement.

5 Section D

There are two key components to Section D. The first component includes an outline of the state's vision for water and the categorisation and ranking of the gaps identified in Section C according to state priorities. The second component of this section is the presentation of known recommendations/strategies to address identified gaps.

5.1 State vision for water

The priority for addressing gaps relates directly to the drivers for water information collection. These drivers are outlined in Section A. The state drivers focus on the need to assess the extent, management, use and condition of water resources to ensure sustainability of these resources into the future. Individual organisational drivers focus on the information required to operate their business and ensure the sustainability of the water resources they rely on.

By planning for, allocating and managing our natural resources in a way that considers social, economic and environmental outcomes, we can support economic growth and maintain our natural and cultural heritage for today and tomorrow.

The Queensland Government's vision is for the state to be Strong, Green, Smart, Healthy and Fair. The water objectives that relate to this vision are:

- Protect and manage the state's water resources
- Ensure natural waters and dependent ecosystems are healthy
- Enable the delivery of safe and reliable water supplies

The strategies that will guide Queensland towards the achievement of these objectives include:

- Planning for climate change
- Delivering on national and state water reforms
- Allocating and managing water resources to ensure fair access
- Providing policies, programs and frameworks that account for water availability, extraction, quality and ecosystem health
- Develop collaborative policies and programs to have healthy waterways
- Ensure science and knowledge is available for securing water availability, quality and aquatic ecosystem health
- Support water service providers and infrastructure owners to have appropriate plans and strategies in place to provide safe and reliable water supplies
- Promote the safe and appropriate use of alternative sources of water including recycling and desalination

The full Strategic Plan 2009-13 is available from the DERM website.

The Queensland Government is working towards a more integrated approach to waterway monitoring and reporting and has developed the Queensland Integrated Waterways Monitoring Framework in co-operation with federal initiatives.

Current waterway monitoring in Queensland encompasses a number of arrangements with programs established for particular purposes. The Queensland Government coordinates long-term state-wide and other major programs, whilst community-based natural resource management groups, industry, local government, water service providers and others undertake monitoring at finer scales.

Comprehensive information on the condition of Queensland's waterways is crucial so they can be effectively managed and protected for future generations. It provides a benchmark for assessing future changes in our waterways and informs a range of management actions and policies regarding the sustainable use of land and water resources. Where appropriately targeted, waterway monitoring programs can also enable the identification of new and emerging issues and initiation of appropriate management responses.

The Framework will facilitate a more collaborative approach to waterway monitoring and reporting across the state, giving a more complete picture on the health of Queensland's waterways. Implementation of the framework will provide direction for the future of waterway monitoring and presentation of data in Queensland. It will improve the quality, consistency and efficiency of waterways monitoring in the state and contribute to enhanced land and water management decision-making by government, industry and the community.

5.2 Categorisation of gaps

The methodology outlined below, and the subsequent ranking of the different gaps has been developed by the lead water agency, DERM, in collaboration with an interagency working group of key stakeholders.

Step One – Identification of gap

To be included in the SWIMP an issue must have been identified as a gap by:

- the lead water agency (DERM), or
- a named person in the Water Regulations, or
- a recognised review of water information and monitoring activities

Step Two – Summary of gaps

Gaps and issues identified by DERM, named persons, or published reports are presented in Section C. From these issues key gaps have been identified by DERM in collaboration with major stakeholders and are presented in numbered lists. Essentially this process involved the removal of issues that were similarly expressed in other gaps. A list of all the numbered key gaps is presented in Table 12 on pages 116-119. All these gaps are considered a priority for the state.

Step Three – Alignment of gaps

Throughout this report gaps and issues have been discussed in terms of the different water data categories they belong to, such as groundwater monitoring, water quality monitoring etc. Most water data categories have similar issues; therefore these issues can be grouped together accordingly. The following key groupings have been established for the gaps listed in Table 12.

- Standards: for data quality, standards, work practices etc.
- Metadata: for issues with the metadata required to improve the interpretation and integration of data.
- Data management systems: for all issues relating to the need for new data management systems or enhancements to existing systems.
- Data reporting and analysis: for issues relating to the reporting and analysis of water monitoring and water information data.
- Spatial and temporal gaps: for spatial gaps as well as the need to increase the level of monitoring activities undertaken. Includes gaps in the data required for water accounting purposes.
- Monitoring equipment: includes the need for new equipment, such as telemetry, or the upgrading of existing equipment.
- Modelling gaps: for issues and gaps relating to data that is critical for modelling purposes.
- Training and resources: for the need for increased resources and increased investment in the training of data collectors and data managers.

Step Four – Categorisation of gaps

The areas of highest priority for investment in water information and monitoring in Queensland are categorised below. Whilst all 53 gaps in Table 12 are regarded as key issues for the state, they are now further categorised and prioritised in order to assist investment decision-making at either state or federal level, including the Bureau's M&E Program.

Queensland organisations are required under federal legislation to report certain water data to the Bureau. This data will be made available to the public on the internet through AWRIS. A key concern for organisations is that their data may be applied inappropriately by end-users with little knowledge of the quality of the data and the purpose for which it was originally collected.

If this data is to be understood and appropriately applied then it is critical that a number of factors influencing the quality of the data are clearly understood and made available to all users. These factors include the methods used to collect, store and analyse data as well as the purpose for collecting the data and any other influences on the quality of the data. The quality of the data management system also impacts on data quality and availability. Gaps in data standards, metadata, data management systems, data reporting and data analysis are the issues that make up Category One.

The expansion and upgrading of monitoring networks also strongly supports the achievement of state objectives particularly in regions with nil or insufficient existing monitoring activity. Accounting for water use and assessment of river health requires certain minimum levels of monitoring. DERM networks have undergone comprehensive network reviews identifying the extent of the gaps in surface, groundwater and water quality networks, as well as for modelling purposes. Other monitoring organisations have also recently assessed their spatial and temporal gaps; all the known gaps of this type are presented in Section C.

The upgrading of equipment is a priority as adoption of the latest technology can lead to more standardisation, more frequent monitoring, better quality data and more timely maintenance of equipment. At the time of upgrading equipment there is opportunity to multiply the data outputs from a site by installing multiple loggers or by installing loggers capable of more comprehensive monitoring, e.g., by appropriately installing new technology at sites previously only monitoring rainfall it is possible to also collect data suitable for water resource assessment and water accounting purposes. Upgrading equipment is also a key concern for the Bureau as it will extend the coverage and improve the quality of data coming from the state.

Data and resources to support modelling purposes are also of key concern. In particular, these data gaps impact on water resource assessment and water accounting activities and the ability to support national geofabric development.

Spatial gaps, the need to upgrade equipment and gaps in the data required for modelling purposes make up Category Two.

The lack of resources that most organisations currently face impacts on their ability to expand and enhance monitoring resources and data collection infrastructure. Most organisations will have little opportunity to address this gap in the near future and need to seek external funding for these types of improvements.

Training gaps relate to a lack of skilled staff to perform water monitoring, data collection and data management activities. This is a key gap in certain regions, such as the QMDB, and in certain organisations such as NRM bodies and local governments. These gaps often require long-term solutions. A lack of resources and the need for more training opportunities make up Category Three.

Step Five – Ranking of individual gaps

Gaps are then given a High to Low ranking within each grouping. This ranking is influenced by the number or size of the organisations noting the gap as an issue and by how strongly linked a gap is to the drivers for monitoring referred to in Section A.

Note that the rankings of gaps reflect the current priority of a particular gap or issue for the state of Queensland and are presented to help direct funding from the Bureau to named persons in Queensland under the M&E Program. They do not reflect a ranking of the capacity of any particular funding applicant to address a listed gap – applications undergo a different ranking process.

5.2.1 Prioritisation of gaps

Table 13 Prioritisation of Queensland water monitoring and information

CATEGORY ONE		
Standards		
35	Standardised approaches to data processing, management and quality coding are required across all monitoring organisations.	H+
36	Standards for the development of rating curves are high priorities for monitoring organisations.	H+
37	Further review work and inter-jurisdictional collaboration is required on a range of field and operational work practices with a view to creating Australian standards.	H+
Metadata		
38	Development and adoption of defined quality coding and metadata as well as appropriate enhancements to data management systems are required to ensure successful integration of data is possible.	H+
49	Many organisations have valuable data that should be digitised to expand datasets and assist with trend analysis and to better understand the quality of data.	H
43	Spatialisation of water consumption data is not currently possible due to limited appropriate metadata.	M
Data management systems		
34	Enhanced information systems to better collect, manage, and deliver NWA and AWAS compliant data and information are required.	H+
42	SunWater requires upgrading of its TimeStudio system to the new WISKI system to ensure reliable storage and reporting of SunWater time-series data.	H+
45	Further enhancement to the uniDap WaterQ system used by Queensland NRM bodies will be required if these bodies adopt the national water quality metadata coding system being developed.	H+
53	Data management systems of many monitoring organisations require enhancement.	H+
32	Enhancements to DERM and SunWater data management systems may be required once specifications for water allocation and trading data are available.	H
41	Lack of centralised and synchronised data management across many water service providers is impacting on the frequency and accuracy of data reporting.	H
47	There is a need for a method to easily integrate data from different SCADA systems.	H
48	Validation of data and enhancement of metadata is required in DERM's surface and groundwater databases.	H
44	Updates to the data management systems of water data providers are necessary each time changes are made to the metadata coding required to be delivered under the *Water Regulations 2008*.	M
46	Updates to the data management systems of water data providers are necessary each time changes are made to the water data transfer format preferred by the Bureau of Meteorology for data delivered under the *Water Regulations 2008*.	M
Reporting and analysis		
39	Alignment of data reporting standards and formats between state and federal agencies such as the Bureau is required.	H
40	Improved and standardised analysis techniques would add value across all water	H

	monitoring datasets.	
31	Aggregating state water trading information up to a national level is complex and requires significant collaboration between state and federal agencies.	H
30	Multiple reporting requirements of federal agencies for water trading information are an issue for state organisations.	M
51	Mechanisms need to be developed to transfer data into the National Groundwater Information Service data model being developed by the Bureau of Meteorology.	M
CATEGORY TWO		
Spatial and temporal gaps		
1	Spatial and temporal gaps exist in many bore networks.	H+
8	Spatial and temporal gaps exist in surface water monitoring networks measuring water levels and flows.	H+
25	Spatial and temporal gaps exist in the water quality monitoring networks of the lead water agency, NRM bodies and local governments.	H+
17	Insufficient monitoring of wetland extent changes and risk to and condition of wetlands.	H
18	Gaps exist in spatial and temporal monitoring in flood warning networks, including in the high resolution ALERT-type networks, inland towns and regions and in the catchments of major storages.	H
33	There is a wide range of data that is currently unavailable for inclusion in the National Water Account due to inadequacies in data collection processes and systems, incomplete data measurement and recording, or is currently not required to be measured or recorded but is required for the first NWA and for implementation of the AWAS across Queensland.	H
20	There is a specific need for improved rain and water level monitoring in catchments above large storages.	M
21	The frequency of sampling for some parameters, such as sediments and nutrients, needs to be increased, especially during flood events.	M
Monitoring equipment		
2	The installation of data loggers on bores would result in data better able to characterise recharge events and water level depletion.	H+
3	A number of existing data loggers attached to bores require upgrading to improve data currency and to minimise data loss.	H+
9	A number of existing monitoring sites require upgrading to improve data currency and to minimise data loss.	H+
10	Upgrades to new technology flow sensors will improve the quality and quantity of river flow data collected.	H
16	There is a need to upgrade to automatic systems and install telemetry for instantaneous recording of storage levels.	H
19	Upgrades to gauging equipment are required for some organisations managing flood warning systems.	H
26	More data loggers and probes are required to obtain real-time water quality data sets.	H
Modelling gaps		
4	Bore locations should be aligned to a known datum to improve the quality of data collected and to support development of a national geofabric dataset.	H+
11	Gauging stations and storage gauges should be aligned to a known datum to improve the quality of data collected and to support development of a national	H+

	geofabric dataset.	
21	Stage-discharge ratings relationships for new and existing gauging and flood warning stations are required to provide data to assist predictions of critical flood heights at key towns and rural areas, and to assist water resource objectives.	H+
22	A major review is required for all gauging and ratings in the QMDB rivers and in other rivers where this would assist the collection of data for both flood warning and water resource assessment purposes.	H+
50	The surface hydrology spatial dataset requires cleaning, segmenting, networking, direction, edge matching, editing and attribution to improve the quality of data and maximise benefits for water managers and data users.	H+
6	A lack of sufficient bore monitoring data, particularly in high risk areas, impacts on the development of accurate models.	H
12	Enhanced rating of gauging stations and storages is required to improve the accuracy of data collected.	H
14	Additional data collection is required to reduce uncertainty in river modelling – issues particularly noted in the QMDB and the northern North-East Coast catchments.	H
24	A lack of skilled operators is a critical issue in obtaining enhanced ratings at flood warning sites.	H
5	There is a lack of measured data relating to connected groundwater systems and base flows (surface water-groundwater connectivity).	M
13	Bathymetric surveys of storages are required to confirm storage capacities.	M
28	Inconsistent methodology for determining sediment, nutrient and pollutant loads from event monitoring impacts on data quality.	M
29	There is a need for enhanced modelling capacity, particularly in the south east and south west regions.	M
CATEGORY THREE		
Training and resources		
7	A lack of appropriately trained staff and adequate operational resources are emerging issues across groundwater monitoring agencies.	H+
15	A lack of appropriately trained staff and adequate operational resources are emerging issues across surface water monitoring agencies.	H
52	A coordinated training and accreditation framework would assist in enhancing standardisation in monitoring techniques and processes for quality coding and metadata capture.	H
23	Technical and institutional support is required for local governments and regional bodies operating monitoring networks, especially rainfall and river height monitoring for the purposes of flood warning.	M

5.3 Recommendations

5.3.1 Category One priorities

Appropriate data management and standardised approaches to data collection, storage, analysis and reporting are seen as critical issues for state and federal agencies as well as for most water information and monitoring organisations. Queensland organisations are keen to support the development of national standards or standardised coding of data, whichever is more appropriate. They are also keen to see more streamlined and integrated reporting frameworks for the reporting of data from state organisations to state and federal government agencies.

A number of strategies are in place to improve integration and standardisation amongst monitoring organisations in the state, such as:

- The Queensland Integrated Waterways Monitoring Framework.
- The delivery of data from Queensland water service providers to the Bureau using *qldwater*'s SWIM system. *qldwater*, supported by Bureau funding, has developed a standardised framework for coding data and metadata to be delivered by water service providers to the Bureau through the SWIM system. This system is also used to deliver NPR information.
- The delivery of data from NRM bodies through the uniDap WaterQ system. This strategy ensures the data delivered from Queensland NRM bodies and several catchment authorities from around Australia are delivered to the Bureau in the required WDTF.
- With M&E Program funding DERM has developed a set of standard codes for water quality data that may be used as the basis for national standards. These have been developed with input from other stakeholders in Queensland and other jurisdictions.
- DERM has also used M&E Program funding to develop proposed standards for the use of Acoustic Doppler Current Profilers. These standards are being developed by DERM in collaboration with key stakeholders in other jurisdictions.

Wherever possible the application of national standards frameworks for similar types of monitoring organisations is the ideal situation. However there is significant work to be undertaken before national standards can be developed. This includes the need to prepare an audit of existing standards (including analysis of adoption rate, application issues etc.), determine the best approach for application of different standards for different organisations ('fit for purpose' standards that align the need for standardisation with an organisations business drivers and capacity to implement the standards) and the need to identify cross-agency and cross-jurisdictional issues (such as with terminology). Whilst the Bureau has responsibility for the establishment of national standards for water information and water monitoring, the jurisdictions need to be equally involved in the development of standards to ensure jurisdictional experience/learnings are included and to encourage wider adoption.

It may not be realistic to expect all organisations to adopt the same methodologies therefore it is crucial that more standardisation of metadata is developed to ensure the quality of data and its comparability with other data is clear to all users.

Closely linked to the need for standardisation or standardised coding of data is the need to streamline reporting requirements and standardise terminology for similar water information from organisations within the state to state and federal government agencies. One example of this is the need to align reporting timeframes and terminology for water service providers delivering similar urban water data for National Performance Reporting and to the Bureau under the Water Regulations. Another example is the multiple reporting of water trading information from jurisdictions to the federal government.

Recommendations to enhance metadata and standards include the following.

- Standardised approaches to the development of rating curves.
- Digitisation of the valuable historical information that many organisations hold in paper format. Some of this is actual data and some of this is metadata. If this information is stored in the data management systems with the data it will enhance the ability to assess data quality. An audit and prioritisation of this data should be undertaken so that the size of this issue is better understood.
- The development of national standards in collaboration with key water organisations in each jurisdiction – to be led by the Bureau. It is not practical for all organisations to collect data to the same level of detail or to adopt the same methods of collection and analysis; therefore it is recommended that standardised codes of metadata for the different water data categories be developed to describe the level of detail and methods employed.
- Metadata protocols should be developed to ensure that this information is presented with the data so that the user is made aware of the purpose behind the collection of the data and any other information that may influence the quality of the data collected. This will allow users of the data to have a better understanding of the quality and comparability of the data.
- Streamlining and standardisation of data reporting requirements from organisations within the state to reduce the impact on individual organisations and to ensure consistency in data reporting. For example it would be more efficient if water trading information was delivered to a single government agency, such as the Bureau. The Bureau could then stream data to the NWMS National Portal or to AWRIS, as appropriate.

The enhancement of data management systems is a priority for the state as the quality and availability of data are reliant on good data management processes. Recommendations to enhance data management systems include the following.

- Bureau funding to support enhancement to the data management systems of Queensland organisations to ensure sustainable delivery of data in the preferred WDTF. These organisations include SunWater and Seqwater as well as the SWIM and WaterQ systems

- Bureau funding to develop a data management system to automate the provision of state-wide water account data collection and report preparation, where appropriate. This would involve initial scoping of a suitable system.

Strategic coordination of activities in the state relating to the Water Regulations may be required in the future depending on the needs of the Bureau; as such they are currently hard to quantify. The interagency working group of key stakeholders established as part of current strategic coordination projects is the key channel for future coordination activities. This group has agreed to meet on an as needs basis into the future to keep this valuable communication network going; coordination activities relating to specific projects will need to be managed as part of those project activities.

Almost all named persons in Queensland have adopted CC Attribution licensing for the water data they provide to the Bureau. This license allows named persons to retain copyright control of their data whilst allowing data users to copy and distribute their data as long as they credit the named person as the source of the data. This system protects the named person by offering strong indemnity for improper use of their data. Increased understanding of the benefits of this system may encourage more data sharing between named persons in the state in the future. Currently SunWater and DERM are using CC licensing to share water monitoring data; Seqwater is also interested in sharing water monitoring data with DERM under CC licensing arrangements.

5.3.2 Category Two priorities

Strategies in place to address spatial gaps, upgrade equipment and address modelling gaps include the following.

- DERM has identified spatial gaps in its monitoring networks through comprehensive reviews of these networks. Strategies to address these gaps include the following.
    - As new bores/data loggers are activated, the priority rankings established through the network review process will be used to continuously realign the network to available operational resources through bore/data logger abandonment and monitoring schedule reductions. This will ensure that the ongoing operation and maintenance of the groundwater monitoring network is sustained.
    - The new monitoring network in the GAB will be progressively built over time. There will be a gradual transition from the previous network to the current, approved monitoring network, recognising the resource limitations. The monitoring network will be a balance between the ‘ideal’ monitoring requirement and resource constraints.
    - Priority rankings for the state surface water network will also be undertaken in the near future. Current funding limits the capacity to comprehensively upgrade the state surface water network in any one project. However DERM continues to invest in upgrades to the network as funding is available each year. DERM investment is focused on upgrading the existing network and any expansion of the network to address the

spatial gaps identified in the DERM network reviews would require external funding.

- There is an urgent need to establish an independent monitoring program for CSG impacts on groundwater resources. A program has been developed to monitor 300 bores in areas close to CSG activity. This approach will complement the baseline assessment and monitoring programs being undertaken by CSG companies, independent monitoring by the Queensland Water Commission, existing programs within the department and landholders themselves.

Recommendations to enhance monitoring networks and address modelling gaps include the following.

- Expansion of the surface water monitoring networks in the QMDB, particularly to improve real-time management of flow and water extraction. The introduction of the Murray-Darling Basin Plan in 2011 will inform investment opportunities in this region.
- Capture of high/medium flow ratings at certain gauging stations to get accurate discharge figures. This issue can be addressed either by actual measurement or through the use of in-situ Doppler instruments.
- Conducting bathymetric surveys of storages to understand the true capacity of storages.
- Expansion of the state ambient water quality monitoring network (SWAN) to include current and proposed gauging stations in unmonitored regions; gauging stations at the outflow of all unmonitored basins and sub-basins should monitor water quality parameters and more frequent sampling at SWAN sites is required – 10-12 samples at a minimum.
- A review of gaps in flood prone regions, improvements to flow ratings, increase in near real-time hydrologic capacity and development of sustainable arrangements for the operation and maintenance of large scale automated flood warning networks (and other hydrological networks) in all areas of Queensland. DERM supports the Queensland flood warning network by assisting with real-time data provision where possible. The key players in the state flood warning network are the Queensland office of the Bureau, Emergency Management Queensland, local government, SunWater and Seqwater. Flood events put pressure on councils to undertake expansion or enhancement of the network however their capacity to do so is extremely limited at present and federal assistance is required to achieve the listed enhancements.
- A strategy to determine how Queensland can most efficiently participate in the provision of data to support the Bureau's Geofabric datasets would assist with ongoing support for this dataset. The Bureau is requesting data to support development of a National Groundwater Information System and a national surface hydrology database. There are a number of issues to be resolved first, such as, standardised terminology and the need to validate data in the GWDB. The capture and revision of spatial data in the GBR, QMDB, Gulf and western catchments is required by the Bureau to produce a single point of truth surface hydrology database using agreed inputs and an agreed data model. Funding

under the M&E Program will be sought to undertake this data capture in time to support development of a national geofabric dataset.

- The installation of telemetry at water storages allows for real-time understanding of water levels and actual volumes of water currently available from those storages. Whilst there are a number of organisations with gaps in this area, funding for new telemetry systems would need to be sourced external to most organisations.
- Strategies to address modelling gaps are intrinsically linked to strategies to address spatial and temporal gaps and monitoring equipment gaps, such as the alignment of bores and gauging stations to AHD, increasing the monitoring of surface-groundwater interaction, installing new bores and gauging stations, upgrading data loggers and installing new loggers. There is also a need to increase the capacity for modelling through increased resources and training.
- IQQM models are being developed to simulate and assess stream flows, water infrastructure performance, losses and use for many catchments. IQQM models are very data intensive and require daily data. Previous models used by the then-NRW have used monthly data. Improved data collection procedures are required to obtain adequate data to produce accurate models. IQQM is a daily time step model and is calibrated in reaches using gauged flows, recorded use and stream losses to determine the natural residual inflows to the reach. The natural flows are obtained by using the full calibrated model with no demands or storages. Where necessary, the inflows to the model and the residual flows are extended to a standard using calibrated Sacramento models.
- Continued funding assistance from the Bureau is required to further develop the collection of appropriate data for water accounting purposes.
- DERM notes the emerging requirements for aquatic ecosystem health information as critical components in the development of national environmental accounts. Whilst this information is out of scope for the current SWIMP the Commonwealth Government decision to invest $18 million over four years to establish a National Plan for Environmental Information may require an expansion of any future SWIMP to include aquatic ecosystem parameters.

5.3.3 Category Three gaps

DERM groundwater and surface water network reviews identified the need to increase the skill level of operational staff through the development of training programs. The managers of the state's GAB network have also identified the need for skills and training packages to be developed to enable professional training. Training is particularly an issue in present times due to the need to replace an ageing workforce.

Many NRM bodies struggle to maintain on-going monitoring programs due to the continual need to apply for external funding to keep these programs running. This cyclical funding issue also makes it difficult for them to retain staff with appropriate levels of skill and experience.

Many local governments currently lack sufficient resources to develop their monitoring programs above their current levels. Local body amalgamation has resulted in the combination of previously independent monitoring programs under the one council. The

result of such significant amalgamation means that councils must undergo a period of re-evaluation of their monitoring programs and objectives. This process is still underway and any new program plans will be restricted by limited resource availability.

Similarly Seqwater has recently become responsible for a much larger monitoring network than it was originally resourced and staffed to manage.

Strategies in place to address training and resources gaps include:

- Training materials and work practices developed by DERM are available for use by other organisations.
- Seqwater is addressing its staffing issues through the addition of new staff to manage its monitoring networks.

Recommendations to address training and resources gaps include the following.

- More coordinated training could take place within Queensland where multiple agencies could resource and attend the same training sessions. This would also encourage standardised adoption of work practices.
- The Bureau has a role in developing national technical expertise; this could be achieved through the development of national technical expert panels. Opportunities for technical staff from different jurisdictions to get together and learn from each other have been very limited to date. There is significant opportunity for the Bureau to build on its first national technical workshop to develop panels of expertise that will significantly enhance standardisation amongst jurisdictions.

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Websites of Queensland named persons

Below are links to the websites of those named persons in Queensland who currently supply the Bureau with data under the *Water Regulations 2008*.

Allconnex Water

Brisbane City Council

Burdekin Shire Council

Cairns Regional Council

Cassowary Coast Regional Council

Cloncurry Shire Council

DEEDI

DERM
Fitzroy Basin Association
Fraser Coast Regional Council
Gladstone Area Water Board
Gold Coast City Council
Hinchinbrook Shire Council
Ipswich City Council
Logan City Council
Mackay Regional Council
Moreton Bay Regional Council
Queensland Murray-Darling Committee
Queensland Urban Utilities
Queensland Water Commission
Redland City Council
Reef Catchments Mackay Whitsunday
Rockhampton Regional Council
Scenic Rim Regional Council
SEQ Catchments Ltd
Seqwater
South Burnett Regional Council
South West NRM Ltd
Southern Downs Regional Council
Stanwell Corporation
Sunshine Coast Regional Council
SunWater
Tarong Energy
Torres Shire Council
Toowoomba Regional Council
Townsville City Council
Unitywater
Western Downs Regional Council
Whitsunday Regional Council
Wide Bay Water Corporation

7 Acronyms

ABS	Australian Bureau of Statistic
ADCP	Acoustic Doppler Current Profiler
AHD	Australian Height Datum
ALERT	Automated Local Evaluation in Real Time
AWAS	Australian Water Accounting Standards
AWRIS	Australian Water Resources Information System
AWS	Automatic Weather Station
Bureau	Bureau of Meteorology
CBD	Central Business District
CC	Creative Commons
COAG	Council of Australian Governments
COI	Commission of Inquiry
CRAMER	Cross Region and Agency Monitoring and Evaluation Review
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEEDI	Department of Employment, Economic Development and Innovation
DEM	Digital Elevation Model
DERM	Department of Environment and Resource Management
DIP	Department of Infrastructure and Planning
EC	Electrical Conductivity
EHA	Environmental Hydrology Associates
EHMP	Ecosystem Health Monitoring Program
EMS	Event Monitoring System
EMSS	Environmental Management Support System

EPA	Environmental Protection Agency
FTP	File Transfer Protocol
GA	Geoscience Australia
GAB	Great Artesian Basin
GABSI	Great Artesian Basin Sustainability Initiative
GAWB	Gladstone Area Water Board
GBR	Great Barrier Reef
Geofabric	Australian Hydrological Geospatial Fabric
GILF	Government Information Licensing Framework
GMA	Groundwater Management Area
GWDB	Groundwater Database
IQQM	Integrated Quantity and Quality Models
IP	Internet Protocol
IROL	Interim Resource Operations Licence
IT	Information Technology
LIDAR	Light Detection And Ranging
MDBA	Murray-Darling Basin Authority
M&E Program	Modernisation and Extension of Hydrologic Monitoring Systems Program
ML	Megalitre
NAP	National Action Plan for Salinity and Water Quality
NASY	Northern Australia Sustainable Yields
NDRRA	National disaster Relief and Recovery Assistance
NDRP	Natural Disaster Resilience Program
NGIS	National Groundwater Information Service
NPR	National Performance Report

NRM	Natural Resource Management
NRW	Department of Natural Resources and Water
NWA	National Water Account
NWADP	National Water Accounting Development Project
NWC	National Water Commission
NWI	National Water Initiative
NWMS	National Water Market System
NWQMS	National Water Quality Management Strategy
pH	Potential of Hydrogen
QA	Quality Assurance
qldwater	Queensland Water Directorate
QMDB	Queensland Murray-Darling Basin
QMDC	Queensland Murray-Darling Committee
QMS	Quality Management System
QWC	Queensland Water Commission
ROL	Resource Operations Licence
ROP	Resource Operations Plan
ROT	Remote Observer Terminal (Bureau of Meteorology)
RTI	Right to Information
RWQPP	Reef Water Quality Protection Plan
SCADA	Supervisory Control and Data Acquisition
SEAP	Stream and Estuary Assessment Program
SedNet	Sediment network modelling software
SEQ	South East Queensland
Seqwater	Queensland Bulk Water Supply Authority

SoE	State of the Environment
SWAN	Surface Water Ambient Network
SWIM	Statewide Water Information Management
SWIMP	Strategic Water and Information Monitoring Plan
SYNOP	Synoptic station (Bureau of Meteorology)
TELEMETER	Telemetry site (Bureau of Meteorology)
WADC	Water Accounting Development Committee
WAR	Water Allocations Register
WAS	Water Accounting system
WASB	Water Accounting Standards Board
WDTF	Water Data Transfer Format
WMS	Water Management System
WTP	Water Treatment Plant
WRP	Water Resource Plan