Operation of Wivenhoe Dam and Somerset Dam January 2011 Flood Event

Explanation of Operational Methods and Decision-Making Practices

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seqwater
WATER FOR LIFE

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1 INTRODUCTION

1.1 Background

Managing the operation of Wivenhoe Dam and Somerset Dam during flood events is a complex and highly technical task which requires a detailed understanding of the following matters:

- The Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam (Revision 7) (the Manual).
- The process used for operational decision-making during flood events impacting the Dams.
- The details of the many modelling components of the Real Time Flood Model.
- The operation of the Real Time Flood Model and the ways it is used to support operational decision-making during flood events.
- The strategy evaluation and risk assessment processes used by the Flood Engineers to make operational decisions during flood events.
- The best practice methods associated with determining stream flow measurements in real time.
- The basic principles of hydrologic modelling associated with estimating flood flows in large river catchments.
- The qualitative and quantitative rainfall forecasts issued by the Bureau of Meteorology (BoM) and how these forecasts should be applied.

This report aims to explain some of the fundamental elements of managing the Dams during flood events. However, its aim is not to fully inform unskilled readers as to the detail of all modelling and processes used. To develop a comprehensive understanding of this process requires tertiary qualifications in civil engineering or hydrology and several months training. It is therefore not possible to properly impart engineering knowledge of this nature or level through a written report such as this

1.2 Meaning of terms

In this report, the following terms are defined as below:

"Act" means the Water Supply (Safety and Reliability) Act 2008;

“AEP” means Annual Exceedance Probability, the probability of a specified event being reached or exceeded in any one year. This may be expressed as a ratio (e.g. 1 in Y) or a percentage;

“AHD” means Australian Height Datum;

“ALERT” means Automated Local Evaluation in Real Time System, a system of monitoring and displaying rainfall and water level data. It is a combination of field stations, communication networks and data collection software;

“AR&R” means *Australian Rainfall and Run-off (Book 6),* The Institution of Engineers Australia (Engineers Australia) national guidelines for the estimation of design flood characteristics;

“BoM” means the Bureau of Meteorology;

“Commission” means the Queensland Floods Commission of Inquiry;

“Controlled Document” means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

“Dams” means Wivenhoe Dam and Somerset Dam;

“DERM” means the Queensland Government department, the Department of Environment and Resource Management;

“EL” means elevation in metres Australian Height Datum;

“Enviromon” is the Bureau of Meteorology data collection software used to collect and display rainfall and water level data;

“**FEWS**” means Flood Early Warning System and relates to the Delft-Fews flood management software developed by Deltares;

“Flood Engineer” means a person designated to direct flood operations at the Dams in accordance with Section 2.4 of the Manual;

“Flood Engineers” means the collective group of persons who individually have designation as a **Flood Engineer**;

“Flood Event” is a situation where the Duty Flood Operations Engineer expects the water level in either of the Dams to exceed the Full Supply Level;

“Flood Event Report” means the report prepared by Seqwater on the operation of Somerset Dam and Wivenhoe Dam during the January 2011 Flood Event, dated 2 March 2011;

“Flood Operations Centre” means the office location used by Flood Operations Engineers during a flood event to manage the event;

"FLOOD-Col" is the data collection software used in the Flood Operations Centre to collect and display rainfall and water level data;

"FLOOD-Ops" is the modelling software used in the Flood Operations Centre to model the runoff from the catchments;

"FSL" or "Full Supply Level" means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

"Gauge" when referred to in (m) means river level referenced to AHD or a local datum, and when referred to in (m^3/s) means flow rate in cubic metres per second;

"Manual" or **"Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam"** means the current version of the Manual (Revision 7);

"m^3/s" means a rate of water flow being one cubic metre of water per second or 1,000 litres of water per second;

"Operating Target Line" means the Wivenhoe/Somerset Operating Target Line from Strategy S2 of the Manual;

"QPF" means Quantitative Precipitation Forecast provided by the Bureau of Meteorology and is an estimate of the predicted rainfall in millimetres, usually in the next 24 hours;

"Rating" means the relationship between height and flow at gauging stations, demonstrated using a Rating Curve or Rating Table;

"RTFM" means Real Time Flood Model and is a combination of Flood-Col, Flood-Ops and other ancillary software;

"Seqwater" means the Queensland Bulk Water Supply Authority, trading as Seqwater;

"URBS" means Unified River Basin Simulator.

2 REAL TIME FLOOD MODEL AND FLOOD EVENT DECISION-MAKING

2.1 Introduction

The Real Time Flood Model (RTFM) is the basic tool used by engineers and hydrologists when making decisions during flood events impacting Wivenhoe Dam and Somerset Dam. A basic understand of the RTFM, its many components, and how they are used to support decision-making, is fundamental to developing an understanding of how flood events are managed.

2.2 Description of the RTFM

The RTFM is not a single component or model, but a suite of tools used to support flood operations decision-making. The term RTFM is used to broadly describe three main individual components and models and a number of supporting components, models and processes that are used to support flood operations decision-making in accordance with the Manual. This collection of individual components and models was used during the January 2011 Flood Event.

All components and models run independently and separately, some discretely at selected time intervals, and some on a continuous basis. However, each of the components share data and are interdependent. A brief description of the three main individual components is as follows:

- Flood-Col – the component that captures rainfall and stream height (including Dam height) data in real time and processes the data for input into Flood-Ops. This component runs continuously and can output data to Flood-Ops at any selected point in time.

- Flood-Ops – the component that processes rainfall data to estimate stream flow hydrographs. It contains a number of individual WT42 catchment models that provide coverage over the Somerset and Wivenhoe Dam Catchments, as well as the Lockyer Creek, Bremer River and Pine River Catchments. These models run at discrete times selected by the Flood Engineers based on how rainfall is occurring in the Brisbane River and Pine River Basins. The run times for Flood-Ops during the January 2011 Flood Event are contained in the Flood Event Report. Output from Flood-Ops changes as rainfall occurs and forecasts change and the Flood Engineers generally select model run times with this in mind. The output from this component is used in the Gate Operations Spreadsheet Model.

- Gate Operations Spreadsheet Model – the component that is used to evaluate a broad range of gate operations strategies and to calibrate the flow hydrographs from Flood-Ops to actual lake levels and river levels. Broadly, it determines dam water levels based on inflows determined from the Flood-Ops models and allows the Flood Engineers to investigate a range of gate operating strategies to determine the most appropriate strategy at any point in time. To support this process, it provides a broad range of outputs that are used to evaluate potential gate operations strategies. These outputs include:

- A graphical output showing Dam inflows and the flows generated from the Lockyer and Bremer catchments.
- A graphical output showing inflows and outflows to and from Somerset Dam.
- A graphical output showing actual and modelled lake levels in Somerset Dam.
- A graphical output showing inflows and outflows to and from Wivenhoe Dam plus modelled Brisbane River flows at Lowood and Moggill.
- A graphical output showing actual and modelled lake levels in Wivenhoe Dam.
- A graphical output comparing lake levels in Somerset Dam to those in Wivenhoe Dam (interaction examination).

Flood Engineers continuously run the Gate Operations Spreadsheet Model to regularly evaluate various gate operations strategies. Options are evaluated in accordance with the Manual, with the aim of selecting the most appropriate strategy at any point in time. During this process the Flood Engineers constantly validate and adjust the calibration of the model to match model results against actual data from Flood-Col.

Accordingly, the Gate Operations Spreadsheet Model runs using continuously changing inputs rather than static singular inputs and therefore it never assumes or relies on a certain strategy or gate opening option. To reflect the constantly changing nature of a flood event, this model uses iterative evaluation of gate opening strategies and no single strategy is ever assumed to be the best option moving forward, as new strategies are constantly evaluated.

The January 2011 Flood Event Report contained “snapshots” of the results of the continuously changing Gate Operations Spreadsheet Model, at discrete points in time coinciding with discrete Flood-Ops model runs. However, these snapshots were not necessarily the assumed strategy moving forward from that point in time because when considered in isolation, they do not provide a complete view of the gate strategy option evaluation process that was occurring during the periods that these snapshots were taken. Snapshots of the Gate Operations Spreadsheet Model taken at other times (such as at times between Flood-Ops model runs) would show different results for predicted lake levels and all other outputs.

To support the operation of each of these three models during the January 2011 Flood Event, the Flood Engineers also used the following components, models and processes:

- Enviromon – this component runs continuously and is used to collect data from field stations and support the validation of Flood-Col. It can also be used as a replacement for Flood-Col should Flood-Col fail.

- URBS – these models run at discrete times selected by the Flood Engineers and are used to support the models contained in Flood-Ops. The collection of URBS models can also be used as a replacement for Flood-Ops should Flood-Ops fail.

- Model Calibration Processes – the Flood Engineers adjust model parameters in real time to ensure the overall model response is consistent with recorded response. This provides a check as to how output from Flood-Ops and the Gate Operations Spreadsheet Model is tracking against actual values. This operation is undertaken at key locations. The frequency of this operation at each location is determined by the Flood Engineers, based on the stage of the Event.

In summary, the RTFM is a term used to describe a collection of individual components, models and processes which, during the January 2011 Flood Event, included:

- Flood-Col
- Flood-Ops (incorporating the WT42 Models)
- Gate Operations Spreadsheet Models
- Enviromon
- URBS Models
- Model Calibration Processes.

2.3 Flood event decision-making

By their nature, flood events can be continually changing and the decision-making process currently used by the Flood Engineers accounts for this. During a flood event impacting Wivenhoe and Somerset Dams, rainfall that varies in intensity and distribution is continuously experienced throughout the 14,000km^2 catchment area of the Brisbane Basin. While rainfall forecasts provide an indication of what may occur, as experienced in January 2011, forecasts can be a poor indication of what is actually experienced. Accordingly, Flood Engineers must constantly react and adapt to circumstances that can change in unexpected ways. This requires a constant evaluation of gate opening strategies that often change hour to hour and certainly a gate opening strategy that may appear appropriate at a certain time during a flood event may be less optimal just a short time later. This is the nature of managing operational decisions in real time during flood events.

Decisions made during flood events are professional engineering judgments made by the Flood Engineers in accordance with the Manual, using data provided by the components, models and processes that comprise the RTFM. All decisions involve a broad risk assessment process and are made to minimise the risks that have the potential to adversely impact the community. All decisions are made using the following principles that are also contained in the Flood Event Report:

- The safety of the public is a primary consideration when making flood releases from the Dams. Every attempt is made to ensure public roads are closed prior to inundation by Dam outflows and that authorities are provided with enough time to prepare communities for the possibility of isolation, and to undertake evacuations.

- Every attempt is also made to ensure urban damage is minimised, and that Dam outflows, with the potential to contribute to urban damage, are delayed until it is apparent no other options are available without risking the safety of the Dams.

For a number of years, Seqwater has been proactively examining ways to quantify the qualitative risk assessment process used during the January 2011 Flood Event and generally in flood event decision-making. The FEWS Project, commenced by Seqwater in 2008, is an example of Seqwater's proactive approach in this area. However, until technology allows the BoM to assign quantitative probabilities to a range of provided forecasts (ensemble forecasts), the scope to introduce a quantitative risk assessment process in flood event decision-making is extremely limited.

Decisions relating to Wivenhoe and Somerset Dams take into account a number of risk assessment factors as described below. Firstly, a range of gate operating strategies are evaluated using the Gate Operations Spreadsheet Model with the following outputs of the model considered using the following processes:

- An examination of qualitative and quantitative forecast rainfall information from the BoM, including forecasts associated with the movement of weather systems.

- An examination of a combined graph showing Dam inflows and the flows generated from the Lockyer and Bremer catchments. This provides an opportunity to broadly assess the flood event and whether flood flows generated from the various catchments are approaching or have passed likely peak values.

- An examination of a combined graph showing inflows and outflows to and from Somerset Dam. This allows a gate operations strategy to be examined with respect to its specific impact on Somerset Dam. It also allows a judgement to be made on whether the strategy is appropriate for the Dam and whether a change in strategy is required or is likely to be required under the gate operations strategy being examined.

- An examination of a combined graph showing actual and modelled lake levels in Somerset Dam. This allows a gate operations strategy to be examined with respect to its specific impact on Somerset Dam. It also allows a judgement to be made on whether the strategy is appropriate for the Dam and whether a change in strategy is required or is likely to be required under the gate operations strategy being examined.

- An examination of a combined graph showing actual and modelled lake levels in Wivenhoe Dam. This allows a gate operations strategy to be examined with respect to its specific impact on Wivenhoe Dam. It also allows a judgement to be made on whether the strategy is appropriate for the Dam and whether a change in strategy is required or is likely to be required under the gate operations strategy being examined.

- An examination of a combined graph showing actual lake levels in both Wivenhoe and Somerset Dams. This is used to optimise the combined flood storages of the Dams in accordance with the requirements of the Manual. During evidence provided to the Queensland Floods Commission of Inquiry (Commission), this graph was referred to as the "interaction curve" and the "Target Operating Line".

- An examination of a combined graph showing inflows and outflows to and from Wivenhoe Dam plus modelled Brisbane River flows at Lowood and Moggill. This allows a gate operations strategy to be examined with respect to its specific impact on Wivenhoe Dam, its impact on rural areas below the Dam (including bridge impacts) and its impact on urban areas below Moggill. It also allows a judgement to be made on whether the strategy is appropriate for the Dam, in accordance with the Manual, and whether a change in strategy is required or is likely to be required to provide a better or more appropriate flood mitigation outcome.

During the January 2011 Flood Event, hundreds of gate operations strategies were evaluated using these processes. Strategy evaluation supports decision-making associated with both moving between strategies contained in the Manual and finding the most appropriate levels of dam releases at any single point of time during the flood event.

The final gate operations strategies implemented during the January 2011 Flood Event were adopted based on the outcomes of a risk assessment which involved reviewing a range of strategies and considering the factors which are listed below. This is standard procedure in flood event decision-making. Obviously, gate operations strategies change over the course of a flood event, as the flood event progresses, as rainfall is received in the catchments and as forecast rainfall predictions change.

During the January 2011 Flood Event, strategies were evaluated and compared based on the following flood event decision-making process where the following factors are examined:

- The impacts of the evaluated strategies on public safety.

- The impacts of the evaluated strategies on the bridges and roads downstream of the Dam over the course of the flood event.

- The impacts of the evaluated strategies on the urban areas downstream of Moggill, over the course of the flood event.

- The impacts of the evaluated strategies on the safety of the Dams.

- The impacts of the evaluated strategies on the drain down of the Dam.

- The impacts of the evaluated strategies on the likely level of the Dam at the conclusion of the flood event.

- The impacts of the evaluated strategies on the environment.

During flood events, a gate operations strategy is selected once all of these factors have been considered and evaluated in accordance with the Manual.

As flood operations decisions were made under pressure and in real time during the January 2011 Flood Event, it was not possible for Flood Engineers to keep a detailed written record of every gate operations strategy evaluated. However, a record of the factors considered in the risk assessment used to select strategies during this Flood Event, is contained in the Flood Event Report and the RTFM. In line with flood event decision-making processes, this risk assessment was also undertaken in accordance with the Manual. Because of this, a detailed hindsight evaluation of the strategy evaluation and risk assessment processes used to select the actual strategies adopted during the January 2011 Flood Event can be undertaken at any time, using the RTFM and the data contained in the Flood Event Report.

2.4 Lake level predictions

Predicting future lake levels in the Dams is a key component of the decision making process. The Flood Engineers take a large number of factors into account when predicting lake level and these are listed below.

- An examination of all rainfall and stream height data available for the Brisbane Basin during the flood event.
- An examination of qualitative and quantitative forecast rainfall information from the BoM.
- An examination of all the runoff-routing (hydrologic) model result hydrographs available from Flood-Ops.
- An examination of a combined graph showing Dam inflows and the flows generated from the Lockyer and Bremer catchments.
- An examination of a combined graph showing inflows and outflows to and from Somerset Dam.
- An examination of a combined graph showing actual and modelled lake levels in Somerset Dam.
- An examination of a combined graph showing inflows and outflows to and from Wivenhoe Dam plus modelled Brisbane River flows at Lowood and Moggill.
- An examination of a combined graph showing actual and modelled lake levels in Wivenhoe Dam.
- An examination of a combined graph showing actual lake levels in both Wivenhoe and Somerset Dams.
- The impacts of the evaluated strategies on public safety.
- The impacts of the evaluated strategies on the bridges and roads downstream of the Dam over the course of the flood event.
- The impacts of the evaluated strategies on the urban areas downstream of Moggill, over the course of the flood event.

- The impacts of the evaluated strategies on the safety of the Dams.

- The impacts of the evaluated strategies on the drain down of the Dam.

- The impacts of the evaluated strategies on the likely level of the Dam at the conclusion of the flood event.

- The impacts of the evaluated strategies on the environment.

Using all of this information, the Flood Engineers examine and evaluate a range of gate operations strategies using an iterative process. The gate operations strategy chosen at any single point in time is an indicator of future lake level. Snapshots of these indicators of future lake levels at single points in time are contained in the Flood Event Report in Appendix A. Snapshots of the Gate Operations Spreadsheet Model taken at other times (such as at times between Flood-Ops model runs) would show different results for predicted lake levels and all other outputs.

In relation to the Flood Event Report, snapshots of the Gate Operations Spreadsheet Model were recreated to reflect, as closely as possible, the state at this model at times corresponding to runs of the Flood-Ops model. No attempt was made to reflect the gate operations strategies being examined during these times in the model snapshots, as these strategy considerations were discussed in the Flood Event Summary in the Report.

The reasons why the snapshots were not necessarily implemented are discussed on page 5.

3 INTERPRETATION OF THE MANUAL

3.1 Introduction

The Manual contains the strategies and objectives used to manage the Dams during flood events. A basic understanding of the Manual is fundamental to understanding how flood events are managed. In particular, an understanding of how the following three matters in the Manual are interpreted is important:

- The application of Strategy W3.
- The application of Strategy W4.
- How the Manual requires the use of "the flow at Moggill".

Each of these three areas is discussed in separate sections below.

3.2 The application of Strategy W3

As stated on page 28 of the Manual, the primary consideration of Strategy W3 is protecting urban areas from inundation. In basic terms, when operating under Strategy W3, the structural safety of the Dam is not considered to be at risk because its lake level is less than EL 74.0m. Therefore, to flood urban areas and the habitable floors of family homes is not allowed when applying Strategy W3 in accordance with the strategy's primary consideration. Accordingly, no deliberate urban flooding is caused when operating under Strategy W3 and certainly, no deliberate flooding of the habitable floors of family homes is ever contemplated when operating under this strategy.

In practical terms, when operating under Strategy W3, controlled releases from Wivenhoe Dam are not allowed to contribute to the inundation of urban areas. This means that it is not acceptable for controlled releases from Wivenhoe Dam to contribute to a flow at Moggill that exceeds 4,000m^3/s when operating under Strategy W3. The figure of 4,000m^3/s at Moggill is used because the Manual defines this value to be the upper limit of non-damaging floods downstream of Moggill. The habitable floors of family homes would be flooded if flows at Moggill exceeded this threshold.

This correct interpretation of Strategy W3 is clearly stated on page 28 of the Manual:

> "The intent of Strategy W3 is to limit the flow in the Brisbane River at Moggill to less than 4,000m^3/s, noting that 4,000m^3/s at Moggill is the upper limit of non-damaging floods downstream."

Under Strategy W3, the Manual allows an upper outflow limit of 4,000m^3/s from Wivenhoe Dam. This is to allow for managing a possible flood event produced primarily by a rainfall system centred on the Stanley and/or Upper Brisbane Catchment areas, above the Dams. Under these circumstances, outflows from Lockyer Creek and the Bremer River into the Brisbane River would be minimal and could approach a zero value. Accordingly, outflows from Wivenhoe Dam could be increased to 4,000m^3/s, particularly to meet the drain down requirements of the Manual.

The reason why this option was provided in the Manual is best understood by considering a statement that is contained in both the January 2011 Flood Event Report and the Manual:

> "As it is not possible to provide a specific procedure for Dam operations during every possible flood event, the Manual takes the approach of providing objectives and strategies to guide operational decision-making during a flood event."

Accordingly, all flood event possibilities must be catered for in the Manual, including managing a flood event produced primarily by a rainfall system above the Dams, centred on the Stanley and/or Upper Brisbane Catchment areas.

Finally, it must be understood that Strategy W3 does not aim to protect urban areas by preventing Wivenhoe Dam from reaching the Strategy W4 trigger point. This is not how Strategy W3 is applied and it is not in accordance with the Manual. Certainly, the Manual does not list this as a consideration under Strategy W3.

3.3 The application of Strategy W4

There is no flexibility once Strategy W4 is engaged. If the Manual is not followed strictly upon the engagement of Strategy W4, the safety of Wivenhoe Dam will be put at risk of failure. The consequences of this would be devastating to the City of Brisbane and people living in the path of the flood wave such a failure would produce.

As shown through the following statements, the wording in the Manual, in regard to Strategy W4, is clear. These statements form the basis of Strategy W4:

- Protecting the structural safety of the Dam is the primary consideration once Strategy W4 is engaged.

- There are no restrictions on gate opening increments or gate opening frequency once Strategy W4 is engaged.

- Radial gate openings are to occur until the storage level of Wivenhoe Dam begins to fall.

As there are no other actions possible, there is no flexibility in the strategy.

The circumstances which allow Strategy W4 to be invoked in accordance with the Manual, must also be understood. Although the Manual states that Strategy W4 "normally comes into effect when the water level in Wivenhoe Dam reaches EL 74.0m AHD", the Manual also allows the Flood Engineers to initiate Strategy W4 if it is likely Wivenhoe Dam will reach EL 74.0m AHD.

Accordingly, it is important to understand that Strategy W4 cannot be invoked at any time during a flood event for any reason. Invoking Strategy W4 will result in the flooding of the habitable floors of homes downstream of Moggill. The only possible benefit of initiating Strategy W4 early is that, overall, there may be a small chance of slightly reducing the final flood peak. However, this approach involves a number of risks, and modelling undertaken in relation to the January 2011 Flood Event indicates that the early initiation of Strategy W4 would have **increased** the final flood peak.

Finally, it must be remembered that the primary reason for triggering Strategy W4 is to ensure that the safety of the Dams is not put at risk. It would not be in accordance with the intent of the Manual to trigger Strategy W4 in a situation where there was no risk to the safety of the Dams.

3.4 The Manual and "the flow at Moggill"

An understanding of how the flow at Moggill is interpreted in the Manual and used in flood event decision-making is important in understanding how flood events are managed. This section examines this issue.

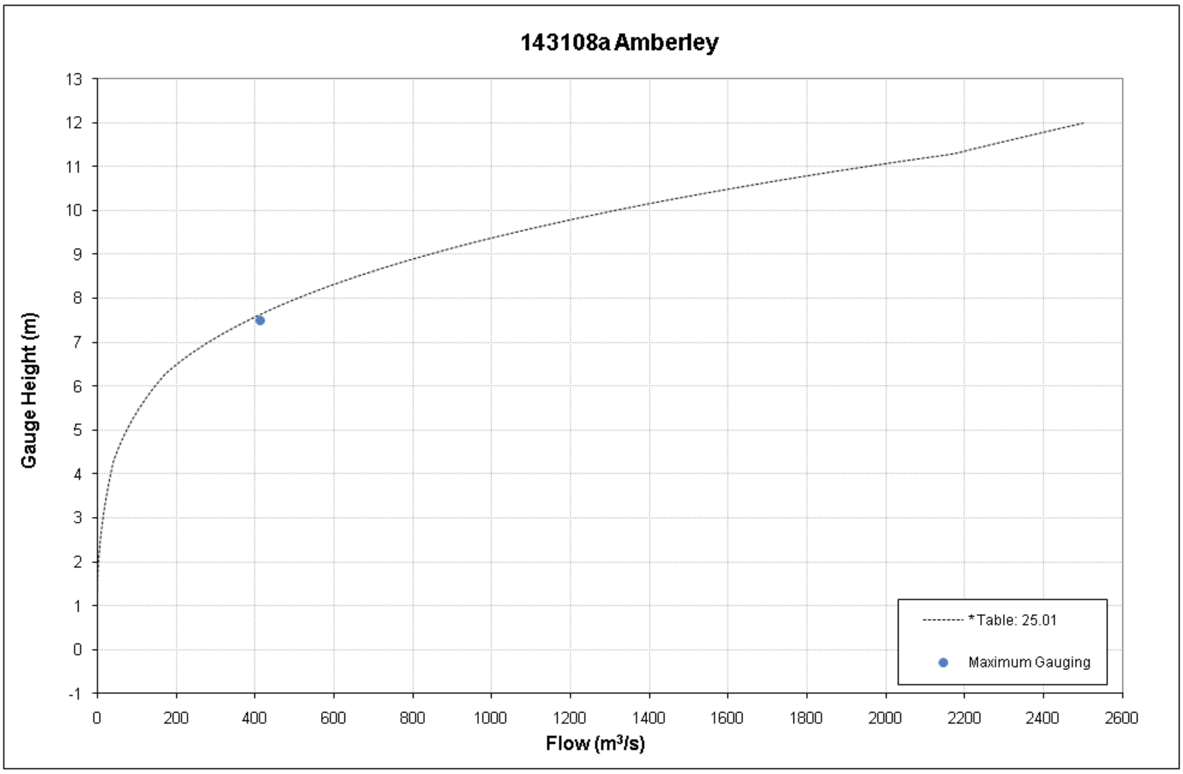
3.4.1 Background – height, flow and tidal impact

Flood flows in rivers are generally not measured directly and continuously in real time. Instead, a relationship between height and flow at gauging stations is established. This relationship is called a "Rating" and is demonstrated using a "Rating Curve" or "Rating Table" that is used to infer or estimate flow at a particular location from a recorded or observed height. The Rating forms the basis for modelling flows in river systems during flood events.

At gauging stations owned and operated by the Department of Environment and Resource Management (DERM), the Rating is based on regular flow measurements recorded by hydrographers. As flood flows are irregular, these flow measurements are usually taken at relatively low levels and flows. High-stage flow estimates are derived by extrapolating these measurements based on velocity, slope and the geometry of the river cross-section.

DERM do not operate gauging stations within catchment areas affected by tides. As such, there are no DERM gauging stations located below Mt Crosby on the Brisbane River, or below Amberley and Walloon in the Bremer Catchment.

A Rating's reliability is indicated by the ratio of the highest measured flow to the highest observed historical flow. In Queensland, this value is typically less than 25% indicating a high level of uncertainty associated with Queensland Ratings. A typical Rating Curve at a non-tidal station follows:



Ratings can also be complicated by flood plain behaviour at a gauging station. For example, at the DERM gauging station on Lockyer Creek at Rifle Range Road, flood flows by-pass the water level gauge, breaking out upstream of the gauge. The DERM Rating often reflects the flow passing the gauge and does not account for the by-pass. Therefore the Rating underestimates the total flood flow at the location.

During the rising limb of a flood, the estimated flow for a given height at a particular location is higher than the corresponding level on the falling limb. This effect is well-recognised by those in the hydrography profession, however it is often ignored as the impact is generally not significant.

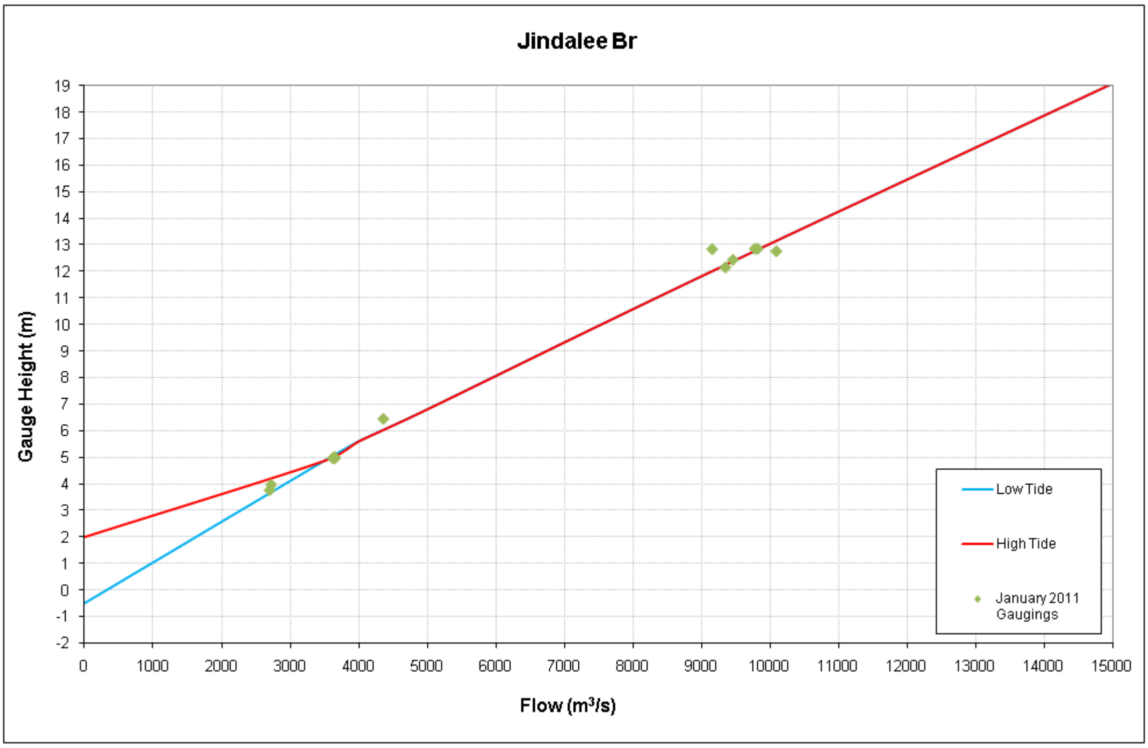
For flood monitoring and operational purposes, gauging stations are owned and operated by other agencies such as Seqwater, the BoM and local councils. These stations are often at locations which, by necessity, are tidally affected. Depending on the location, Ratings can be derived by inference from the nearest official DERM Rating or by model study.

In the Brisbane River below Mt Crosby (which is the upstream tidal limit) the impact of the tide is ‘drowned out’ as the flood flow and water level increases. This effect varies from location to location and can be clearly seen in the plots of recorded water level in Appendix Q of the January 2011 Flood Event Report. As the water level rises, the range of the daily tide reduces until it is finally drowned out by the developing flood. Consequently, there is no reflection of the daily tidal variation in the water level at higher stages of a flood event. The following table summarises the approximate limit of tide:

Location	**Approximate limit of tidal impact**	**Approximate estimated flow**
	m AHD	m^3/s
Moggill	4.0	2,000
Jindalee	5.0	3,500
Brisbane Port Office	6.0 – 7.0	>12,000

Above these estimated levels and flows, a stable usable Rating has been derived from decades of model studies by the BoM, Seqwater and the Brisbane City Council.

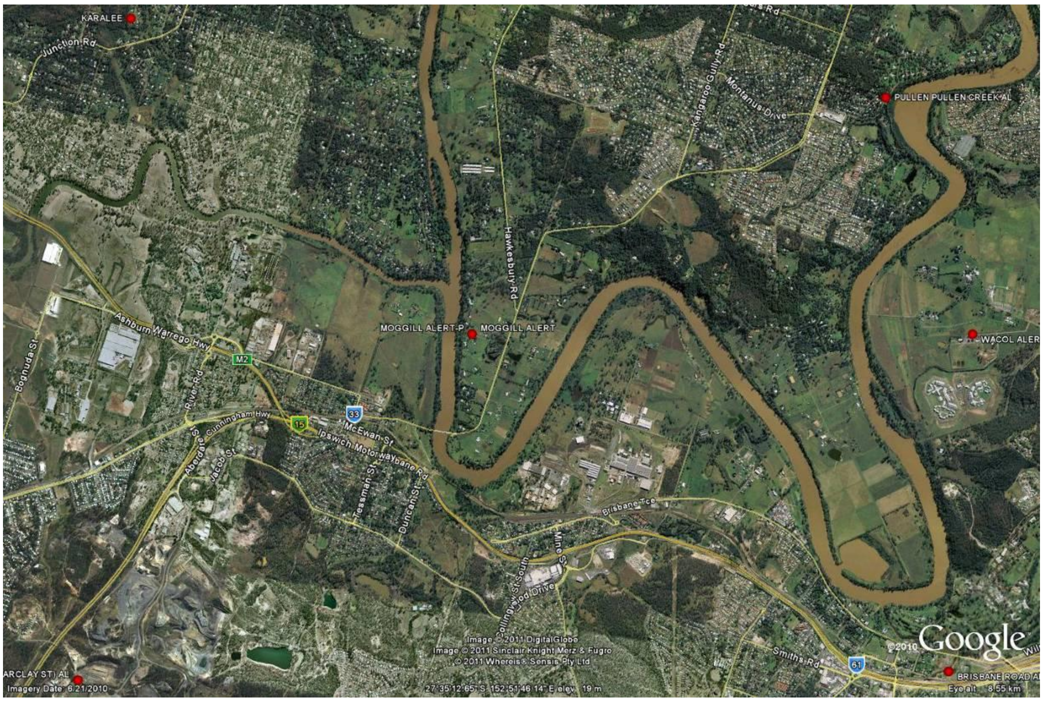
A typical Rating for a tidal station is shown below:



Note that for flows up to 3,500m^3/s, the water level is affected by the tide. However, above this flow, tides have little if any impact.

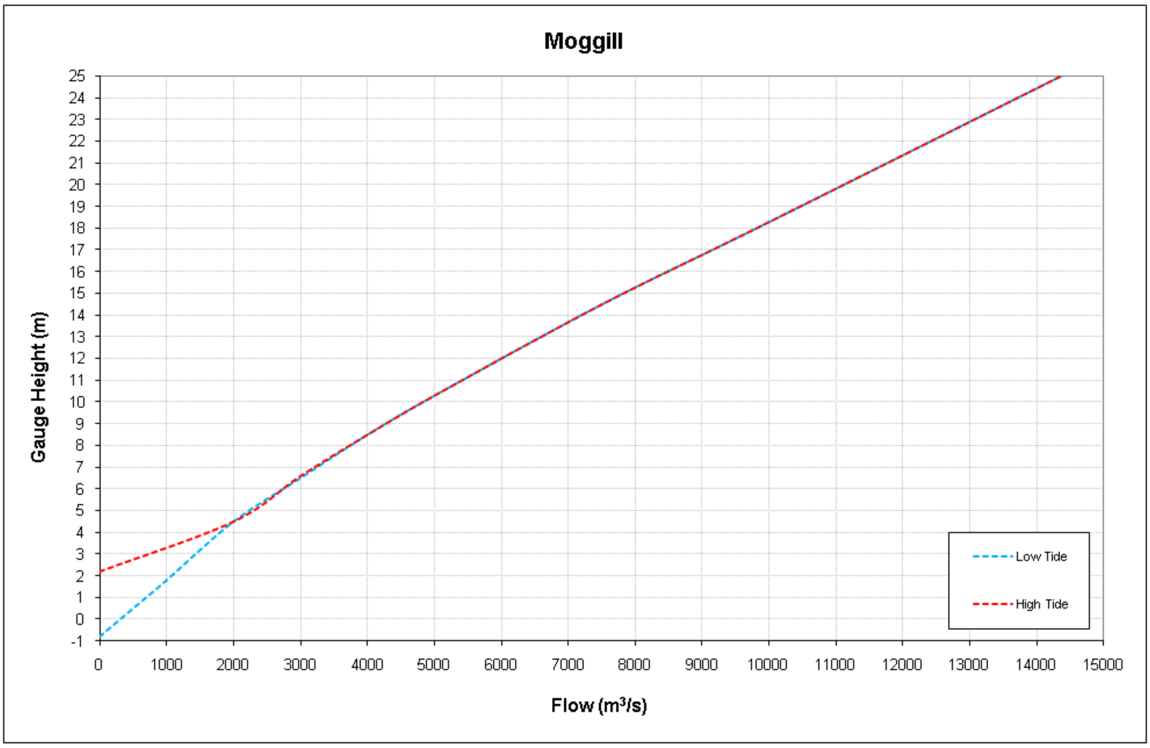
3.4.2 Determining the flow at Moggill

The Moggill gauge is located on the right bank immediately downstream of the junction of the Brisbane and Bremer River, as shown below. It is in the best possible location to represent the combined flow of the two river systems.



Model studies have shown there is little reduction of the peak flow rate in the lower Brisbane River downstream of Moggill. As the increase in catchment area is relatively small and there are no significant inflows downstream of Moggill, the peak flow rate at Jindalee and Brisbane Port Office is also very close to the peak flow rate at Moggill. Because of this, the estimation of flow at Moggill during flood events is critical to the assessment of Brisbane River flooding.

Below is the Rating for Moggill:



For practical purposes, the impact of the tide can be ignored for flows above 2,000m^3/s at Moggill. This is well below the accepted threshold of damaging floods of 4,000m^3/s as stated in the Manual.

3.4.3 How the flow at Moggill is used in the Manual

The flow at Moggill, as referred to in the Manual, means the best possible estimated flow at a location in the Brisbane River downstream of its junction with the Bremer River near Moggill, that can be made at any point in time during a flood event, based on the releases planned from Wivenhoe Dam.

Wivenhoe Dam releases generally take around 16 hours to reach Moggill, with similar travel times for Lockyer Creek flows however much less time for Bremer River flows. Therefore, the estimated flow at Moggill in 16 hours time will always contain uncertainties. These uncertainties include accounting for considerable rainfall that may fall between the Dam and Moggill in the 16 hours following the time of estimation, flows into the Brisbane River from Lockyer Creek and the Bremer River, and the release of water from Wivenhoe Dam.

Moggill was selected as the best possible reference point because it is a generally well-known location just downstream of where the Bremer River enters the Brisbane River. If the Manual was amended so the words "*immediately downstream of the location where the Bremer River enters the Brisbane River*" were replaced with the word "*Moggill*", the way the Manual is applied in practice would not change in any way.

As previously indicated, the Moggill gauge provides the best possible reference for the combined flows of the Brisbane and Bremer Rivers and is a good indicator of flood flows for the lower Brisbane River. However, if this station was destroyed during a flood event, it would not impact on how a flood event is managed or how the Manual is applied, particularly in relation to how the RTFM is run and used.

3.4.4 How the RTFM is calibrated during a flood event

During a flood event, the RTFM is calibrated by adjusting model parameters (such as losses) and comparing model results with recorded water levels and estimated flows obtained from gauging stations, to obtain the best possible fit. In the Brisbane River below Wivenhoe Dam, reliable non-tidal locations include Lowood, Savages Crossing and Mt Crosby Weir. Moggill and Jindalee are also appropriate stations for estimating flows as the tidal impacts are drowned out at relatively low levels and can be practically ignored.

If modelled heights and flows closely match the real time data obtained from these locations, the estimated flow derived from the RTFM model can be confidently assessed as the best available. Redundancy is provided in the network to allow adjacent gauges to be used to infer flows in the event of a station failure.

This best practice method of calibrating and validating flood forecasting models in real time is also used by the BoM. The BoM use this best practice method to derive river flood forecasts throughout Australia. There is no evidence that a better method exists.

Overall, it is accepted by the BoM and Seqwater that the best estimation of the flow at Moggill during a major flood event is obtained through hydrologic model validation and calibration using data from reliable stream height stations including Lowood, Savages Crossing, Mt Crosby Weir, Moggill and Jindalee. This is the approach that is described in the previous paragraphs, is used by both agencies, and is considered best practice.

3.4.5 Peak flow for the January 2011 Flood Event

During the January 2011 Flood Event, Jindalee river flow measurements were commissioned by the Flood Operations Centre and undertaken by a joint Seqwater/DERM team using the latest Acoustic Doppler Current Profiler (ADCP). The ADCP is the very best technology currently available. The actual measurements undertaken are summarised in the table below:

Date	**Start time**	**End time**	**Flow** m^3/s	**Area** m^2	**Mean velocity** m/s	**Average gauge height** m AHD
12/01/2011	11:01	11:19	9,343	3,317	2.82	12.13
12/01/2011	12:49	13:04	9,453	3,486	2.71	12.42
12/01/2011	15:40	16:07	10,085	3,679	2.74	12.74
12/01/2011	17:23	17:57	9,812	3,501	2.83	12.83
12/01/2011	18:05	18:34	9,151	3,383	2.69	12.82
12/01/2011	19:38	20:12	9,771	3,499	2.76	12.83

Date	Start time	End time	Flow m^3/s	Area m^2	Mean velocity m/s	Average gauge height m AHD
14/01/2011	11:35	12:19	4,364	2,214	1.97	6.45
16/01/2011	10:57	11:36	3,653	1,857	1.97	5.03
17/01/2011	10:36	11:29	3,660	2,016	1.82	4.98
17/01/2011	10:49	11:37	3,628	1,872	1.94	4.98
18/01/2011	9:40	10:27	2,732	1,855	1.52	3.98
18/01/2011	11:16	12:00	2,708	1,677	1.62	3.78

The measured flows at Jindalee at the peak of the Flood Event varied between 9,100m^3/s and 10,100m^3/s. This demonstrates that flows cannot be measured with certainty, even using the very best technology available. It also shows the error bound of actual measurements is plus or minus 10%. The average of the measured peak is 9,800m^3/s.

Seqwater's hydrologic model estimated a peak flow of 9,900m^3/s for the January 2011 Flood Event. This estimate is entirely consistent with the flow measurements taken at Jindalee and is within acceptable best practice error bounds of hydrologic and hydrodynamic modelling. When compared to Seqwater's model result, the error is only in the order of 1%. This is a direct endorsement of Seqwater's model and the modelling undertaken by the Flood Engineers during the January 2011 Flood Event.

4 MODELLING ISSUES

4.1 Introduction

Engineers and hydrologists use hydrologic and hydraulic models to estimate potential flood impacts and to determine, in hindsight, accurate estimations of flood flows associated with historic flood events. These methods are widely used and accepted by engineers and hydrologists, and the accuracy and reliability of these methods is well understood and generally universally accepted. The methods are best practice in the industry and there is no evidence that better methods exist. The modelling practices adopted by Seqwater's Flood Operations Centre are also consistent with the best practices recommended by Emergency Management Australia and Australian Rainfall and Run-off (Engineers Australia 1999).

4.2 Hydrologic models

Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. They simulate the runoff generation process by converting gross rainfall from point rainfall measurements to flows. Runoff estimated from rainfall at a particular point is routed to the outlet of a sub-catchment. At this point, the estimated hydrograph (plot of flow versus time) is combined with the estimated runoff from adjacent or downstream sub-catchments. This process continues to a gauging station where results are compared to the catchment outlet.

The hydrologic models utilised in the RTFM are WT42 models, supported by URBS models. The WT42 model, which is a generally accepted industry standard hydrologic model, was developed by DERM in the late 1980s and has been used extensively throughout Queensland since that time. The URBS model is based on the WT42 model and has been enhanced with additional features. The URBS model has been adopted nationally by the BoM for flood forecasting.

Each model is uniquely configured to represent a catchment based on area and stream lengths. The models are calibrated using historical event data to ensure they adequately represent how catchments respond to rainfall. As the models are relatively simple, they generally only take a few seconds to run.

During flood events, input rainfall is converted to flow and results are compared at gauging stations which report in real time. Model parameters can be readily adjusted to match the recorded response. Depending on the gauge location and the causative rainfall, hydrologic models can predict flows at gauging stations with lead times of a few hours to several days. Forecast lead times can be extended by including forecast rainfall but the accuracy of these extended lead times are subject to the uncertainty of the forecast rainfall.

4.3 Hydraulic or hydrodynamic models

Hydraulic or hydrodynamic models are used to estimate water level (height) using flow as the basic input. These models are physically based and rely on numerical solutions using the principles of the momentum and continuity.

In their simplest form, a Rating Curve or Rating Table, which is the relationship between height and flow at a particular location, can be used. Rating Curves can be linked to hydrologic models such as URBS to provide results in terms of heights and flows.

During real time, water level information is collected from the gauging stations. This is termed "recorded water level". Via the Rating, the flow is estimated at these locations.

For more complex situations or for locations other than gauging stations, a hydrodynamic model is required. These types of models require detailed information about the geometry of the river channel and its adjacent floodplain as well as information about structures such as bridges and weirs. They also require knowledge of the "roughness" of the river and its floodplain.

Depending on the complexity, these models can take from a few minutes to several days to run. The models require knowledge of the relative resistance or 'roughness' of the river and its floodplain. This is established through a calibration process. Calibration is carried out using flows estimated from hydrologic models as input. This process requires a great deal of expertise and can take several weeks. This highlights the difficulties in using a hydraulic or hydrodynamic model during the January 2011 Flood Event. To be used effectively during the later stages of the Flood Event, the model would have required calibration that would not have been possible in real time.

4.4 Modelling results for the January 2011 Flood Event

Section 7 of the January 2011 Flood Event Report details the hydrologic models used in the RTFM. Appendix S of the same Report contains results of the model runs at selected times throughout the Flood Event. All model runs have been provided to the Commission for examination.

Table 7.2.2 in Section 7 of the Flood Event Report outlines the WT42 models used during the Flood Event. For each model, the modelled results at the outlet (which is generally where a gauging station is located) were compared with the recorded heights and estimated flows at these locations. There were more than 20 locations within the Brisbane Basin where modelled results were compared with recorded results in real time.

Appendix S of the Flood Event Report contains the results of simulations for selected key locations at:

- Stanley River at Woodford
- Somerset Dam inflow
- Brisbane River at Gregors Creek

- Lockyer Creek at Lyons Bridge
- Bremer River at Walloon
- Warrill Creek at Amberley
- Wivenhoe Dam inflow.

Due to time and space limitations at the time of preparation, model results were not included in the Flood Event Report for every location or for every model run.

4.5 Lockyer Creek and Bremer River model reliability

The reliability of the Lockyer Creek and Bremer River models in the RTFM are tested in real time during flood events using a process of validation and calibration.

The Lockyer Creek model is calibrated in real time at Helidon, Tenthill Creek, Showground Weir, Glenore Grove, Lyons Bridge and O'Reillys Weir. It is acknowledged there are problems associated with some of the stations in the lower Lockyer, due to break outs and /or by-passes at Glenore Grove and Lyons Bridge, and backwater impacts from the Brisbane River at O'Reilly's Weir. However, this calibration process in real time represents the best possible water level and flow estimation information that can be obtained from the catchment during floods.

The Bremer River model is calibrated in real time to gauges at Adams Bridge, Rosewood and Walloon. The Warrill Creek model is calibrated in real time to gauges at Kalbar, Harrisville and Amberley. The Purga Creek model is calibrated in real time to a gauge at Loamside. The combined catchment area of these models represents nearly 95% of the catchment area to Ipswich, and represents the best possible water level and flow estimation information that can be obtained from the catchment during floods.

5 THE USE OF QUANTITATIVE RAINFALL FORECASTS

5.1 Background

As outlined in Section 2 of this report and Section 6 of the Flood Event Report, the Flood Engineers consider and use qualitative and quantitative rainfall forecast information supplied by the BoM when making operational decisions during flood events. This section of the report explains how quantitative forecasts were used in decision-making during the January 2011 Flood Event. Although the BoM advised that due to the inaccuracy of these forecasts they should not be used as the basis for flood operation decision-making, they still provide useful information that is considered and used by the Flood Engineers when making decisions.

A product titled “QPF”, which means Quantitative Precipitation Forecast, is the most accurate product the BoM can provide as a quantitative rainfall forecast for the Dam catchment areas. The QPF is issued twice daily, generally at around 10:00am and 4:00pm, and provides an estimate of the predicted catchment average rainfall for the Dams. No predictions in relation to either rainfall intensity or distribution are provided within the QPF. However, the QPF is considered the primary forecast tool as it is the only product available from the BoM that gives considered and specific forecast information for the Dam catchment areas.

5.2 Lake level and stream flow predictions

During the January 2011 Flood Event, QPFs were used to provide lake level predictions. A selection of these predictions is contained in Appendix A of the Flood Event Report. The existence of the QPFs allowed the following predictions to be made (a requirement of the Manual, page 22, Section 8.4), using the best forecast rainfall and stream flow information available at the time:

- Maximum storage levels in Wivenhoe and Somerset Dams.
- Peak flow rate at the Lowood gauge (excluding Wivenhoe Dam releases).
- Peak flow rate at the Moggill gauge (excluding Wivenhoe Dam releases).

5.3 Using lake level predictions generated from forecast rainfall information to select operating strategy

As explained in evidence before the Commission, scaled up QPFs were often included in the modelling process. This occurred because at critical times during the event, forecasts for the next 24 hours were being exceeded by actual rainfall within a matter of a few hours.

Accordingly, to examine this issue properly, lake level predictions using actual rather than “scaled up” QPFs must be considered. In this regard, a table in the Flood Event Report that shows lake level predictions for Wivenhoe Dam containing values greater than EL 74.0m, follows. As many of the lake level predictions in the Flood Event Report are based on "scaled up" QPFs, the following table also contains lake level predictions based on actual QPFs.

Date and time	Run	Lower bound and upper bound 24 hour QPF (mm)	Average 24 hour QPF (mm)	Catchment average rainfall since QPF issued (mm)	Scaling Factor used on average QPF after accounting for rain recorded in the forecast period as contained in the Flood Event Report	Wivenhoe lake level prediction shown in the Flood Event Report using "scaled up" QPF (m AHD)	Wivenhoe lake level prediction using actual lower bound QPF (m AHD)	Wivenhoe lake level prediction using actual upper bound QPF (m AHD)
Before 09/01/2011 20:00	1-21	-	-	-	-	-	<74.0	<74.0
Sun 09/01/2011 20:00	22	50 – 80	65	54	206%	74.1	72.7	72.7
Mon 10/01/2011 01:00	23	50 - 80	65	71	232%	74.7	72.9	73.0
Mon 10/01/2011 03:00	24	50 - 80	65	72	234%	74.8	73.0	73.0
Mon 10/01/2011 04:00	25	50 - 80	65	73	235%	74.5	72.8	72.8
Mon 10/01/2011 09:00	26	50 - 80	65	82	249%	74.5	72.9	72.9
Mon 10/01/2011 12:00	27	50 - 100	75	16	155%	75.6	73.7	75.1
Mon 10/01/2011 15:00	28	50 - 100	75	30	147%	75.2	73.7	75.0
Mon 10/01/2011 16:00	29	25 - 50	38	0	263%	75.7	73.9	74.4
Mon 10/01/2011 17:00	30	25 - 50	38	0	132%	74.6	74.0	74.6
Mon 10/01/2011 20:00	31	25 - 50	38	4	142%	74.3	73.7	74.2
Tue 11/01/2011 00:00	32	25 - 50	38	21	187%	74.1	73.5	73.8
Tue 11/01/2011 02:00	33	25 - 50	38	36	226%	74.6	73.9	74.2
Tue 11/01/2011 03:00	34	25 - 50	38	40	237%	74.8	74.0	74.1
Tue 11/01/2011 04:00	35	25 - 50	38	48	258%	74.9	74.1	74.2
Tue 11/01/2011 07:00	36	25 - 50	38	78	337%	76.2	74.3	74.3
After 11/01/2011 07:00	-	-	-	-	-	-	>74.0	>74.0

In practice, not all of the QPF upper and lower bound model runs were explicitly completed during the Event, although the results of these model runs could be inferred from other modelling results. Examples of these derivations are as follows:

- Between 20:00 on Sunday 9 January (Run 22) and 09:00 on Monday 10 January (Run 26), the rainfall associated with the majority of the upper bound 24 hour QPF issued at 16:00 on Sunday 9 January, had already fallen. Accordingly, after accounting for continuing loss rates (in the order of 0.5mm/hour to 1.0mm/hour), it was clear that model results using the actual upper bound QPF during this period would provide a generally identical result to the "without forecast" model results. This is demonstrated in the table above.

- Between 12:00 on Monday 10 January (Run 27) and 15:00 on Monday 10 January (Run 28), an average of the lower and upper bound QPF issued at 10:00 on Monday 10 January, combined with rain already experienced in the forecast period, was used as an input to the Flood-OPS model. Because these model runs account for rainfall on the ground, these results generally provide a reasonable estimate of the upper bound result and are also useful for planning purposes. This is demonstrated in the above table. This approach is considered particularly valid for the 24 hour QPF issued at 10:00, which only remains current for 6 hours as an updated QPF is issued at 16:00.

- Because model runs were confirming steady state continuing loss rates in the order of 0.5mm/hour to 1mm/hour, it was clear that model runs using forecasts of 25 millimetres over 24 hours would produce a very similar result to the "without forecast" model runs. This is demonstrated in the results for lower Run 29 to Run 36 shown in the above table.

The table above shows that during the January 2011 Flood Event, the very first time a model run using the actual lower bound 24 hour QPFs predicted Wivenhoe Dam's lake level was likely to exceed 74.0m, was at 4:00am on Tuesday 11 January. Any suggestion that QPFs indicated Wivenhoe Dam's lake level was <u>likely</u> to exceed 74.0m before this time is incorrect.

The following table explains how the QPFs and other rainfall forecast information provided by the BoM were used to make judgements to determine if the Wivenhoe Dam lake level was likely to exceed EL 74.0m during the January 2011 Flood Event.

Date and time	**Wivenhoe lake level prediction using actual lower bound QPF (m AHD)**	**Wivenhoe lake level Prediction using actual upper bound QPF (m AHD)**	**Forecast rainfall considerations associated with judging:** **"Is Wivenhoe Dam's lake level likely to exceed EL 74.0m AHD?" as stated on page 23 of the Manual.**
Prior to 10:00 on Monday 10 January 2011	<74.0	<74.0	The QPFs issued prior to 10:00 on Monday 10/01/2011 were not high enough to indicate that the Wivenhoe Dam's lake level was likely to exceed EL 74.0m AHD. However, as explained in the Flood Event Report, the QPFs issued on Sunday 9 January significantly underestimated rainfall.
Between 10:00 on Monday 10 January 2011 and 16:00 on Monday 10 January 2011	<74.0	>74.0	The lower bound QPF issued at 10:00 on Monday 10/01/2011 (50mm in the next 24 hours) was <u>not</u> high enough to indicate that the Wivenhoe Dam's lake level was likely to exceed EL 74.0m AHD. The upper bound QPF issued at 10:00 on Monday 10/01/2011 (100mm in the next 24 hours) was high enough to indicate that the Wivenhoe Dam's lake level was likely to exceed EL 74.0m AHD. The rainfall system was forecast to be moving south and clear of the Dam catchments. Accordingly, increasing releases during this period, combined with a forecast southward moving rainfall system, had the potential to significantly increase urban flooding below Moggill. Additionally, the forecast southward movement of the rainfall system was expected to show a significantly reduced QPF when issued at 16:00. Accordingly a zero weight was assigned to the upper bound forecast and it was judged possible, but not likely, that Wivenhoe Dam's lake level would exceed EL 74.0m AHD as a result of the QPF issued at 10:00 on Monday 10 January. The QPF issued at 16:00 would be examined closely.

Date and time	Wivenhoe lake level prediction using actual lower bound QPF (m AHD)	Wivenhoe lake level Prediction using actual upper bound QPF (m AHD)	Forecast rainfall considerations associated with judging: "Is Wivenhoe Dam's lake level likely to exceed EL 74.0m AHD?" as stated on page 23 of the Manual.
Between 16:00 on Monday 10 January 2011 and 04:00 on Tuesday 11 January 2011	<74.0	>74.0	As expected, the QPF issued at 16:00 showed a significantly reduced rainfall forecast of between 25mm to 50mm for the next 24 hours, when compared to the previous forecast of 50mm to 100mm. This QPF reinforced the qualitative forecast indications that the rainfall system was moving south and clear of the Dam catchments. Accordingly, increasing releases during this period, combined with a forecast southward moving rainfall system, had the potential to worsen urban flooding below Moggill. The flash flooding experienced in the Lockyer catchment and the potential adverse impacts of increasing releases to combine with these flows was also a consideration during this period. The lower bound QPF issued at 16:00 on Monday 10/01/2011 (25mm in the next 24 hours) was not high enough to indicate that the Wivenhoe Dam's lake level was likely to exceed EL 74.0m AHD. The upper bound QPF issued at 10:00 on Monday 10/01/2011 (50mm in the next 24 hours) was high enough to indicate that the Wivenhoe Dam's lake level could exceed EL 74.0m AHD. The continued forecast southward movement of the rainfall system indicated that the rainfall could move clear of the dam catchments on Tuesday 11 January. Accordingly a zero weight was assigned to the upper bound forecast and it was judged possible, but not likely, that Wivenhoe Dam's lake level would exceed EL 74.0m AHD as a result of the QPF issued at 16:00 on Monday 10 January 2011.
Between 04:00 on Tuesday 11 January 2011 and 07:00 on Tuesday 11 January 2011	>74.0	>74.0	It became clear during this period that the QPF issued at 16:00 on Monday 10 January 2011 was incorrect and had greatly underestimated rainfall. Accordingly, during this period, it was judged likely that Wivenhoe Dam's lake level would exceed EL 74.0m AHD. The transition to Strategy W4 occurred at the end of this period after the Flood Engineers investigated all other possible options, discussed updated forecast information with the BoM and were certain the Dam's lake level would exceed EL 74.0m AHD. Transitioning to Strategy W4 at the beginning of this period would not have altered the outcome of the flood.
After 07:00 on Tuesday 11 January 2011	>74.0	>74.0	It was clear Wivenhoe Dam's lake levels would exceed EL 74.0m AHD during this period and Strategy W4 was invoked.

In summary, the table above demonstrates how the best available forecast rainfall information provided by the BoM was used to consider lake level predictions during the January 2011 Flood Event in accordance with the Manual.

6 OTHER ISSUES FOR CLARIFICATION

Following are some additional issues for clarification that may help in developing a full understanding of the January 2011 Flood Event.

6.1 Closely spaced floods and the January 2011 Flood Event

Comparisons have been made between the January 2011 Flood Event and the closely spaced floods referred to in the Manual. The closely spaced floods referred to in the Manual are two separate and distinct flood events resulting from separate and distinct weather systems. They are characterised by a clear interval of approximately seven days between the peak of the first flood event and the onset of the second flood event. The characteristics of the January 2011 Flood Event are entirely different, as explained below:

- The January 2011 Flood Event was an individual flood event, not two separate flood events.

- The January 2011 Flood Event was caused by a single weather system, not two separate weather systems.

- The January 2011 Flood Event was categorised by a dual peaked hydrograph, with a time interval between the hydrograph peaks of 29 hours. It did not have a clear interval between peaks of approximately seven days.

Additionally, there has never been a flood event similar to the January 2011 Flood Event recorded in the Brisbane Basin.

6.2 Role of Seqwater

It is important Seqwater's role in the January 2011 Flood Event be clearly understood. In particular, the following should be noted:

- Seqwater is responsible for operating Wivenhoe Dam and Somerset Dam during flood events in accordance with the Manual.

- Seqwater is not required to provide flood warnings directly to the public. This is the responsibility of other agencies.

- Seqwater is not responsible for predicting water levels along the Brisbane River, Bremer River or Lockyer Creek. Seqwater is only responsible for estimating flood flow, not flood height information. The estimation of flood height information is the responsibility of other agencies.

- Seqwater is not responsible for defining areas that would be impacted by flooding. This is the responsibility of other agencies.

6.3 Use of a hydrodynamic model

It is not essential to use a hydrodynamic model to operate Somerset and Wivenhoe Dams during flood events.

As described in Section 4 of this report, hydrodynamic models are used to estimate flood heights using flood flows derived from hydrologic models. In this context, hydrodynamic models generally do not generate flows directly from rainfall, however, they are dependent on flows estimated using hydrologic models. Thus the accuracy of hydrodynamic modelling is highly dependent upon the accuracy of the input flows.

As explained in Section 6.2 of this report, Seqwater does not estimate flood heights during flood events as this is the responsibility of other agencies. Seqwater assesses risks and consequences of dam operations by combining dam releases with flood flows from other parts of the catchment. These are estimated using hydrologic models. The potential flood damages of these combined flows are determined using Flood Damage Tables which are derived by other responsible agencies. The Flood Damage Tables are based on flow, not height.

The hydrodynamic models applied during the January 2011 Flood Event were calibrated to the 1974 flood event, which was understood to have a peak flow rate of approximately 10,000m^3/s. Gaugings undertaken during the January 2011 Flood Event using modern technology, showed the flow rate of the 1974 flood event was potentially much higher than previously understood. This fact has also been independently verified since the January 2011 Flood Event. However, even if a working and fully calibrated hydrodynamic model was available, its use would not have impacted the management of Dam releases during the January 2011 Flood Event.

Overall, the major consideration in operating the Dams during flood events is the accurate estimation of flow rates and volumes at any singular point in time. These estimations are best determined in real time using appropriately configured and calibrated hydrologic models.

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