Full Paper

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Benefits of the Mary River catchment Waterwatch Program for integrated stream management and monitoring outcomes

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Key Points

- Over nearly two decades the Mary River Catchment Waterwatch Program has responded to events, opportunities and knowledge gained through the program, to evolve into a comprehensive water quality monitoring program.
- Logistical and technical support, securing ongoing funding and being proactive about improving quality assurance, quality control, and data analysis and interpretation techniques are important for the success of the Waterwatch Program.
- Facilitating long-lasting partnerships with community members, government agencies and professional organisations through the Waterwatch Program, generates wider benefits for integrated stream management.
- Waterwatch data holds immense value to community members, the MRCCC, government agencies and other professional organisations in decision-making for integrated stream management.

Abstract

The citizen science-based Waterwatch Program in the Mary River catchment in South East Queensland has successfully operated for 18 years. This paper will discuss how the Waterwatch Program has evolved and been maintained, and the role that the program plays in improving stream management in the catchment. The program has grown steadily and currently involves 112 volunteers who monitor 126 sites. Involvement of community members in the Waterwatch Program allows for frequent water quality observation and long-term data collection from public and private sites. The validity of data is assured through the implementation of regular refresher training courses, workshops and adherence to quality assurance guidelines developed by the Mary River Catchment Coordinating Committee (MRCCC). Through comparing data with the Water Quality Objective (WQOs) guideline values, the MRCCC has developed a report card system to determine the health of individual Waterwatch sites and produce subcatchment Waterwatch reports that are shared with community members and local and state government agencies. These report cards and the underlying data facilitate higher levels of interest in water quality and a better understanding of catchment management practices throughout the community. The data is also used for several purposes that contribute to improved stream management. These range from individual landholders identifying improvements or problems in their sub-catchment to the Queensland Department of Environment and Heritage Protection (DEHP) using the long-term data to verify and amend water quality objective guidelines.

Keywords

Waterwatch, Mary River Catchment, citizen science, data quality, monitoring

Introduction

The Mary River Catchment covers 9,466 km^2 from Maleny to Fraser Island and is one of the most diverse catchments in Queensland. The Mary River is 320 km long, and water quality varies from fresh through to saline where the river flows into the RAMSAR listed Great Sandy Strait, Fraser Island World Heritage area and

the southern Great Barrier Reef. The Mary River provides life to humans, wildlife and domestic animals. The population of over 200,000 people is situated on agricultural land, in urban areas and rural subdivisions and is engaged in a range of economic activities ranging from dairy, beef, forestry, fishing, horticulture, mining, sugar, farm forestry, tourism, sand and gravel extraction, light and heavy industry. Several rare and threatened aquatic species reside in the Mary River catchment including the endangered Giant barred frog (*Mixophyes iteratus*), vulnerable Australian lungfish (*Neoceratodus forsteri*), endangered Mary River cod (*Maccullochella mariensis*), endangered Mary River turtle (*Elusor macrurus*) and the critically endangered White throated snapping turtle (*Elseya albugula*). Water quality is fundamental to the sustainability of local agriculture, to the recovery of threatened species and to the ecological and cultural values reflected in the RAMSAR, World Heritage, High Environmental Value and Marine Park listings within the catchment and its receiving waters.

MRCCC's long-term 18 year old Waterwatch Program monitors the health of the Mary River and its many tributaries through collection of baseline water quality data that is relevant to the habitat requirements of the threatened species, the water quality threats to the receiving waters, particularly the Great Barrier Reef and water quality requirements for the community (e.g. irrigation). The Waterwatch Program currently consists of 112 volunteers including individuals, families and organisations who collect water quality data across 126 sites (See Figure 1). Each month the volunteers measure physical and chemical water quality parameters (pH, electrical conductivity, dissolved oxygen, turbidity, temperature) using Waterwatch kits and record observations regarding waterway health, environmental conditions and presence of native and exotic flora and fauna. There is no other comparable regular long term monitoring underway in the Mary River catchment.

This paper reflects upon the last 18 years, outlining how the Waterwatch program has evolved, been maintained, reported on water quality and contributed to integrated stream management in the Mary River catchment.

Evolution of the Waterwatch Program in the Mary River catchment

Throughout its life the Mary River catchment Waterwatch Program has evolved in terms of the breadth of community involvement, the creation of subcatchment based networks and the sophistication of the program in terms of quality control, data analysis and interpretation. This process of evolution has been influenced by key events and partnerships that created new opportunities and challenges for the program.

In the earlier years of the program levels of community involvement fluctuated and changed in focus in response to both funding and community interest. When the program first began in the early 1990's, the Waterwatch Program was exclusively a school-based program with several schools throughout the Mary River catchment participating. The late Dr Peter Oliver was the first Waterwatch Coordinator for the Waterwatch Program in the Mary River catchment and he is widely recognized for his exceptional ability to engage and communicate with people. At this time, few people thought about the river in terms of the whole catchment. Dr Oliver used creative methods to help the students think about the concepts of a catchment and how the health of the Mary River affects the health of Great Sandy Strait (e.g. "Dugong Rock" song).

At around the same time, the concept of a catchment was gaining prominence through the formation of the Mary River Catchment Coordinating Committee (MRCCC), and through support from Land and Water Australia and the Queensland Government which established one of six state wide integrated catchment management pilot programs in the Mary Catchment. Eagerness to contribute to Waterwatch was generated by the river bank restoration projects of this pilot program. Landholders in what is now the Gympie - Curra Network (see Figure 1), commenced data collection. Lack of funding and logistical barriers resulted in the Waterwatch Program going back to focusing on the school-based program in the late 1990s. By 2001 the program shifted again from a schools-based program to incorporating the broader community. At the time community interest in water quality data collection was high, particularly in response to interest in salinity levels due to severe drought and the call for a nation-wide program to improve water quality and salinity issues. Ultimately this nation-wide program became the "National Action Plan for Salinity and Water Quality (NAPSWQ)" (Australian Government Natural Resource Management Team, 2000). Although a number of

local schools have been involved, it has proved difficult to maintain their long term involvement. As a result, since the early 2000s the majority of volunteers have been riparian landholders or other community members.

As the program evolved and a critical mass of volunteers became involved in particular areas, subcatchment networks have been formed (see Figure 1). The first of these networks was the Upper Mary (Maleny and Kenilworth) Waterwatch Network which was created in 2002 as result of a Waterwatch focused stall the MRCCC held at the annual Maleny Wood Expo. Queensland National Parks and Wildlife Service are important partners in monitoring water quality in this part of the catchment. Gympie to Amamoor (Mary Valley) was the second Waterwatch Network to form due to landholder water quality concerns about the annual Gympie Country Music Muster (over 30,000 attendees in late August), which usually coincided with floods. The Western Catchment Network was the third network to form in 2002/2003. The Munna Creek catchment is a large grazing area and the formation of this network was driven largely by landholder concerns arising from the National Action Plan for Salinity and Water Quality (2000). Lack of water and salinity issues generated interest in understanding water quality in the irrigation based communities to the west of Gympie on Widgee and Wide Bay creeks. As a result, the Wide Bay/Widgee Waterwatch Network became the fourth network to form in 2006.

An Everyone's Environment Grant from the Queensland Government in 2012 enabled the formation of the Eastern and Lower Catchment networks, which picked up some of the Munna Creek Catchment and interested community members along the Mary River upstream from Maryborough. HQPlantations have a long-term commitment to collecting data from sites within their forestry estate located in the Eastern Catchment network. Two new networks were also formed by splitting the Upper Mary and Gympie to Amamoor networks. Therefore, in 2018 there are eight networks: Upper Mary, Kenilworth, Gympie to Curra, Imbil to Amamoor, Wide Bay/Widgee, Munna Creek, Lower Catchments and Eastern Catchments. This brief history of the formation of each network demonstrates the combination of factors that have contributed to interest in Waterwatch in the catchment and how the program has capitalised on these opportunities.

A system of quality assurance and quality control underpins the Waterwatch Program, ensuring rigor and consistency in the data collection, collation and analysis (MRCCC, 2017). A critical moment in the evolution of this side of the program was a 2002 partnership with the Queensland Government's Environmental Protection Agency (EPA) to implement a pilot program to update and improve the Waterwatch Program and assist with the preparation of a Water Quality Assurance Manual for the Mary River Catchment. The EPA also contributed to shadow testing water monitoring equipment, testing procedures and data collection methods to confirm that the citizen science Waterwatch Program data collection methods are accurate and valid. The manual is reviewed regularly.

The long term Waterwatch dataset has enabled development of a detailed understanding of the criteria for good water quality and the extent to which this varies throughout the catchment. The EPA developed the Water Quality Objectives (WQOs) guideline values and environmental values for the habitat of several threatened species within the Mary River catchment with the assistance of the MRCCC in 2015. Analysis of the long term Waterwatch data has enabled MRCCC to identify that these WQOs were not appropriate for all sites. The data illustrates the presence of several different water types within the Mary River catchment which are due to different underlying geology and other naturally occurring influences (Figure 1). Water type specific water quality guideline values have been developed by the MRCCC using Waterwatch data and procedures outlined in the regulations (Department of Environment and Resource Management, 2010). Table 1 summarises the guidelines developed by MRCCC for each of the six water types (Burgess, 2014).

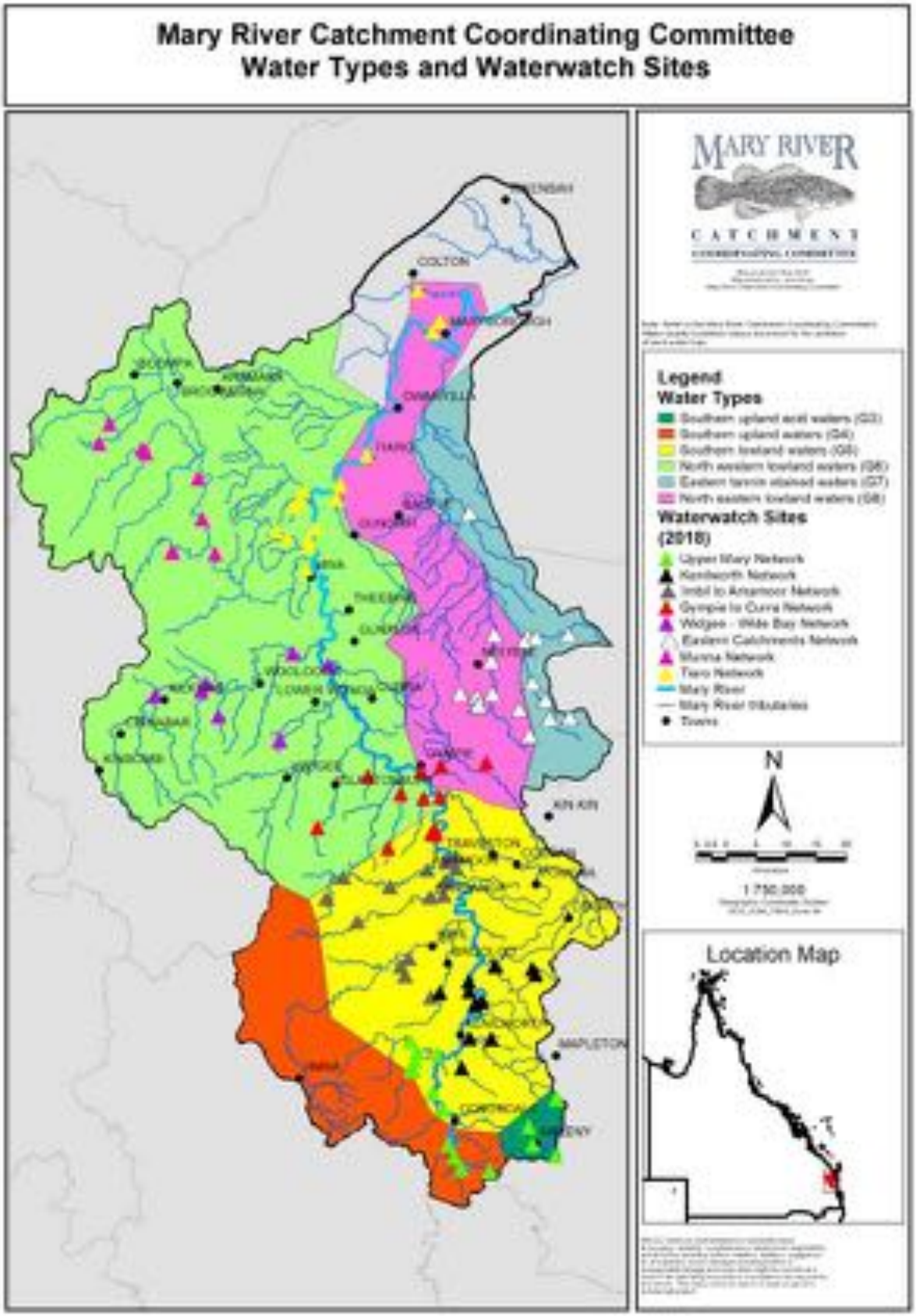

Figure 1. Map of water types and Waterwatch sites within Waterwatch Networks in the Mary River catchment

Table 1. Mary River Catchment Coordinating Committee water quality guideline values

Mary River Catchment Coordinating Committee Water Quality Guideline Values		
Quality Guideline Title & Description	**Guideline Values**	
G3 – Southern Upland Acid Waters Upland (>150m) freshwaters draining acid red soils of the Maleny/Mapleton plateau**.**	Electrical Conductivity pH Dissolved Oxygen Turbidity Summer Temperature Winter Temperature	0 – 580 μS/cm 6.0 – 8.0 90 – 110 % saturation 0 – 25 NTU 18 – 28 °C 13 – 21 °C
G4 – Southern Upland Waters Upland (>150m) freshwaters in the main trunk of the Mary River and all tributaries which drain into the Mary River upstream of Deep Creek except for Southern Upland Acid Waters.	Electrical Conductivity pH Dissolved Oxygen Turbidity Summer Temperature Winter Temperature	0 – 580 μS/cm 6.5 – 8.2 90 – 110 % saturation 0 – 25 NTU 18 – 28 °C 13 – 21 °C
G5 – Southern Lowland Waters Lowland (<150m) freshwaters in the main trunk of the Mary River and all tributaries which drain into the Mary River upstream of Deep Creek.	Electrical Conductivity pH Dissolved Oxygen Turbidity Summer Temperature Winter Temperature	0 – 580 μS/cm 6.5 – 8.0 85 – 110 % saturation 0 – 50 NTU 18 – 28 °C 13 – 21 °C
G6 – North Western Lowland Waters Lowland freshwaters (<150m) in all western tributaries which drain into the Mary River downstream of Six Mile Creek. As well as Gutchy Creek and its tributaries.	Electrical Conductivity pH Dissolved Oxygen Turbidity Summer Temperature Winter Temperature	0 – 1200 μS/cm 6.5 – 8.0 85 – 110 % saturation 0 – 50 NTU 22 – 30 °C 16 – 24 °C
G7 – Eastern Sandplain Tannin Stained Waters Tannin stained waters of the eastern tributaries of Tinana Creek. *from footnotes in Mary WQO document for water bodies in the natural state.	Electrical Conductivity pH Dissolved Oxygen Turbidity Summer Temperature Winter Temperature	0 – 580 μS/cm 3.6 – 6.0* 85 – 110 % saturation 0 – 50 NTU 22 – 30 °C 16 – 24 °C
G8 – North Eastern Lowland Waters Lowland freshwaters (<150m) in the main trunk of the Mary River and all Eastern tributaries which drain into the Mary River downstream of Six Mile Creek, except for Eastern Sandplain Tannin Stained Waters.	Electrical Conductivity pH Dissolved Oxygen Turbidity Summer Temperature Winter Temperature	0 – 580 μS/cm 6.5 – 8.0 85 – 110 % saturation 0 – 50 NTU 22 – 30 °C 16 – 24 °C

There are no scheduled guidelines for temperature, but the MRCCC has developed local guidelines in accordance with the procedures in the legislation to identify extreme summer and winter water temperatures. These water types are used to prepare the Waterwatch report cards for sites with sufficient data. Having a location specific guideline enables a more sophisticated and meaningful analysis and interpretation of water quality at each site.

Maintenance of the Waterwatch Program

Maintenance of the Waterwatch Program involves ongoing logistical and technical support, securing ongoing financial support, encouraging and keeping existing volunteers informed and recruiting new volunteers. This section outlines these aspects of the program in further detail and describes strategies that have proved successful in the Mary River catchment and could be of assistance in Waterwatch programs elsewhere.

Logistical and technical support to the Waterwatch Networks is like the oil that keeps the Waterwatch machine running smoothly. Having strategic coordination in place is required to ensure the citizen science program is reaching its full capabilities (Bonney et al. 2014; Lukyanenko, Parsons & Wiersma 2016). Strategic logistical coordination of the monthly rotation of the Waterwatch kit within each Waterwatch Network is achieved by producing monthly rosters and through ongoing communication with all who are involved with the Waterwatch Program. Waterwatch rosters are negotiated with individual volunteers and cover a four-month period where each volunteer is allocated the Waterwatch kit for approximately three days during a month. The three day period enables volunteers to collect/receive the Waterwatch kit on the first day, perform the water test on the second day, and pass the Waterwatch kit on to the next volunteer on the third day. Depending on the circumstance, the Waterwatch kit is allocated a "pick up/drop off point" such as a local store or petrol station where volunteers will routinely pass. Identifying specific local landholder networks (e.g. school bus runs, regular volunteer commutes etc) within each Waterwatch Network has proved crucial for the smooth transfer of the kit between volunteers and between the network and the MRCCC. Volunteers occasionally go on holidays and fail to tell the Waterwatch Coordinator or fellow Waterwatch volunteers within their Network, and this causes the Waterwatch kit to go astray. However, through detective work conducted by the Waterwatch Coordinator, Waterwatch kits are promptly located and placed back on track for the monthly rotation.

Technical and scientific expertise also underpins the Waterwatch Program. At the end of each monthly rotation, all Waterwatch kits are returned to the MRCCC office in Gympie, where the testing equipment is calibrated and thoroughly checked by MRCCC scientific staff and data sheets are entered into the extensive Waterwatch database for verification by the Waterwatch Coordinator. The MRCCC's Waterwatch Quality Assurance Manual (MRCCC, 2017) provides guidance to ensure that:

- All Waterwatch site/s are safe
- All volunteers complete the Waterwatch induction process
- All volunteers attend yearly refresher training
- The water testing methodology and calibration of equipment and data management maintains the highest standard.

Volunteer concerns or suggestions for improvements are taken seriously and are implemented in updates of the manual. This approach is consistent with the literature, which recognises that valid and high-quality data is achieved by the implementation of standardised testing equipment and calibration records (Kosmala et al. 2016). Scientific expertise is also required for analysis and interpretation of the data and preparation of reports to funding bodies, volunteers and other interested organisations.

Building partnerships with local government has been crucial for the continuation of Waterwatch. Although the Waterwatch Program commenced with little to no funding from local government, strong partnerships have been developed between the MRCCC and two of the four regional Councils in the catchment. These partnerships grew from partnerships with some of the smaller Councils prior to Council amalgamation in 2009. The Sunshine Coast Regional Council (SCRC) and Gympie Regional Council (GRC) have been major supporters of the Waterwatch Program since 2009 with both providing funds from their respective Environment Levies. The MRCCC currently supports Waterwatch Networks in the two other Council areas; Noosa Shire Council (NSC) and Fraser Coast Regional Council (FCRC) without funding from these two Councils. Efforts to secure funding from these Councils are ongoing but are constrained by limited Council budget allocations for environment based activities. Funding has also been received from other sources (e.g. Queensland Government, Australian Government) when applications have been successful.

Maintaining volunteer commitment and recruiting new volunteers is a constant focus of the Waterwatch Program. Waterwatch volunteers are recruited through presentations at community events, word of mouth and through interested landholders who have participated in other MRCCC projects and would like to continue an ongoing relationship with the MRCCC. Often these presentations are linked with workshops occurring as part of other projects such as Reef Water Quality programs or threatened species focussed projects. To encourage a

longer term commitment, volunteers are made aware that at least 24 data points are essential to make statistically significant comments on trends. This equates to monthly data collection for at least two years from their Waterwatch site. Volunteers are also invited to information sharing events where they have a chance to meet others in their Network and learn about how their data is used and what it says about the health of their site. The majority of the Waterwatch volunteers, past and present, have performed water testing for at least two years. Some Waterwatch volunteers are so dedicated to the Waterwatch Program that they perform water quality testing on Christmas Day and educate family members on the importance of water quality monitoring. Other volunteers take their water testing too seriously, with one particular volunteer routinely performing taste-testing of their local creek - this practice is not advised or encouraged but does provide an interesting perspective on his monthly water test. Usually, the main reasons people leave the program are relocation or work commitments. Volunteers seldom retire from the program due to conflict or poor communication within their Waterwatch Network.

Waterwatch reporting and monitoring outcomes

As a result of the established quality assurance processes and the long term commitment of many volunteers, the MRCCC now has a credible and extensive long-term water quality dataset for the Mary River catchment. Waterwatch volunteers are indispensable in the creation of this unique and extensive dataset. Volunteers adhere to the formalised system of recording physical and chemical water quality parameters and documenting observations, as outlined in the Mary River Waterwatch Quality Assurance Manual (MRCCC, 2017).

Waterwatch Reports are produced for each Waterwatch Network to better inform community members and government agencies regarding the water quality of the Mary River catchment. Waterwatch Reports contain long-term data analysis with results displayed in inter-site comparisons box and whisker plots and graphical "report cards" clearly expressing percent compliance with the WQOs. Inter-site comparisons are useful for identifying sites that are unusually variable or generally have higher or lower values than other sites. Report card grades range from A to F for each of the Waterwatch sites (see Figure 2). All Waterwatch sites are compared to a reference site in excellent condition. A report card with the grade of A is considered to have excellent water quality and represents greater than 80 percent compliance with the accepted WQOs. A report card grade of B is considered to have good water quality and is between 66 and 80 percent compliance with the WQOs and a report card grade of C is average water quality which is between 50 and 66 percent compliant. An F indicates the water is of poor water quality and was less than 50 percent compliance with the WQOs (Figure 2). While the report card grades do not directly include important aspects of waterway health such as riparian vegetation, instream habitat or macroinvertebrates, they do provide an excellent general rating of the physical and chemical water quality during a given time (MRCCC, 2018).

In addition to the long-term physical and chemical water quality parameters analysed in the Waterwatch Report Cards, Waterwatch volunteers also conduct systematic monitoring of other aspects of waterway health. For example, during every monitoring event the volunteers record percentage shade on the water, presence of key invasive aquatic weeds and sightings of endangered, locally iconic and introduced fauna species. This data is entered into the Waterwatch Database and the Queensland Government's public WildNet database. It is not unusual for the Waterwatchers to flag problems such as excessive sediments loads resulting from landslips or proliferation of aquatic weeds. Volunteers are the eyes and ears of the catchment during their monthly visit to the same section of river or creek. Observations they record and report back to MRCCC about waterway health are extremely useful for identifying both acute and chronic problems.

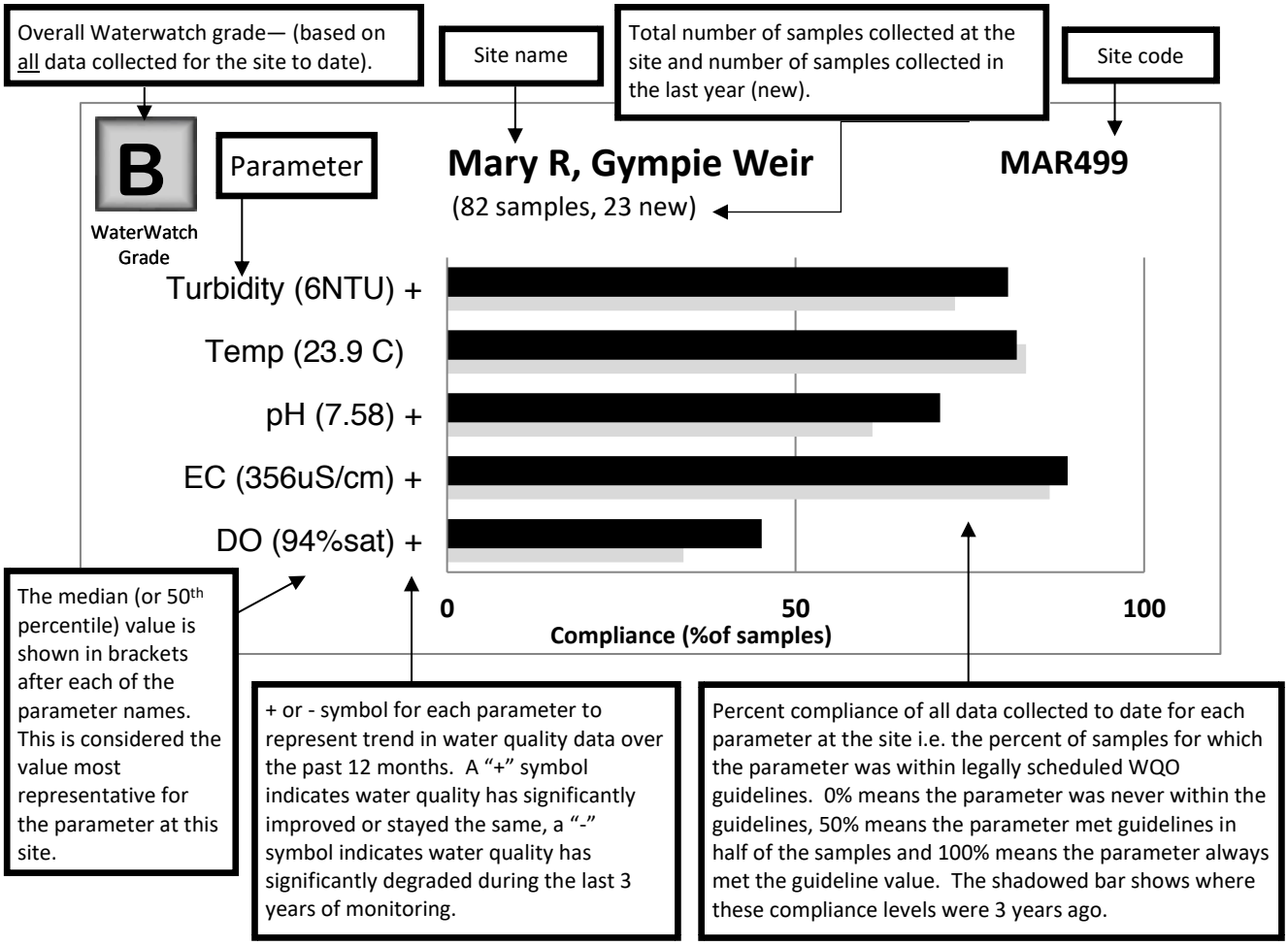

Figure 2. Explanation of MRCCC's Waterwatch Report Card

Waterwatch contributes to integrated stream management

There are numerous ways in which the Waterwatch Program contributes to integrated stream management and to the MRCCC achieving our objective of promoting a common view of a sustainable and productive catchment.

Waterwatch has created a baseline for water quality across many tributaries and sites throughout the catchment. On a subcatchment and reach scale the Waterwatch data and the report card grades provide a snapshot of the overall water quality. In some instances this can be used to highlight areas of good practice (or low risk landuse), and also areas that would benefit from increased effort and investment to improve water quality. The water types identified in Table 1 demonstrate the value of this long term data for assessing waterway health. This is fundamental background information when assessing the impact of any integrated stream management interventions. The Waterwatch data is already being used in this way by the MRCCC as part of assessing water quality outcomes of some of our major projects. Although attributing changes in water quality to specific project is difficult with any water quality monitoring, the Waterwatch data provides confirmation of long term trends and also flags areas that could be further investigated.

Through strong partnerships and collaboration with government agencies, the MRCCC's Waterwatch Program is frequently called upon to provide information to better inform decision makers. For example, the

Queensland Department of Environment and Heritage (DEHP) are currently collaborating with the MRCCC's Waterwatch Program to inform and amend the current WQOs. The review and amendment of the existing WQOs will influence future strategic planning within the Mary River catchment and overall stream management outcomes.

The MRCCC's array of onground projects completed over the last 23 years and the Waterwatch Program are intimately intertwined and mutually supportive programs. Community members who have participated in onground projects often join the Waterwatch Program, or if they are an existing Waterwatch volunteer, they may learn about a project and express interest in participating. The motivation to participate is often linked with a better understanding of water quality and how land management affects it. This knowledge is acquired through involvement in Waterwatch. Partnerships between community members, government agencies and resource management groups promote the implementation of more project work (Bonney et al. 2014).

Participation in the Waterwatch Program and availability of Waterwatch Reports enables individual landholders to be proactive in caring for their section of creek. This could involve the landholder identifying a specific problem such as a landslip or weed problem or tracking their progress with restoring their riparian area. We have one landholder in our Waterwatch Program who is determined to achieve an A grade for her site and she used the report cards as an indicator of progress with her creek restoration. Uniting the desire to seek knowledge and improve their local environment motivates community members to participate in voluntary work (Bonney et al. 2014; Gooch 2003; Measham & Barnett 2007). The MRCCC has observed that the program also creates a sense of ownership of catchment health that is likely to be a result of both the deeper knowledge of water quality and a sense of shared responsibility that can come from being part of a network.

Waterwatch also plays an important role in helping create and maintain the social networks that underpin integrated stream management. For example, the MRCCC has direct experience of the Waterwatch Network playing a role in helping people deal with crises such as drought because of the social connection and support being in a network of like-minded people creates. Being part of the network also provides access to people with shared interests, to new knowledge, information and opportunities.

The inkind financial contribution made by volunteers in a Waterwatch program is significant. The inkind contribution of the Waterwatch volunteers in the Mary River catchment can be conservatively estimated to be in order of $80,000 per year which is in the same order as the funding MRCCC received to run and oversee the program. Monitoring teams or individuals would find it difficult to acquire such an extensive database similar to the Waterwatch Program, due to the cost-effective spatial coverage that the volunteers provide (Bonney et al. 2014; Conrad & Hilchey 2011; Cox et al. 2012; Dyer et al. 2014; Gouveia et al. 2004).

This paper demonstrates the benefits that a Waterwatch Program can bring for integrated stream management and the way in which this has been achieved in the Mary River catchment. The wealth of information obtained by citizen scientists is usually unknown to policy makers (Bonney et al. 2014) and could be useful if made available to appropriate scientific organisations (Cox et al. 2012). The use of Waterwatch data is constrained by a tendency for water quality data collected by citizen scientists to be dismissed and not incorporated into government datasets due to volunteers not being professionally qualified to obtain valid data (Bonney et al. 2014; Conrad & Hilchey 2011; Dyer et al. 2014; Kosmala et al. 2016; Measham & Barnett 2007). In contrast, a study performed by Dyer et al. (2014) compared pH and electrical conductivity datasets collected by Waterwatch and professionals, and found no statistically significant difference between the datasets. This confirms that Waterwatch data is reliable and appropriate to be included in legislative datasets or monitoring plans.

Conclusions

The Mary River catchment is a unique natural resource that needs to be monitored to better inform stream management decisions. Waterwatch data holds immense value not only to community members and the MRCCC, but to government agencies and other professional organisations. Collection and analysis of Waterwatch data provides essential baseline information that can facilitate detection of long term trends and short term problems. The Waterwatch Program contributes to higher levels of interest in water quality and a better understanding of the catchment and integrated stream management.

Systematic monitoring such as that provided by the Waterwatch program requires ongoing funding, ability to respond to opportunities to expand and improve the program, and strong partnerships with local government and other natural resource management partners. Strong communication with and support of volunteers is essential as are mechanisms for providing feedback so that the data can be used by volunteers and other stakeholders.

Over nearly two decades, Waterwatch has facilitated a process of proactively acquiring water quality baseline datasets and sharing information with community members, government agencies, decision-makers and natural resource management groups. This data and the networks created through the program have made a positive difference to the way in which water quality is understood, assessed and managed in the Mary River catchment.

Acknowledgments

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References

Australian Government Natural Resource Management Team (2000), A national action plan for salinity and water quality NAPSWQ). Department of Agriculture, Fisheries and Forestry, Canberra, ACT.

Bonney, R.B., Shirk, J.L., Phillips, B.T., Wiggins, A., Ballared, H.L., Miller-Rushing, A.J. & Parrish, J.K. (2014), Next steps for citizen science. Science, vol. 343, 1436-1437.

Burgess, S. (2014), 2014 Mary River Catchment Waterwatch Results – Whole of catchment summary of long term Waterwatch data, Mary River Catchment Coordinating Committee http://mrccc.org.au/wp-content/uploads/2014/06/2014WholeCatchmentWWReport.pdfConrad, C., & Hilchey, K. (2011), A review of citizen science and community-based environmental monitoring: issues and opportunities. Environmental Monitoring and Assessment, vol. 176 (1-4), 273-291.

Cox, T.E., Philippoff, J., Baumgartner, E. & Smith, C.M. (2012), Expert variability provides perspective on te strengths and weaknesses of citizen-driven intertidal monitoring program. Ecological Applications. vol. 22 (4), 1201-1212.

Department of Environment and Resource Management (2010), Environmental Protection (Water) Policy, Mary River environmental values and water quality objectives Basin No.138, including all tributaries of the Mary River, Department of Environment and Resource Management. Water Quality & Ecosystem Health Policy Unit.

Dyer, F., Harrison, E., Gruber, B., Nichols, S, Tschierschke, A., & O'Reilly, W. (2014), Waterwatch data quality: an opportunity to augment professionally collected data sets. In Vietz, G; Rutherfurd; I/D, and Hughes,

R. (editors), Proceedings for the 7th Australian Stream Management Conference. Townsville, Queensland, 457-462.

Gooch, M. (2003), A sense of place: ecological identity as a driver for catchment volunteering. Australian Journal of Volunteering, vol. 8 (2), 23-32.

Gouveia, C., Fonseca, A., Câmara, A., & Ferreira, F. (2004), Promoting the use of environmental data collected by concerned citizens through information and communication technologies. Journal of Environmental Management, vol. 71 (2), 135-154.

Kosmala, M., Wiggins, A., Swanson, A. & Simmons, B. (2016), Assessing data quality in citizen science. Frontiers in Ecology and Environment, vol. 14, 551-560.

Lukyanenko, R., Parsons, J. & Wiersma, Y.F. (2016), Emerging problems of data quality in citizen science. Conservation Biology, vol. 30 (3), 447-449.

Mary River Catchment Coordinating Committee (2018), Website - www.mrccc.org.au

Mary River Catchment Coordinating Committee (2017) Waterwatch quality assurance manual.

Measham, T.G., Barnett, G.B. (2007) Environmental volunteering: motivations, modes and outcomes. Australian Geographer, vol. 39 (4), 537-552.