

TARDIS – Making Rainfall and Water Level Data Accessible and Useful

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Abstract

Many Queensland local government authorities have rainfall and water level gauges which provide real time rain and water level data. In order to effectively utilise this type of data these authorities require the ability to rapidly access the data, relate it to flood effects on the ground, share relevant intelligence with flood response operations and the ability to trigger relevant warnings to the community. TARDIS (Torrent and Rainfall Distribution Information System) has been developed to achieve this functionality.

TARDIS is a joint venture initially developed by Townsville City Council (TCC) then further developed and enhanced by Moreton Bay Regional Council (MBRC) and Sunshine Coast Council (SCC). TARDIS utilises the real time rain and water level information captured using the Bureau of Meteorology Enviromon software and stores the data using Microsoft SQL Server. The TARDIS application provides a user friendly interface that allows rapid production of useful maps, graphs and reports containing both current and historical data captured from Enviromon in a readily accessible data base.

This paper describes the current features of TARDIS and how TCC and MBRC use the application to access and utilise rainfall and water level data as part of their flood warning systems to maximise benefits to their respective Councils flood response and warning capabilities.

Introduction

In Queensland, local government authorities (councils) are responsible for flash flood warning, local road closures and activation of a Local Disaster Co-ordination Centre (LDCC) to co-ordinate multi agency response during flood events. Many have a network of rainfall and water level gauges to provide real time rain and water level data to monitor such severe weather situations.

This paper describes an application called ‘TARDIS’ developed to make this rainfall and water level data readily accessible and easy to rapidly convert to useful maps graphs and reports.

Background

Townsville City Council

Towards the end of the last decade, Townsville City Council (TCC) in conjunction with the Bureau of Meteorology (BoM) was maintaining the infrastructure for more than 40 rainfall and/or water level gauging stations and was planning to increase its network. The data from these gauges was relied upon heavily for flood modelling, emergency management and post-event analysis.

TCC utilise the BoM supplied Enviromon software to receive, interpret, quality-check, organise, display and archive this data. While Enviromon was fit for purpose, it did not fully meet the local government authorities need for access to current and historic data in an easy to use and understand format.

At this time, Brisbane City Council (BCC) had already developed a user friendly interface to access Enviromon data which was being used by a number of South East Queensland Councils. This system did not suit TCC's needs because, being hosted on BCC's internal computer servers, it would create an unacceptable reliance on systems external to TCC.

In 2011, TCC commenced a project to develop a robust, low cost, user-friendly interface for accessing rainfall and water level data captured by Enviromon. This project was completed with funding assistance from the Queensland and Australian Governments via the Natural Disaster Resilience Program, technical support from the Bureau of Meterology in Brisbane and programming by John O'Connell. The outcome of the project was TARDIS (Torrent And Rainfall Distribution Information System).

During development of TARDIS it was recognised that other local government authorities and Enviromon users could find this software useful. Other government authorities were offered the option to establish a partnership arrangement with TCC to use and, if desired, further enhance TARDIS. Moreton Bay Regional Council (MBRC) and Sunshine Coast Council (SCC) have since entered into this arrangement. The following sections of this paper describe how MBRC utilise TARDIS as part of their flood warning system and is written from a MBRC perspective.

Moreton Bay Regional Council

The Moreton Bay local government area covers a total area of 2040 km² between 20 and 44 km north of Brisbane GPO and has an estimated resident population 409,000. The region contains a diverse mix of land uses (e.g. rural, semi-rural, urban and forest) and provides a key urban growth corridor for South-East Queensland, expected to accommodate another 150,000 people over the next 20 years. Floodplains represent one of the most common landforms in the region.

MBRC has highly variable floodplain with 14 separate drainage catchments including Pine, Caboolture and Stanley rivers and numerous large creek catchments. Flood prone properties and critical traffic routes susceptible to flooding are distributed over the various rivers and creeks, generally located in flash flood areas (rain to flood time is less than 6 hours).

In Queensland, local government authorities (councils) are responsible for Flash Flood Warning. With the exception of the Stanley River at the highway, the Bureau of Meteorology (BoM) does not issue specific flood warnings for creeks and rivers in the MBRC region. The responsibility of council for Flash Flood Warning was reiterated by the 2012 Queensland Floods Commission of Inquiry.

Flood Warning in the MBRC region is challenging because of short response time and distribution of trouble spots over various catchments. Council monitors potential flooding using a network of rainfall and water level gauges. In total, 41 Water Level and 89 rainfall gauges provide information relevant to MBRC catchments. These provide real-time information using the ALERT radio telemetry system and the BoM software package 'Enviromon'.

In order to effectively utilise the real time rainfall and water level data MBRC required the ability to rapidly access the data, relate it to flood effects on the ground, share relevant intelligence with flood response operations and the ability to trigger relevant flash flood warnings to the community.

The direct use of the BoM Enviromon Software to access flood data is limited for MBRC because:

- there are a restricted number of users (3 users per installation),
- the software needs to be installed on each computer it is viewed from,
- it is generally not user friendly for the wide audience of internal stakeholders wanting to access rain and water level data,
- historic data is difficult to access, and
- there is very limited functionality to analyse and relate data to likely flood effects.

TARDIS in the form developed by TCC provided a user-friendly interface allowing rapid production of useful rainfall and water level maps, graphs and reports containing both current and historical data captured from Enviromon in a readily accessible database. This was an effective tool for accessing the data and following a trial, MBRC entered into an agreement with TCC to install the system and subsequently further developed it to incorporate a range of additional features including:

- Flood effects predicted from rainfall (actual and/or forecast)
- Relating water level gauge levels to flood effects
- Automation of flood situation reporting
- Reports on roads and likely effects at water level gauges
- Maps showing flood warning message thresholds and status of warning messages
- Tools for managing flood warning system including gauge status and gauge status reporting
- Flood Dashboard – An overview of emergent situation

Figure 1 shows where TARDIS fits in MBRC's Flood Warning System.

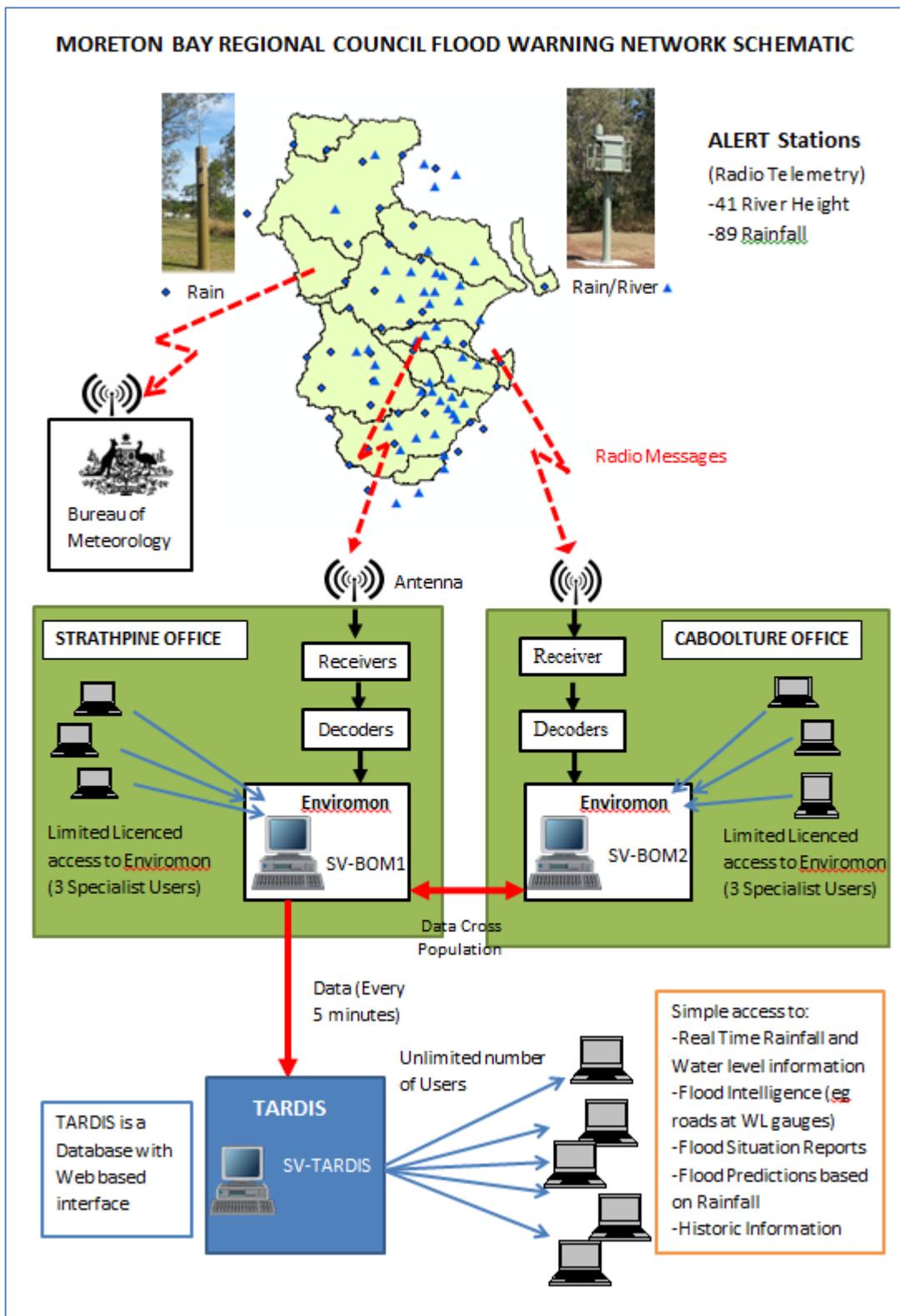


Figure 1 MBRC Flood Warning Network Schematic

An Overview of TARDIS

General Layout and Functionality

TARDIS uses Microsoft SQL Server to store rainfall and water level information. This provides practically unlimited capacity to store all historical and future readings. The application is accessed from any supported web browser including Internet Explorer 8 or higher, Firefox and Chrome and calls stored procedures to interrogate the database and return relevant data for selected maps, graphs and reports. The interface is user friendly and fast.

TARDIS has been designed to be immediately usable by casual users. Consistent user interfaces are used throughout the application with many features specifically designed for ease of use in flood response scenarios including:

- ‘Auto-Refresh’ meaning maps, graphs or reports can be left on-screen, automatically keeping themselves up to date with the latest information.
- ‘Auto-Resize’ meaning maps, graphs and reports resize themselves to fit in their browser window. This allows multiple maps, graphs and reports to be viewed on screen simultaneously.
- Intuitive and familiar button clicks, scrolling and hand motions allowing the user to pan and zoom.
- Most screens refresh in a second or less.
- Ability to temporarily disable or re-enable gauge stations if they are malfunctioning during an event. Disabling a station means that it is still recording readings but is hidden from all maps, graphs, reports and excluded from calculations until normal service is resumed.
- Maps are colour coded with legends describing their severity.

Accessing Rainfall Data

Historic, real time or forecast rainfall data can be accessed via a map, graph or report. The rainfall contour scale automatically adjusts to the period summarised. Station Rainfall Graphs and IFD Graphs are directly available via the hyperlinks (or via the graphs menu). Data and reports can be exported in a number of formats such as CSV, HYDSYS, Word, Excel or PDF. The date and time shown defaults to current date and time but can also show any historical or future time. The period summarised defaults to 24 hours but can range from 15 minutes to 12 months. The transition from historical to current to forecast data is seamless.

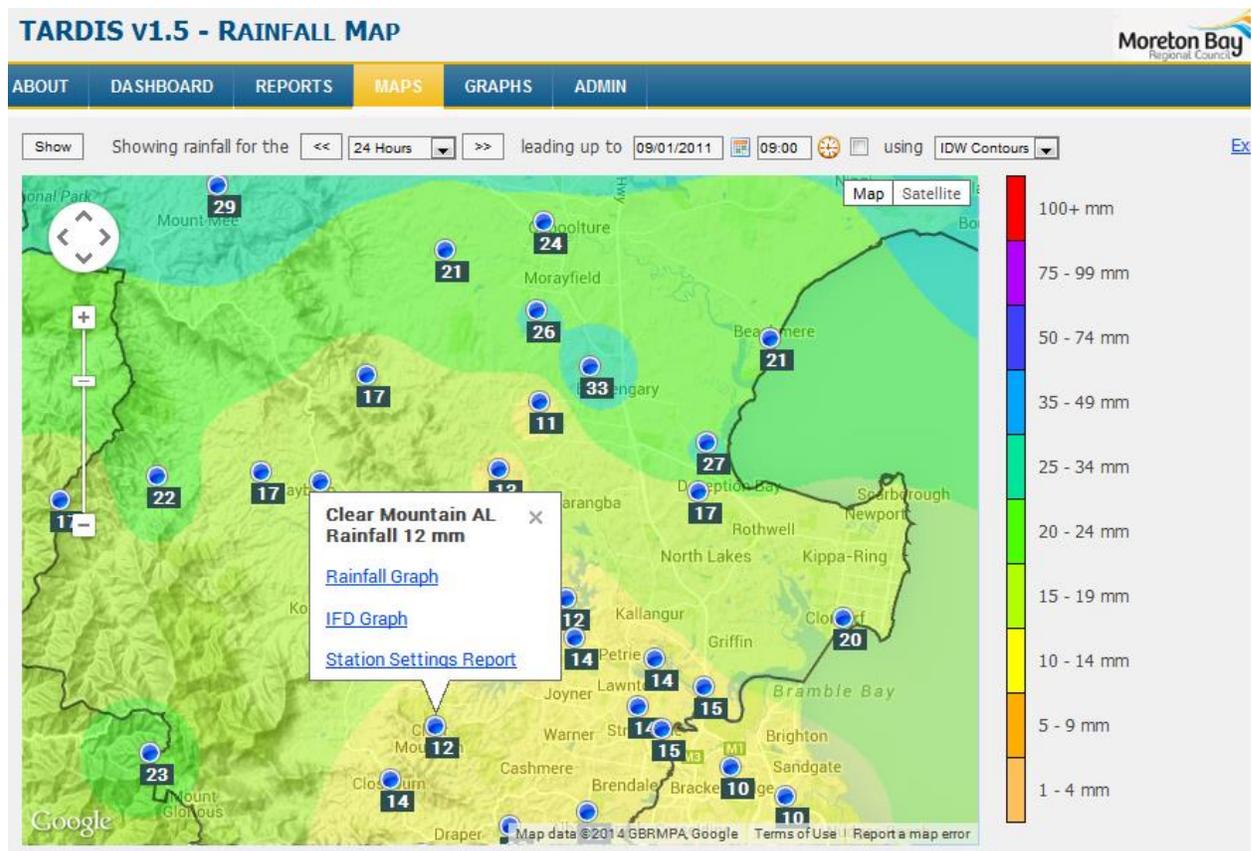


Figure 2: TARDIS Rainfall Map

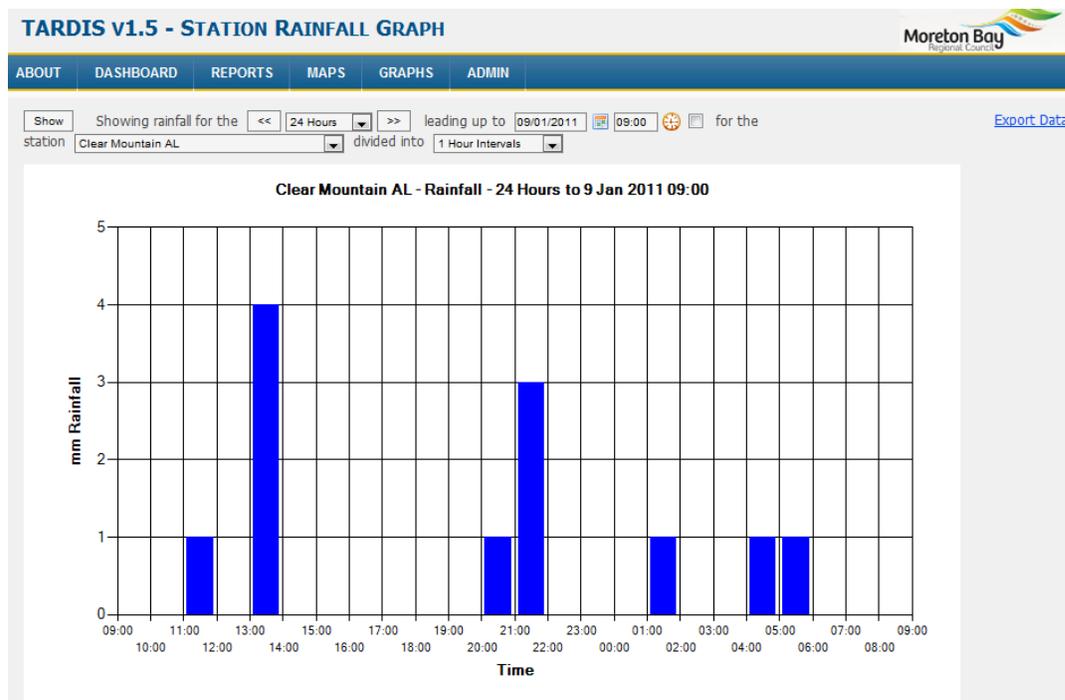


Figure 3 TARDIS Rainfall Graph

IFD Curves for event probabilities up to 2000yr ARI can be shown.

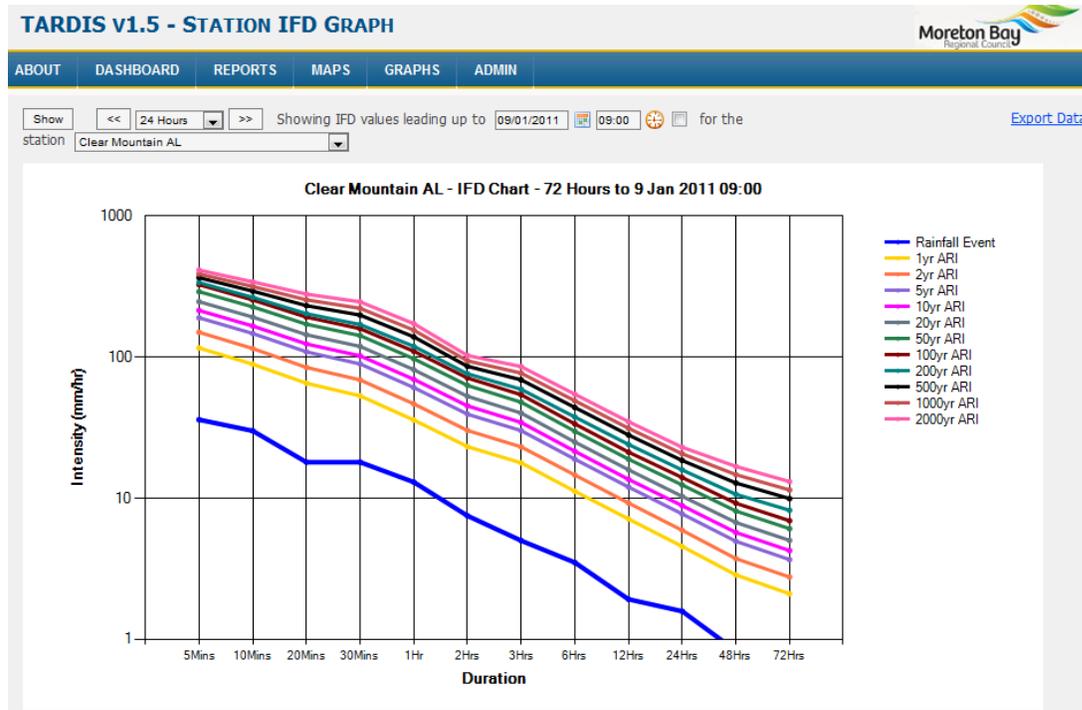


Figure 4 Station IFD Graph

Water Level

MBRC used all available flood information (historic and design) to relate water levels at Water Level Gauges to likely flood effects which can be related to the gauge height. These flood effects were used to determine appropriate Minor, Moderate, Major and Extreme flood classification levels for each Water Level gauge. The Water Level map shows the severity of flooding using colour coding depending on which flood classification level is exceeded.

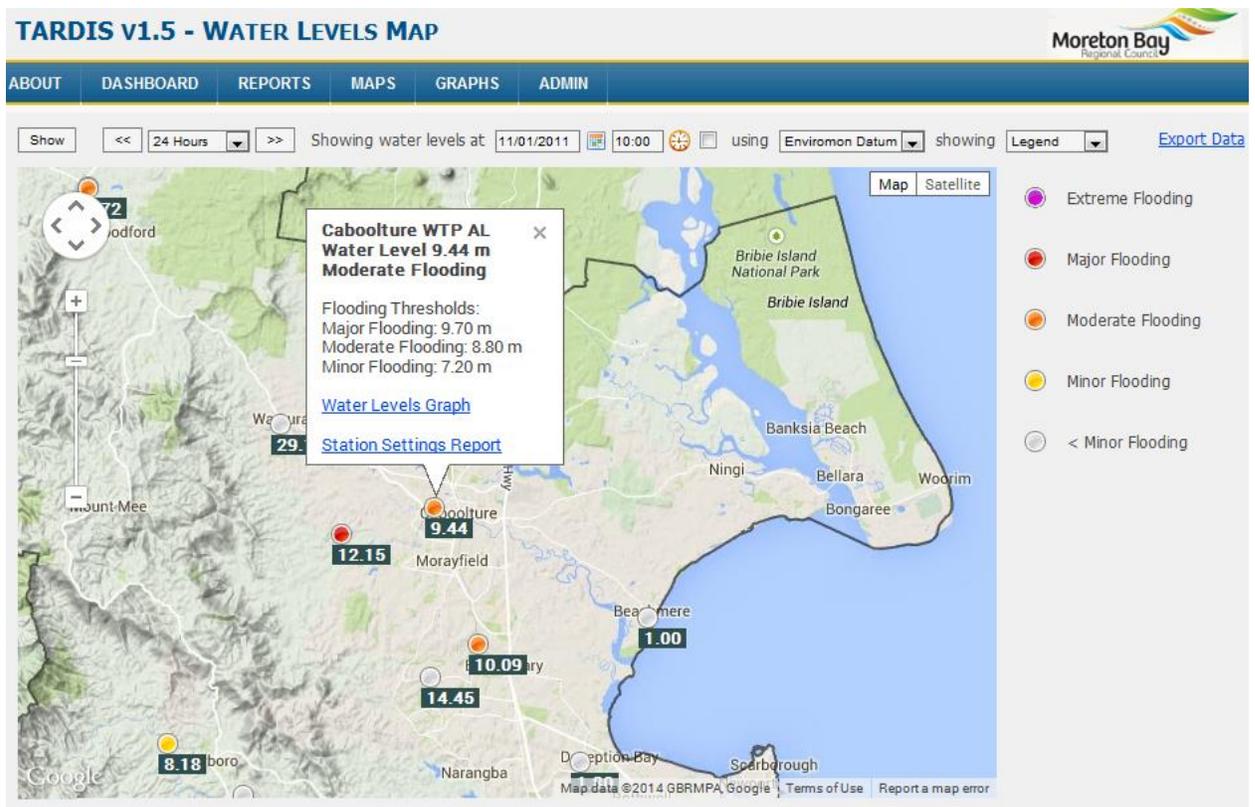


Figure 5 Water Levels Map

The water level graph is directly accessible via the hyperlink.

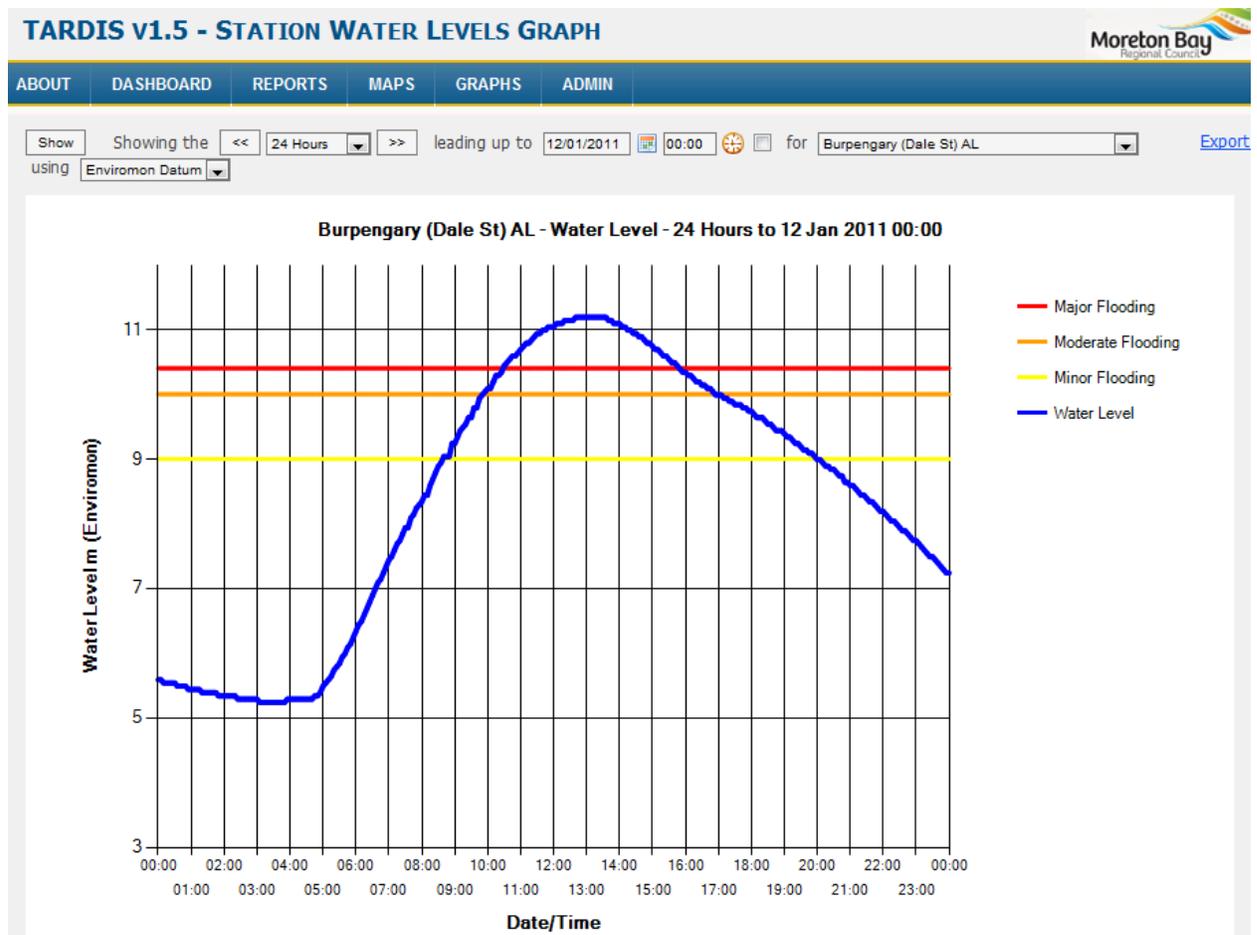


Figure 6 Station Water Levels Graph

MBRC store ‘likely effects’ at Water Level gauges in TARDIS. Likely effects include inundation of roads, property, exceedance of warning message thresholds and flood severity classifications. TARDIS uses this information in conjunction with water level at the time of interest to quickly produce reports summarising the status of roads, property and flood warning messages at Water Level Gauges. These reports are colour coded to draw the users attention to locations where the water level is approaching or exceeding critical levels. These reports can be set to auto refresh for easy tracking of likely flood effects based on Water Level Gauge levels. Operations staff can access these reports using TARDIS directly.

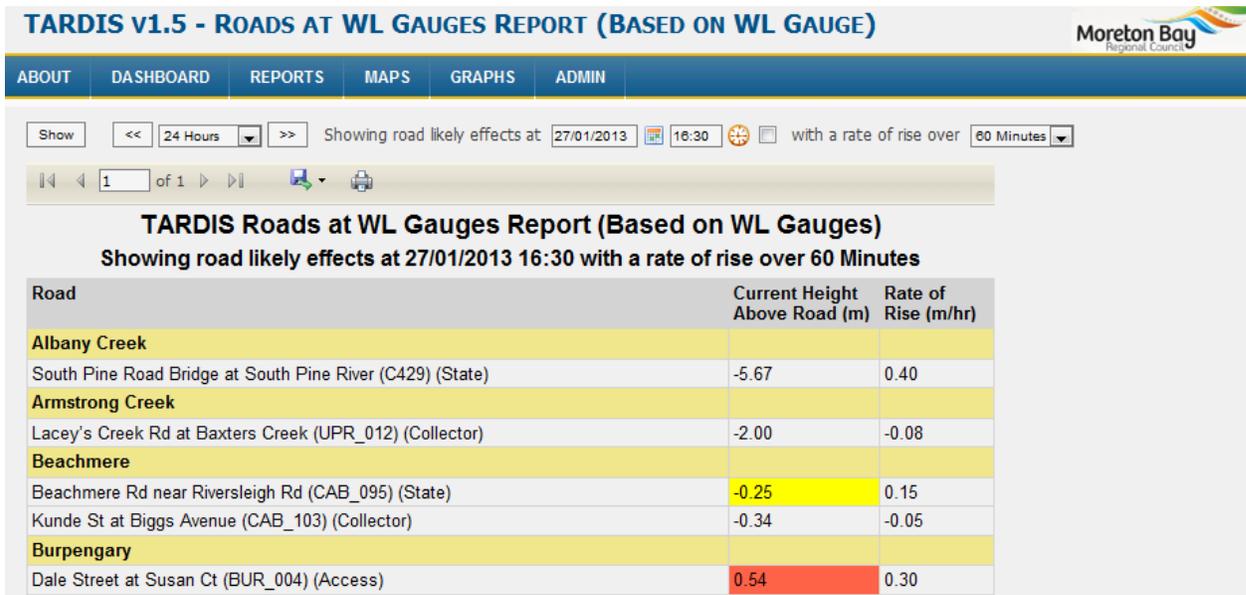


Figure 7 Roads at Water Level Gauges Report (Only part of report shown for demonstration purposes)

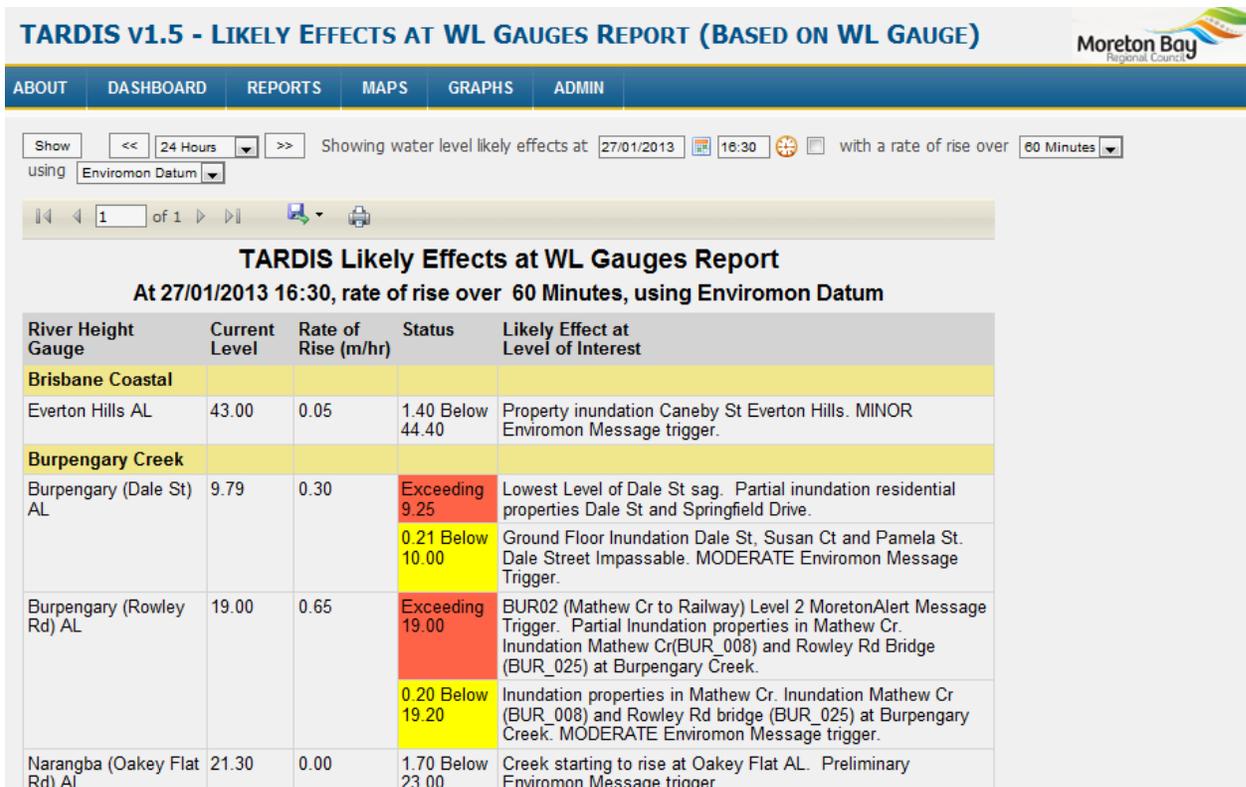


Figure 8 Likely Effects at Water Level Gauges Report (Only part of report shown for demonstration purposes)

Yellow shaded 'status' items are approaching a critical level and the interpretation is to prepare for appropriate action. Red shaded 'status' items are exceeding a critical water level and should have been actioned.

Area Average Rainfall

The likely flood effects resulting from rainfall is of interest at various locations along creeks and rivers. In TARDIS, stream points are used to represent these locations of interest. The likely flood effects at stream points is not dependent on the rainfall recorded at a single gauge but rather rainfall recorded at all the gauges within the catchment upstream. Thiessen Polygons based on the rainfall gauge locations are used to define the notional area of influence of each gauge. Using these areas the weighting of each gauge contributing to the catchment of the stream point is calculated and used to calculate the Area Average Rainfall.

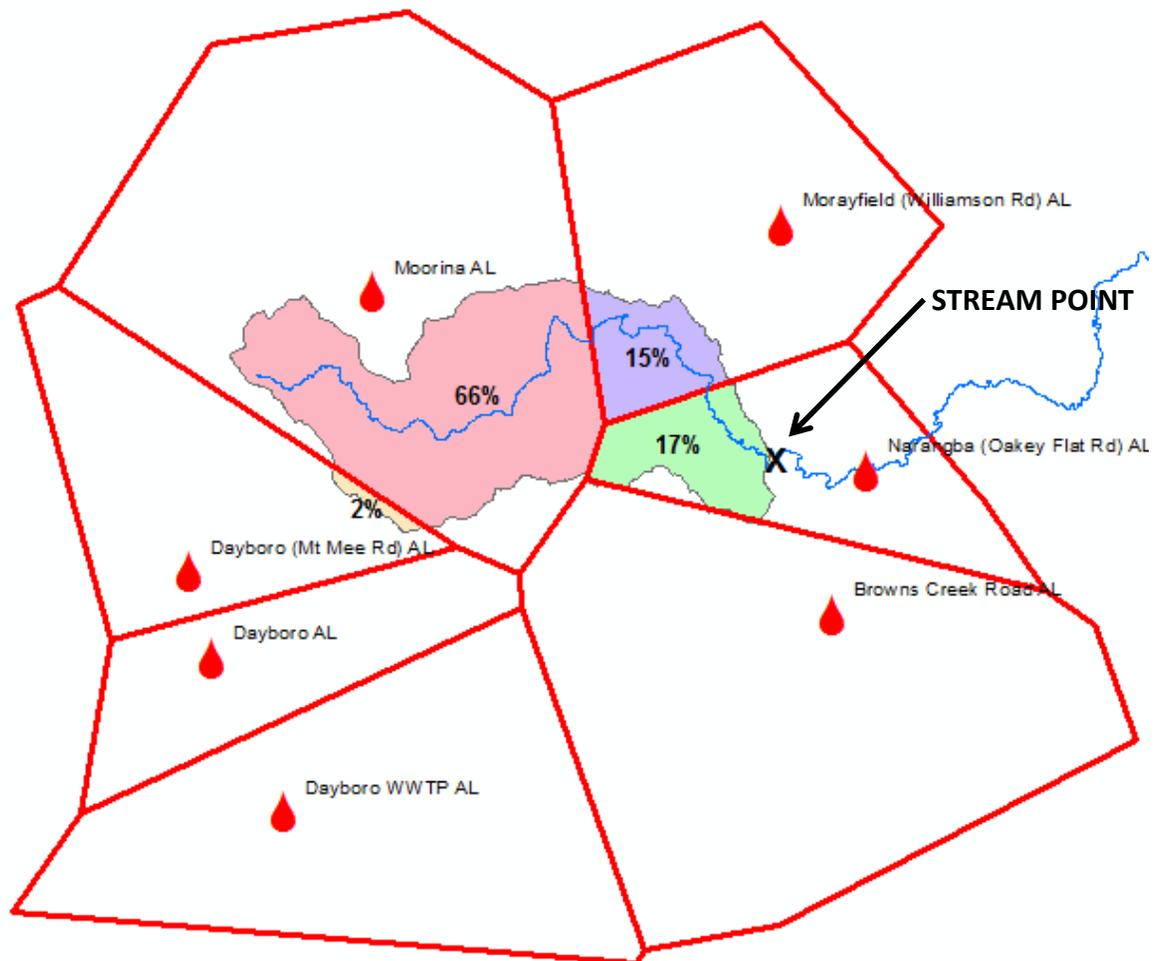


Figure 9 Stream Point 'X' Catchment Percentages for Area Average Rainfall Calculations

MBRC have developed relationships between the 1, 2, 3, 6 and 12 hour AAR and likely flood magnitude (minor, moderate, major and extreme). These 'pre-cooked' relationships were developed from the results of WBMN modelling using a series of uniformly distributed rainfalls run over various time periods. The relationships were input into TARDIS and enable mapping of Area Average Rainfall at numerous locations of interest along creeks and rivers, colour coded to provide an indication of likely flood effects predicted from

rainfall. Functionality is included to compensate for different antecedent conditions with a rainfall loss per hour applied depending on the selected ground saturation level.

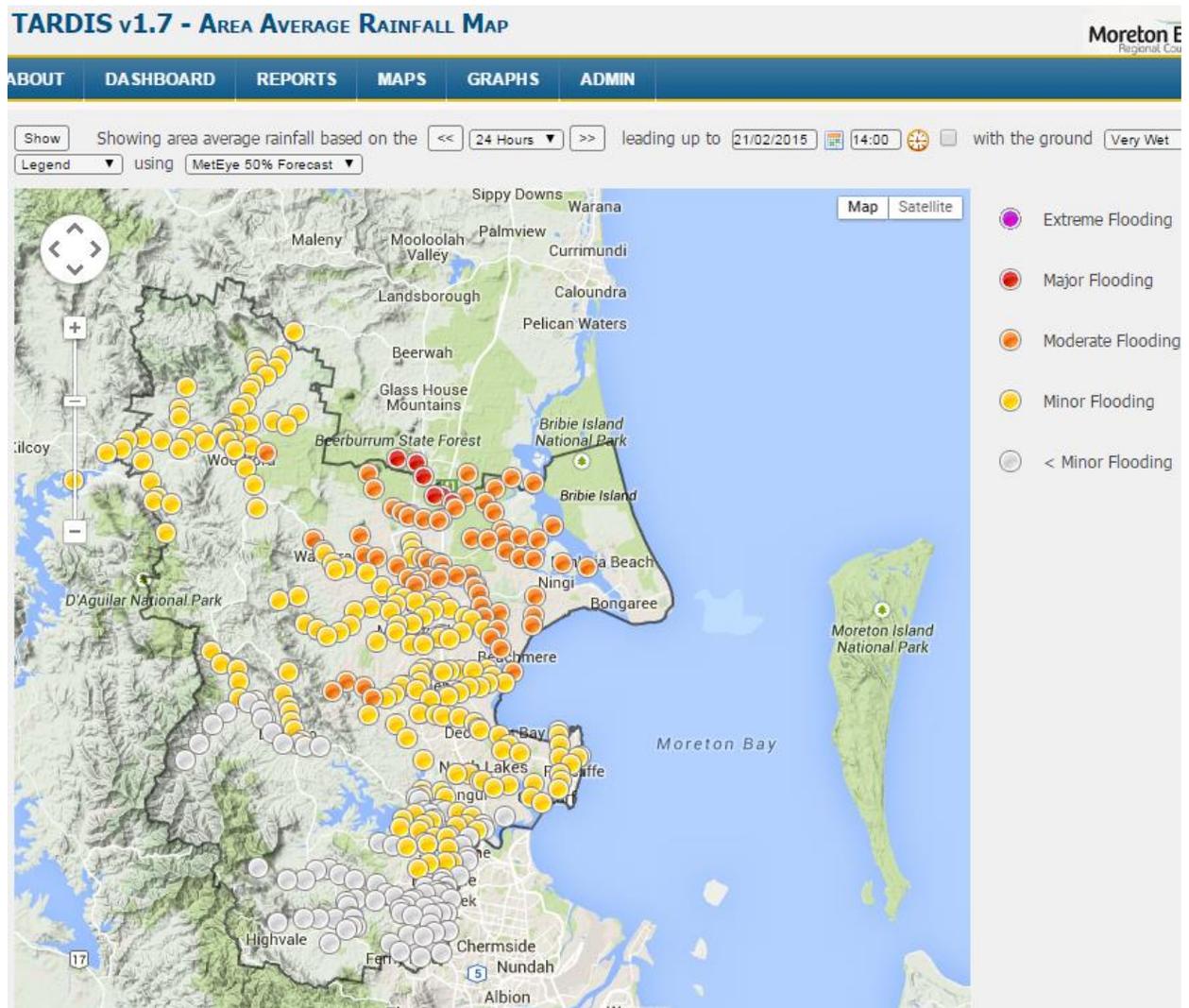


Figure 10 Area Average Rainfall Map

Area Average Rainfall is also related to road inundation and water levels at some locations. This enables prediction of roads at threat and water levels based on rainfall. The accuracy of these predictions can be limited however this tool provides a picture of likely effects from rainfall. It also provides an idea of flooding likely to result from various forecast rainfall scenarios. The results are accessed in Map or Report formats.

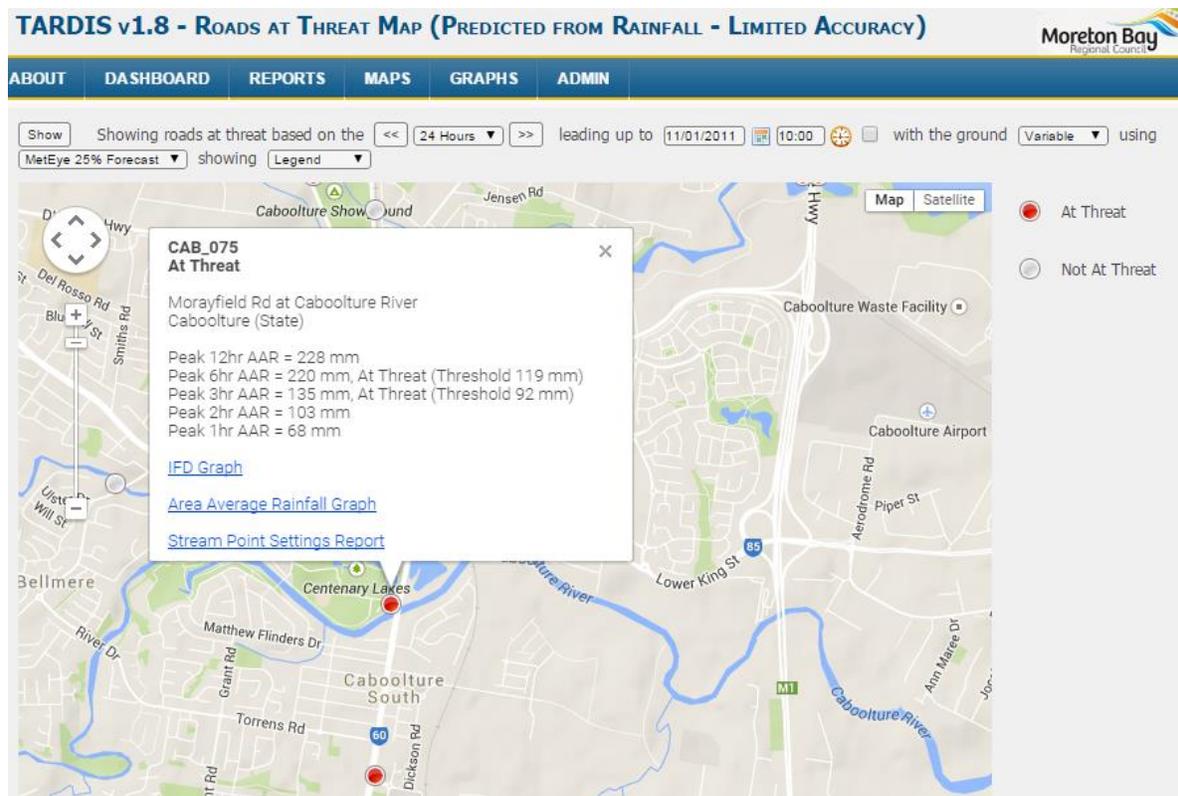


Figure 11 Roads at Threat based on Rainfall Map

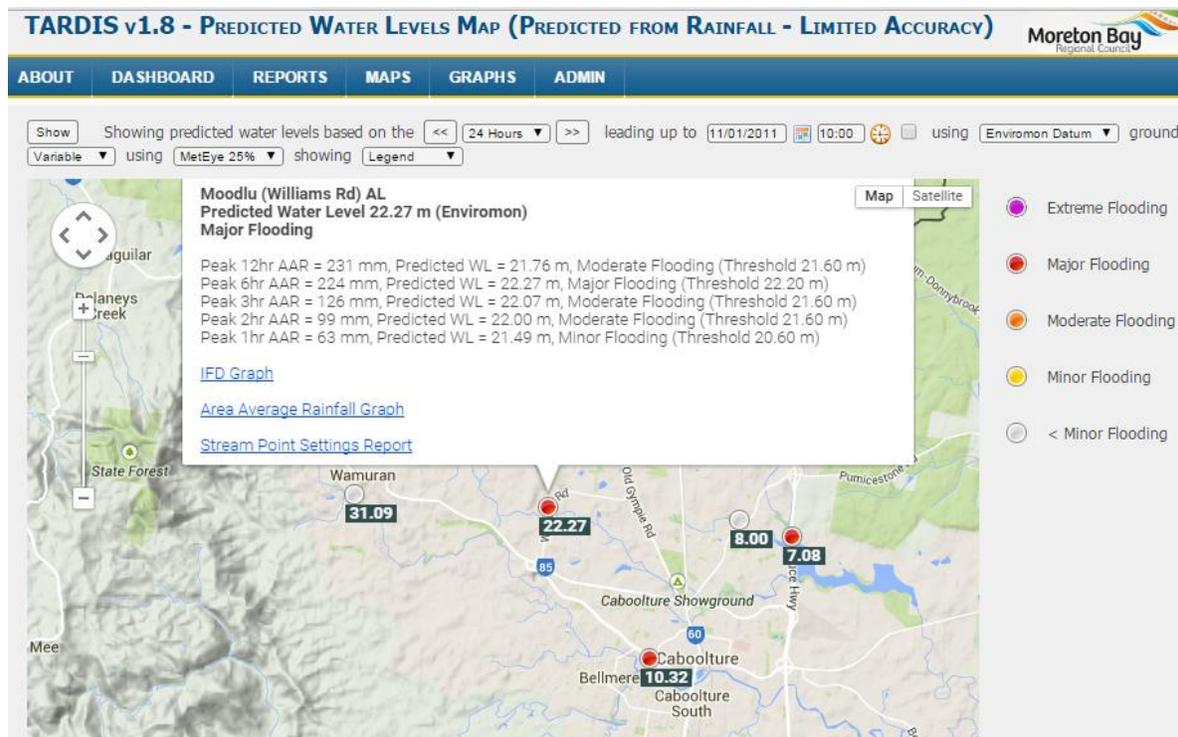


Figure 12 Predicted Water Levels Map

TARDIS has the ability to incorporate forecast rainfall into its area average rainfall based flood predictions. MBRC subscribe to BoM Australian Digital Forecast Database (ADF) rainfall forecasts which provides up to 48 hours of 3 hourly interval forecast rainfall for 50%, 25% and 10% chance of exceedance scenarios. TARDIS automatically retrieves this forecast data. TARDIS will automatically incorporate the forecast rainfall into its area average rainfall calculations. It uses a combination of actual rainfall readings before present time and forecast rainfall after the present time on a pro-rata basis. The option to manually input forecast rainfall is also available.

Flood Situation Reports

A Flood Situation Report provides a comprehensive report detailing many aspects of flood event. This report is available as both an automatically generated unverified report and a report moderated by a flood engineer. The Flood Situation is configurable with tick box selection of information to be included.

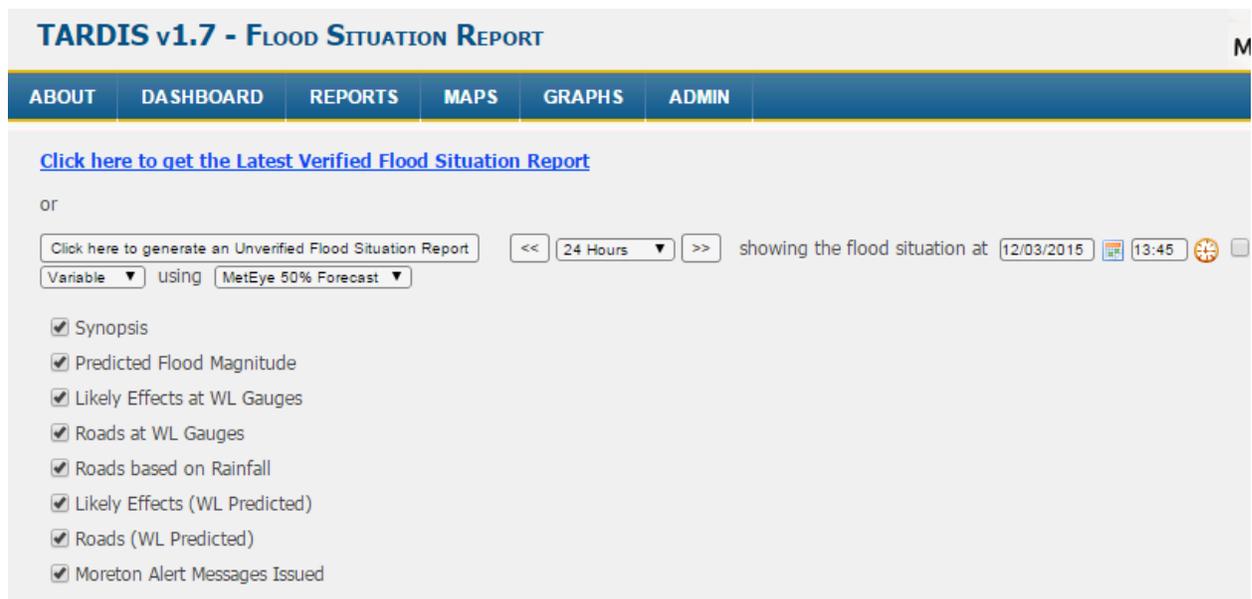


Figure 12 Tick box selection for contents of Flood Situation Report.

MBRC’s Flood Information Centre use a flood situation report to communicate flood intelligence with the LDCC and Operations.

Dashboard

A dashboard provides a summarised executive overview of current flood situation on a single screen. The dashboard includes links to more detailed maps and reports where appropriate and defaults to automatically refresh itself every few minutes, keeping up-to-date.

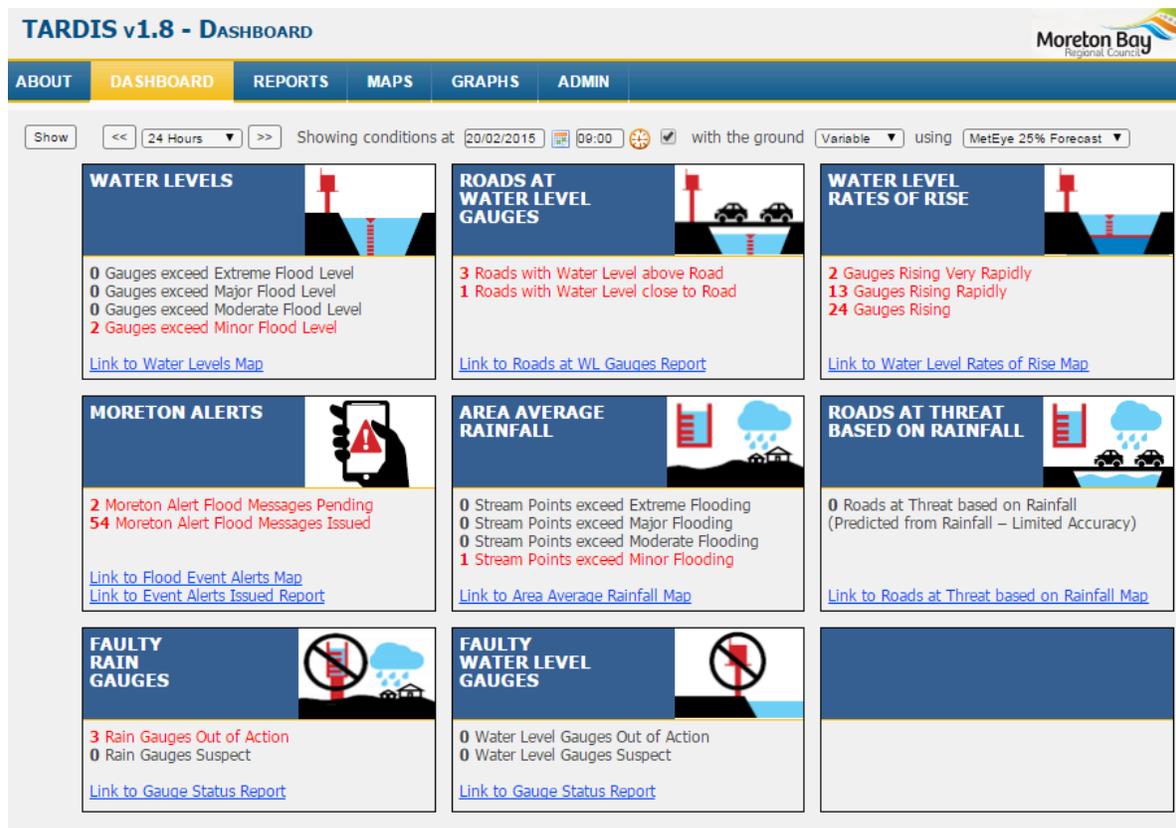


Figure 13 TARDIS Dashboard

TARDIS Community

TARDIS is a joint venture, owned by TCC, MBRC and SCC and other organisations are invited to join the group and use TARDIS. Interested organisations are provided with an executable copy of the software at no cost. The community model means that there is a single version of the software so that all new features and enhancements are available to the whole TARDIS community. The costs of using TARDIS are the installation costs and optionally, any enhancements or new features developed. TARDIS is fully self-contained on the user organisations network.

TCC, MBRC and SCC have each contributed to overall functionality available in TARDIS in the process of adapting TARDIS for their particular requirements. The current functionality of TARDIS is summarised in Figure 14. An overview of some of this functionality is provided above and in a separate paper 'Flood Forecast Mapping Sans Modelling' (Smythe, Newell & Drury 2015).

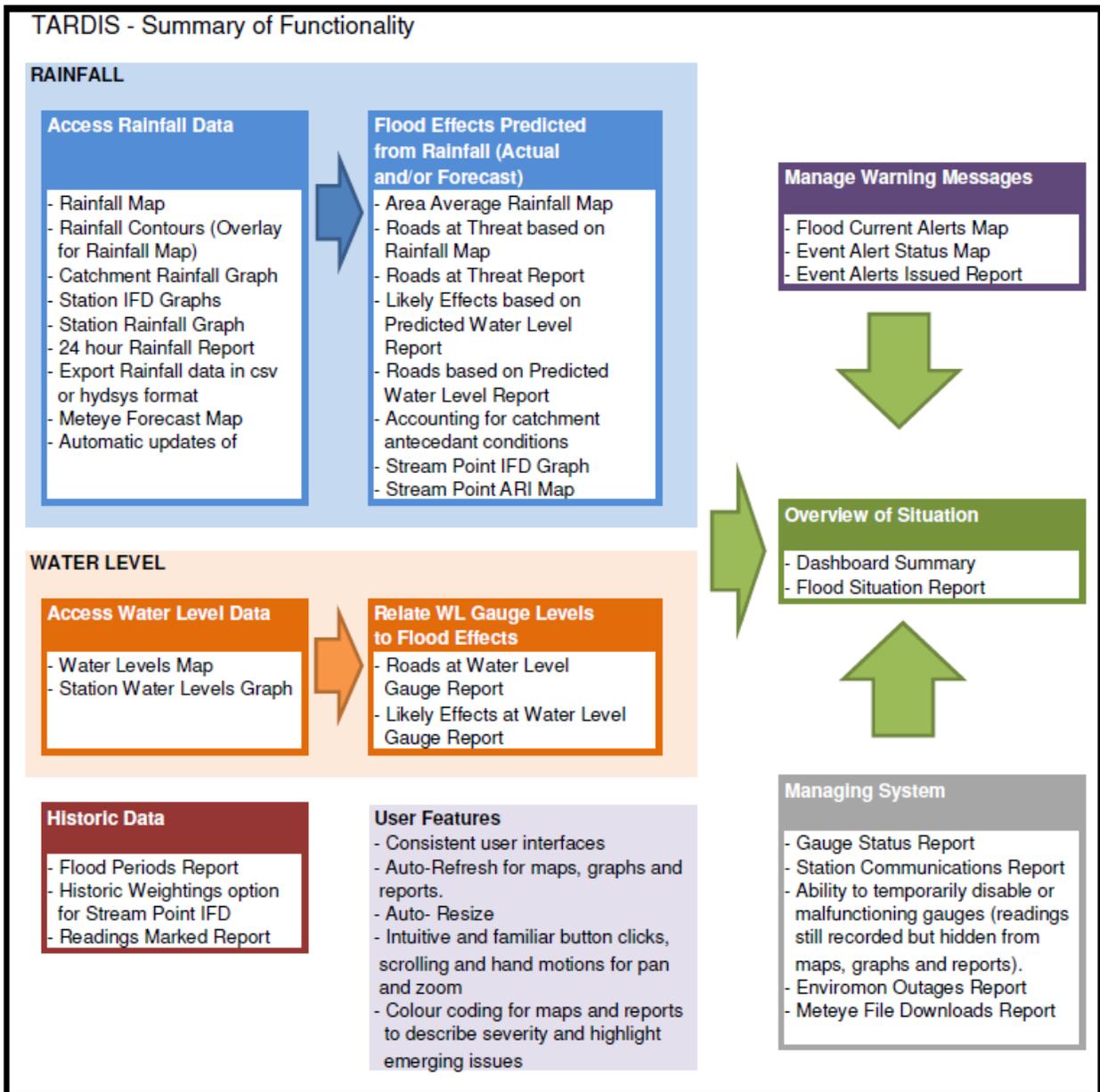


Figure 14 Summary of TARDIS Functionality

Real Time Operation

At the time of writing, the most significant real time testing of TARDIS by MBRC was during flooding experienced over 20th and 21st February 2015.

In the lead up to this event, TARDIS was used to prepare scenario reports providing predictions of flood magnitudes, flood levels and road closures likely to result from the various BoM rainfall forecast scenarios. These reports were prepared morning and evening when the BoM updated forecasts and TARDIS automatically retrieved ADFD rainfall forecasts for 50%, 25% and 10% chance of exceedance scenarios.

During the event, TARDIS was used to prepare flood situation reports, manage issuing of warning messages, monitor rainfall and water levels at gauges, monitor likely flood effects and keep abreast of the flood situation. TARDIS was used extensively during this event by both technical and non-technical users.

Following the event, the feedback received about TARDIS by all, including technical and non-technical users and flood response operations, was very positive.

Conclusion

TARDIS is now in active use at three local government authorities in Queensland. It is a simple to use, robust tool for rapidly accessing, displaying and storing rainfall and water level data. It is designed to be immediately usable by casual users and is accessed from a web browser.

TARDIS further incorporates functionality to maximise the usefulness of this data including:

- Relating rainfall and water level data to flood effects on the ground.
- Enabling rapid production of flood situation reports to share relevant flood intelligence with flood response operations.
- Message management tools to track when warning message thresholds have been reached and the status of messages.

Based on experience with application of the tool and positive feedback received from flood response operations the authors conclude that TARDIS meets intended objectives and provides a tool that makes rainfall and water level data accessible and useful.

References:

Smythe, C, Newell, G & Druery C 2015 'Flood Forecast Mapping Sans Modelling'. Paper presented at the 2015 Floodplain Management Association National Conference, Brisbane