Brisbane River Catchment Flood Study: Comprehensive Hydrologic Assessment

Hydrologic Model Recalibration Report

Prepared for the State of Queensland (acting through): Department of State Development, Infrastructure and Planning/Department of Natural Resources and Mines

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Aurecon team

The Aurecon Team consists of Aurecon as lead consultant, supported by Deltares, Royal HaskoningDHV, and Don Carroll Project Management and Hydrobiology.

Contents

Appendices

Figures

Tables

1 Introduction

The purpose of the Brisbane River Catchment Flood Study is to provide an up-to-date, consistent, robust and agreed set of methodologies and flood estimates for various locations within the Brisbane River catchment. The outputs of the hydrology phase of the study include estimated flood flows and volumes, discharge hydrographs and associated uncertainties. These outputs will subsequently be used as inputs to the hydraulic modelling phase of the study to determine flood levels, extent and velocity estimates and associated flood maps for the purpose of floodplain planning and risk management.

Hydrologic modelling techniques are being utilised to estimate design flood flows and volumes using both the standard design event approach as outlined by Australian Rainfall and Runoff (ARR) (EA, 2003) and also as part of a Monte Carlo simulation framework.

As part of the Comprehensive Hydrology Assessment for the Brisbane River Catchment Flood Study (BRCFS), a review of the URBS model developed by Seqwater for the Wivenhoe and Somerset Dams Optimisation Study (WSDOS) was undertaken. A review of the rating curves generated by Seqwater, DNRM, BoM and other sources was also undertaken.

These reviews were required as the purposes for the hydrologic modelling in the WSDOS study and the current investigation are different. The following differences in the objectives for the BRCFS Hydrology Study are present:

- Greater emphasis on the range of floods beyond the observed and 'measured' range, including design and synthetic floods up to the Probable Maximum Flood (in excess of current Wivenhoe Dam capacity), thus it is important to include the extrapolation of the revised rating curves
- Improved representation of the key flood production characteristics of the different sub-catchments for estimation of design floods over the broader range of flood magnitudes
- Ensuring consistency of modelling assumptions with ARR recommendations for modelling of extreme events

A combination of the outcomes from these reviews defined the modifications required to the Seqwater URBS model for use in the BRCFS. These modifications call for a recalibration of the URBS model to ensure that its application covers the range of events required by the BRCFS study, (50% AEP up to the Probable Maximum Flood). The calibration process has therefore been implemented to establish a single set of model parameters that achieve a reasonable calibration across a wide range of flood event types and magnitudes. It is acknowledged that slightly improved performance statistics for any individual event could be achieved by adjusting the parameters for each event.

This report presents the recalibration of the URBS model, incorporating the changes recommended by these two review processes. This report should be read in conjunction with the following reports:

- *Hydrologic Model Calibration and Validation Review Report*, Aurecon Team, April 2014
- *Data, Rating Curve and Historical Flood Review Report*, Aurecon Team March 2014
- *Brisbane River Flood Hydrology Models Main Report*, Seqwater December 2013
- *Brisbane River Flood Hydrology Models Appendices*, Seqwater December 2013

This report also represents the second pass recalibration efforts, following first pass recalibration and receipt of comments from the IPE and Seqwater (as included in Appendix C).

1.1 URBS model review

The URBS model review assessed the modifications required to the URBS model to ensure that it is fit for purpose in deriving design flood estimates for the Brisbane River Catchment Flood Study (BRCFS). A summary of the outcomes of the URBS model review, as presented in the report titled *Hydrologic Model Calibration and Validation Review Report* is as follows:

1. Remove the Kedron Brook catchment from the Brisbane River catchment area in the Lower Brisbane model
2. Adopt the inclusion of: impervious fractions to represent increased runoff volume in urban areas; urbanised areas to represent reduced response times; and reduced reach length factors for heavily modified reaches in the Lower Brisbane model
3. Adopt changes to the channel routing parameters for the following sub-catchment models:

   Lockyer Creek to O'Reillys Weir – n = 0.85

   Purga Creek to Loamside – n = 0.85

   Bremer River to Walloon – n = 0.85
4. Reject amendments to conceptual storages based upon BCC DMT hydraulic model, but modify the adopted relationships by reducing the storage for flows above 10,000 m^3/s. Do not change the representation of the online conceptual storages as doing so introduces greater complexity that is not warranted
5. Reject the suggested change of including a diminishing CL rate by introducing a maximum soil storage infiltration capacity. This adds further complexity without necessarily producing a better model calibration
6. Maintain the linear base flow model as the introduction of a non-linear base flow model does not change the model calibration performance significantly. Introduce a Base flow Volume Factor to cap the base flow based upon the findings of the AR&R Project 7 Stage 2 Final Report

What was also clearly identified in the review was the need for channel routing and conceptual storage parameters to be reassessed during the hydraulic modelling phase of the BRCFS. This means that a further iteration of calibration will need to occur once a fully calibrated hydraulic model of the Lower Brisbane River becomes available.

1.2 Rating curve review

A detailed review of the existing rating curves generated by Seqwater, DNRM, BoM and other sources was undertaken and recommendations were made as to the rating curves to be adopted for the BCRFS Hydrology. The recommendations, as presented in the *Data, Rating Curve and Historical Flood Review Report*, are summarised in Table 1-1 and Table 1-2.

Table 1-1 Summary of primary gauge rating recommendations

Gauge description	Recommended rating description
Catchment: Stanley River to Somerset **Stream:** Stanley River **Site:** Woodford **Gauge No:** 143901A **Owner:** DNRM	Power-law fit of data up to 2.5m then hydraulic model results Flows below 20m³/s weir controlled and dependent on local Stanley River flows only. Flows above 50m³/s dependent on combined flows from Stanley River (at gauge) and downstream tributary. Rating provides a good fit of revised hydrologic model results, however could be unreliable if flow distribution varies significantly from the ratio assumed by the hydraulic modelling
Catchment: Brisbane River to Wivenhoe **Stream:** Brisbane River **Site:** Linville **Gauge No:** 143007A **Owner:** DNRM	Power-law fit of data up to 2.7m then hydraulic model results Site is considered a good gauge location. Flow gauging and hydrologic model data are consistent and high flows are well contained. Rating provides a good fit of flow gaugings and hydrologic model data
Catchment: Lockyer Creek to O'Reilly's Weir **Stream:** Lockyer Creek **Site:** Glenore Grove **Gauge No:** 143807 **Owner:** BoM	Power-law fit of data up to 2.5m then hydraulic model results Rating is considered to be good up to around 13m (900m³/s) with generally good fit of flows (translated from Lyons Bridge) and hydrologic model data. Generally good agreement above this level and rating is considered reasonable, but becomes very sensitive to changes in level
Catchment: Bremer River to Walloon **Stream:** Bremer River **Site:** Walloon **Gauge No:** 143107A **Owner:** DNRM	DNRM rating up to 5m then hydraulic model results Generally good fit of flow gaugings and hydrologic model data up to about 9m. Rating becomes fairly sensitive at high flows and potentially affected by backwater from major Brisbane River/Warrill Creek floods due to 'choke point' that forms in the reach downstream of the Warrill Creek confluence
Catchment: Warrill Creek to Amberley **Stream:** Warrill Creek **Site:** Amberley **Gauge No:** 143108A **Owner:** DNRM	Power-law fit of data up to 5m then hydraulic model results Good fit of flow gaugings. Deviates significantly from Seqwater rating above 8m due to breakout of flows upstream of gauge location. Rating is considered to be good, but becomes very sensitive to changes in level above 10m (1200m³/s)
Catchment: Purga Creek to Loamside **Stream:** Purga Creek **Site:** Loamside **Gauge No:** 143113A **Owner:** DNRM	DNRM rating up to 6m then hydraulic model results Generally good fit of flow gaugings and hydrologic model data. Rating is considered to be reasonable, but becomes very sensitive to changes in level above 7.5m (170m³/s)
Catchment: Lower Brisbane River **Stream:** Brisbane River **Site:** Mt Crosby Weir **Gauge No:** 430003A **Owner:** Seqwater	Rating updated based on review of gaugings, steady-state release flows and DMT TUFLOW model results Gauge location is considered to be reasonable with well-defined weir crest and relatively confined channel. Rating provides generally good fit of flow gauging, steady flow release and most hydrologic data, although it is noted that a number of the hydrologic model results deviate significantly from the rating Importantly, the rating is considered relatively unreliable between around 1,200 and 2,000m³/s. Interference of the bridge is considered a likely cause

Gauge description		Recommended rating description
Catchment: **Stream:** **Site:** **Gauge No:** **Owner:**	Lower Brisbane River Brisbane River Centenary Bridge 43982 BoM	Rating updated based on review of gaugings, steady-state release flows and DMT TUFLOW model results Rating provides generally good fit of flow gauging, steady flow release and hydrologic data. Rating is considered to be reasonable, with a fairly well contained site and flow gauging up to high flows (10,000m³/s). However, site is subject to significant dynamic effects, meaning that there is not a direct relationship between flow and level

Table 1-2 Summary of secondary gauge rating recommendations

Gauge description		Recommended rating description
Catchment: **Stream:** **Site:** **Gauge No:** **Owner:**	Stanley River to Somerset Stanley River Peachester 143303A DNRM	3-stage best-fit of flow gauging and hydrologic model data Reasonable match of flow gauging and hydrologic model data below 6m. Gauge becomes sensitive to changes in level above 7m with limited reliable data available for calibration. Hydrologic model data shows noticeable scatter but consistent general trend
Catchment: **Stream:** **Site:** **Gauge No:** **Owner:**	Stanley River to Somerset Kilcoy Creek Mt Kilcoy 143312A DNRM	Seqwater Rating based on two-stage best-fit of flow gauging and hydrologic model data Reasonable match of flow gauging data up to 5.5m. Upper rating is based solely on hydrologic model data and significant scatter is observed in the results above 5m. Upper rating is also very sensitive to changes in level. Upper rating is therefore considered to be unreliable but of fairly low importance overall
Catchment: **Stream:** **Site:** **Gauge No:** **Owner:**	Brisbane River to Wivenhoe Brisbane River Gregors Creek 143009A DNRM	3-stage best-fit of flow gauging and hydrologic model data Good agreement with DNRM HEC-RAS model although details of model are not confirmed. Reasonable match of flow gauging data up to 9m and hydrologic model data above that level, however noticeable scatter is evident in the low level flow gauging data. Site is well confined but known to have issues with changes to section and sand extraction downstream. The rating is considered to be reasonable, but not necessarily consistent
Catchment: **Stream:** **Site:** **Gauge No:** **Owner:**	Lockyer Creek to O'Reilly's Weir Lockyer Creek Gatton 143904 BoM	3-stage best-fit of flow gauging and hydrologic model data Reasonable agreement with Seqwater rating. Flow measurements translated from Middle Creek gauge site to improve shape of low-flow rating. Gauge site has been closed since construction of Wivenhoe Dam
Catchment: **Stream:** **Site:** **Gauge No:** **Owner:**	Brisbane River to Wivenhoe Brisbane River Caboonbah 143900 BoM	3-stage best-fit of flow gauging and hydrologic model data Rating based on flow gauging up to 2,600 m³/s and is considered to be good within this range. Little data available for validation of rating above this range but few recorded higher levels and gauge site has been closed since construction of Wivenhoe Dam

Gauge description		Recommended rating description
Catchment:	Brisbane River to Wivenhoe	3-stage best-fit of flow gauging and hydrologic model data Rating shows similar trend to Seqwater rating based on hydrologic model data and independent SKM hydraulic model, however consistency of this model to BRCFS hydrology not confirmed. Rating was adjusted to improve better match of hydrologic model results and improve consistency with downstream flows at Glenore Grove and Rifle Range Road No flow gauging data is available for comparison. Gauge location is well confined and should provide reasonable rating conditions up to bank-full condition, but is not rated above 16m (2700m³/s)
Stream:	Brisbane River	
Site:	Middle Creek	
Gauge No:	143008A	
Owner:	DNRM	
Catchment:	Lockyer Creek to O'Reilly's Weir	Seqwater rating Relatively close proximity to Gatton gauge. Very limited low-level flow gauging and limited hydrologic model data due to short gauge record. Gauge location is well confined and should provide reasonable rating conditions up to bank-full condition, but is not rated above 17m (2700m³/s)
Stream:	Lockyer Creek	
Site:	Gatton Weir	
Gauge No:	143236A	
Owner:	Seqwater	
Catchment:	Lockyer Creek to O'Reilly's Weir	3-stage best-fit of flow gauging and hydrologic model data Reasonable agreement with DNRM and Seqwater ratings. Stream flow gauging only available for low flows. Significant scatter in hydrologic model data as model calibration weighted heavily towards the Glenore Grove site which has six times the catchment area. Rating is considered to have limited reliability
Stream:	Lockyer Creek	
Site:	Helidon	
Gauge No:	143203C	
Owner:	BoM	
Catchment:	Lockyer Creek to O'Reilly's Weir	DNRM Rating Good agreement with flow gauging up to 7.6m so considered to be a relatively reliable rating, however rating becomes sensitive to changes in level above 5m
Stream:	Laidley Creek	
Site:	Warrego Hwy	
Gauge No:	143904	
Owner:	BoM	
Catchment:	Lockyer Creek to O'Reilly's Weir	Power law best-fit of flow gauging and hydrologic model data Reasonable fit of flow gauging data up to 15.85m (830m³/s). Perched channel in wide floodplain with unreliable and potentially inconsistent response above bank-full capacity. Rating should not be used above bank-full (15.5m approx)
Stream:	Lockyer Creek	
Site:	Rifle Range Rd	
Gauge No:	143229A	
Owner:	DNRM	
Catchment:	Bremer River to Walloon	DNRM Rating (Seqwater rating very similar) up to 4.4m gauge height then power law best-fit of hydrologic model data Good fit of flow gauging up to 4.3m. Basis of projection above this level unknown and appears to predict higher levels/lower flows than Seqwater hydrologic model results. Rating becomes sensitive to changes in level above 4m
Stream:	Bremer River	
Site:	Adams Bridge	
Gauge No:	143110A	
Owner:	DNRM	
Catchment:	Bremer River to Walloon	Best-fit of hydrologic model data Reasonable agreement with hydrologic model data but no independent confirmation data available. Poor detail below 4.5m. Higher emphasis should be placed on Walloon gauge rating
Stream:	Bremer River	
Site:	Rosewood	
Gauge No:	143909	
Owner:	BoM	

Gauge description		Recommended rating description
Catchment:	Warrill Creek to Amberley	Seqwater rating Based on hydraulic model up to around 200m³/s. Reportedly very low reliability above this but shows reasonable match of the limited hydrologic model data available
Stream:	Warrill Creek	
Site:	Junction Weir	
Gauge No:	143118	
Owner:	Seqwater	
Catchment:	Purga Creek to Loamside	Best fit of hydrologic model data only Limited record length and no independent data. Generally low confidence in gauge rating magnitude
Stream:	Purga Creek	
Site:	Peak Crossing	
Gauge No:	143869	
Owner:	Seqwater	
Catchment:	Lower Brisbane River	Rating updated based on review of gaugings, steady-state release flows and DMT TUFLOW model results Rating provides reasonable fit of flow gauging, steady flow release and hydrologic model data. Well contained site but believed to be subject to changes in rating. Available data displays some historical variation, most notably an abrupt change during/after the 2011 flood event. Gauge is considered to be reasonably rated but not particularly consistent
Stream:	Brisbane River	
Site:	Savages Crossing	
Gauge No:	143001C	
Owner:	DNRM	
Catchment:	Lower Brisbane River	Rating updated based on review of gaugings, steady-state release flows and DMT TUFLOW model results Rating provides generally good fit of steady flow release and hydrologic data, but no flow gauging available for comparison. Rating is considered to be reasonable, with a fairly well contained site. Revised rating tends to predict higher flows than previously estimated due to dynamic effects and attenuation evident in the TUFLOW model but not properly represented in the hydrologic model
Stream:	Brisbane River	
Site:	Moggill	
Gauge No:	143951	
Owner:	BoM/Seqwater	
Catchment:	Lower Brisbane River	Rating updated based on review of gaugings, steady-state release flows and DMT TUFLOW model results Rating is highly tide dependent even up to high flow rates (>10,000m³/s). Site has also been subjected to dredging and other changes, the effects of which are unquantified Overall, the current rating appears to give a reasonable estimate of the flow order-of-magnitude and match of historical flood events for flows in the range 6,000 to 16,000 m³/s. The site/rating is complex and improving the rating would require significant work (hydraulic modelling) that is outside the scope the current study
Stream:	Brisbane River	
Site:	Brisbane City	
Gauge No:	143838	
Owner:	Seqwater	

The adopted rating curves are provided in the '*Data, Rating Curve and Historical Flood Review Report*'. The effect of revising the rating curves at various locations has resulted in changes to the rated flows adopted in the calibration of the sub-catchment models. Table 1-3 provides a summary of the changed characteristics for the calibration events.

Figure 1-1 below has been reproduced from the '*Data, Rating Curve and Historical Flood Review Report*' (March 2014). This figure shows that review of the flood gauge rating curves is a complex and iterative process that is tied into other aspects of the hydrologic assessment, including calibration of hydrologic models and flood frequency analysis of gauges across the catchment. These processes are dependent upon the gauge ratings, but achieving catchment-wide consistency may require ongoing review and adjustment of the ratings.

The recalibration of the hydrologic model feeds into the Design Event Approach and Flood Frequency Analysis. These techniques are being applied concurrently and the results are being fed back into the recalibration. This process forms a feedback loop in terms of the overall flood estimation methodology. The iteration is continued until a satisfactory consistency between outcomes is achieved.

Table 1-3 Relative impact on rated flows

Sub-catchment model	Key gauging station	Relative impact on rated peak flow
Stanley River	Woodford	+30 to +75%
	Somerset Dam	Nil
Upper Brisbane River	Linville	+1 to -6%
	Gregors Creek	-1 to -6%
	Wivenhoe Dam	Nil
Lockyer Creek	Gatton	
	Glenore Grove	-10 to +30%
	Lyons Bridge/Rifle Range Road	
Bremer River	Walloon	+4 to +21%
Warrill Creek	Amberley	0 to +35%
Purga Creek	Loamside	-1 to +25%
Lower Brisbane River	Savages Crossing	-2 to +7%
	Mt Crosby Weir	-1 to +4%
	Moggill	-3 to +8%

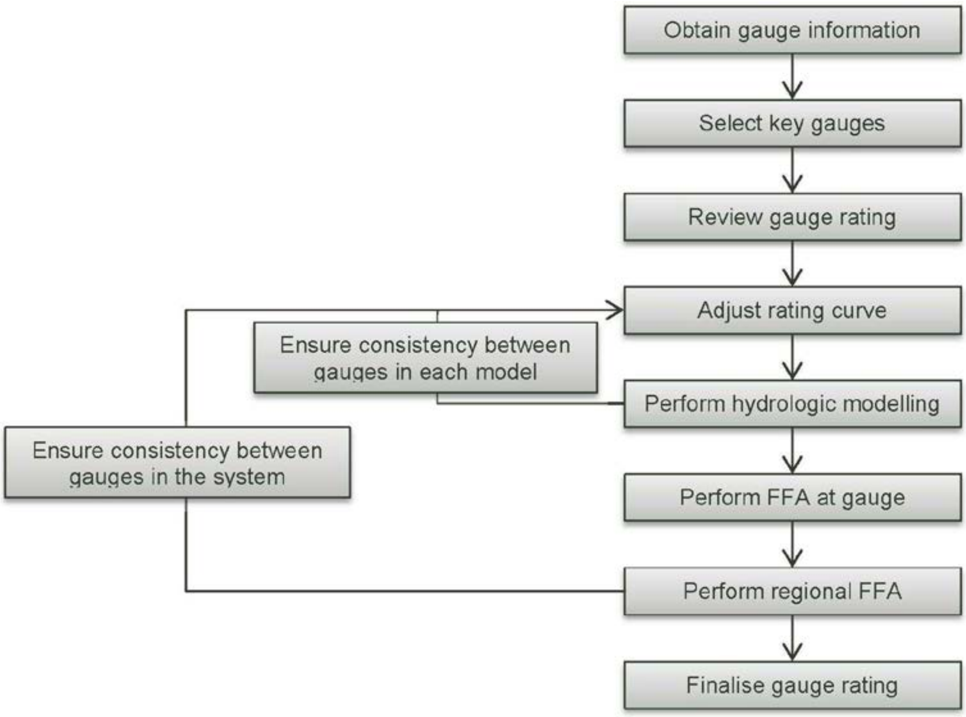


Figure 1-1 Overview of rating curve review methodology

2 Recalibration methodology

A limited timeframe was available for the recalibration process; therefore a complete recalibration of all 38 calibration events adopted by Seqwater was not possible. A reduced scope of works was undertaken, which followed the same process as Seqwater wherever possible. No changes were made to the rainfall input files adopted by Seqwater. No further validation of the rainfall depths and associated temporal patterns was attempted as part of the recalibration process.

The recalibration process is outlined below.

2.1 URBS model modifications

A summary of the URBS model changes for each of the seven sub-catchment models is provided in Table 2-1.

Table 2-1 Adopted URBS model changes

	Stanley	Upper Brisbane	Lockyer	Bremer	Warrill	Purga	Lower Brisbane
Include revised rating curves	✓	✓	✓	✓	✓	✓	✓
Include channel routing non-linearity (n = 0.85)			✓	✓		✓	
Remove Kedron Brook catchment (Seqwater subareas 111, 113, 97, 99 and105)							✓
Include impervious fractions, urbanised areas and reduced reach length factors							✓
Modification of conceptual storage volumes (based on physical storage characteristics)		✓					✓

Whilst recommendations have been made regarding a cap to the base flow volume factor, this recommendation is tailored towards extreme event flows and does not impact upon events with magnitudes in the range of the calibration events.

2.2 Selected calibration events

A reduced number of events were selected for calibration. Seqwater carried out the original URBS model calibration to 38 events, with verification to a further 10 events. For the purposes of the recalibration, the five events with the greatest impacts along the Brisbane River, and particularly in the Lower Brisbane River area, were selected for calibration. These events are:

- January 1974
- May 1996
- February 1999
- January 2011
- January 2013

It is acknowledged that the selection of these particular events may lead to some bias for some sub-catchment models as the events are not necessarily the most significant for that specific sub-catchment. The selection of predominately large floods would tend to influence the adopted loss rates and this may result in adopted loss rates that are more applicable to large to rare flood event magnitudes.

2.3 Recalibration process

Wherever possible, a similar process to that adopted by Seqwater was used for the recalibration. The following tasks were undertaken during the recalibration process:

- Update the model catchment and vector files as per Table 2-1
- Update the rating curves as per Table 1-1 and Table 1-2
- Review model schematisation to ensure it best represents flow characteristics in particular areas of interest and update if necessary (eg lower Lockyer schematisation)
- Use Seqwater's calibration process (refer to Section 6.5, *Brisbane River Flood Hydrology Models Main Report*, Seqwater 2013) to calibrate each of the seven sub-catchment models for the five selected events. The primary and secondary calibration points were aligned with those from the rating curve review process. Alpha and beta values were retained within the recommended Seqwater ranges wherever possible
- Review the calibration performance at other gauges and determine whether it is acceptable
- Use Seqwater's ranking and weighting criteria to assess the calibration performance
- Determine a revised set of recommended parameters for each model
- Verify the model to all 38 of Seqwater's calibration events using the recommended parameters. In this process, the initial and continuing losses were updated for the five selected calibration events. For the remaining 33 events the initial and continuing losses remained as per the Seqwater calibration parameters. Whilst this method may not be the technically optimal method, it was selected in the interest of time cost savings to the delivery of the hydrology study
- Compare the verification results to Seqwater's results using their recommended parameters

To allow easy comparison with Seqwater's results, the results have been presented in a similar format wherever possible.

2.4 Calibration performance ranking

Seqwater adopted a ranking scheme to assess the calibration performance for the calibration events. These criteria considered quantitative measures of the flood hydrograph calibration and qualitative assessment of the quality of data and magnitude of the flood event. The Seqwater methodology assessed five criteria:

- Peak ratio (PR) represents the difference between the calculated (modelled) peak flow and the estimated (rated) peak flow. The estimated peak flow is calculated using the recorded peak height and the gauge site rating curve
- Volume ratio (VR) represents the difference between calculated (modelled) event volume and the estimated event volume. The estimated event volume is calculated by converting the recorded water level hydrograph to a rated flow using the gauge site rating curve
- Nash-Sutcliffe (NS) represents the calibration event modelled hydrograph goodness of fit (ie shape and timing). Nash-Sutcliffe can range from -∞ to 1, with a NS value of 1 being a perfect fit
- The magnitude of the flood event was classified using the BoM flood warning classification scale of Minor, Moderate and Major
- Quality and availability of data, expected to be of higher quality data in later events

Using the Seqwater methodology assigned each calibration result a class score on a five point scale ranging from zero (no data) to five (excellent calibration), which were then used to weight the parameters for each event calibration to derive recommended model parameters. Table 2-2 quantifies the parameters used to assign class and score to each of the criteria.

Table 2-2 Criteria for ranking and weighting of calibration events (after Seqwater 2013)

Class	Score	Peak Ratio	Volume Ratio	Nash-Sutcliffe	Event Magnitude	Quality of rainfall data
Excellent	5	< ±10%	< ±15%	≥ 0.95	Major	Post-2008
Good	4	< ±15%	< ±25%	≥ 0.90	Moderate	Post-1994
Fair	3	-	-	≥ 0.85	Minor	Post-1955
Poor	2	< ±50%	< ±50%	≥ 0. 50	-	Pre-1955
No data/exclude	0	> ±50%	> ±50%	< 0.50	-	-

3 Calibration results

3.1 Introduction

This section provides a summary of the recalibration results achieved for each sub-catchment model. Results are presented for the primary gauge locations considered in the recalibration process. The ranking of each event in accordance with the adopted Seqwater weighting scheme is also presented, along with a comparison of the recommended model parameters. Some discussion is provided on the reasons for potential differences that have been observed.

3.2 Stanley River

3.2.1 Woodford gauge rating

The Woodford gauge is situated in a hydraulically complicated location close to the D'Aguilar Highway, approximately 700 m upstream of an old concrete water supply weir. This weir is in turn 200 m upstream of a confluence with a tributary inflow (Monkeybong Creek). Independent hydraulic modelling suggests that the weir is drowned out for relatively small flows (<50 m^3/s). The hydraulic control thereafter shifts to the reach downstream of the confluence. This has a significant impact on the gauge rating, which consequently becomes primarily a function of the combined Stanley River and Monkeybong Creek flows for moderate to major flood events, with the Stanley River flow between the gauge site and confluence having a minor influence.

For the calibration events examined, the contributions of Stanley River and Monkeybong Creek are typically 85% and 15% respectively at peak flow, although the actual ratio will vary during any particular event depending on the magnitude and timing of the rainfall across the catchment. The rating is therefore considered unreliable at low flows, but becomes increasingly independent of the actual ratio as the flow increases.

3.2.2 URBS model changes

Upon completion of the gauge rating review, the following changes were made to the URBS model:

- The reach length factor upstream of Woodford was increased to 2, consistent with the reach length factor upstream of Peachester
- The storage at Woodford was removed
- The reporting location for the Woodford gauge was moved to the junction of the main channel and the tributary downstream of the gauge

3.2.3 Calibration plots

Calibration plots for the Stanley River model in the January 2011 event are provided in Figure 3-1. Additional plots overlaying the recalibration results with Seqwater's results and the rated flows are provided in Appendix B.

Flow **Height**

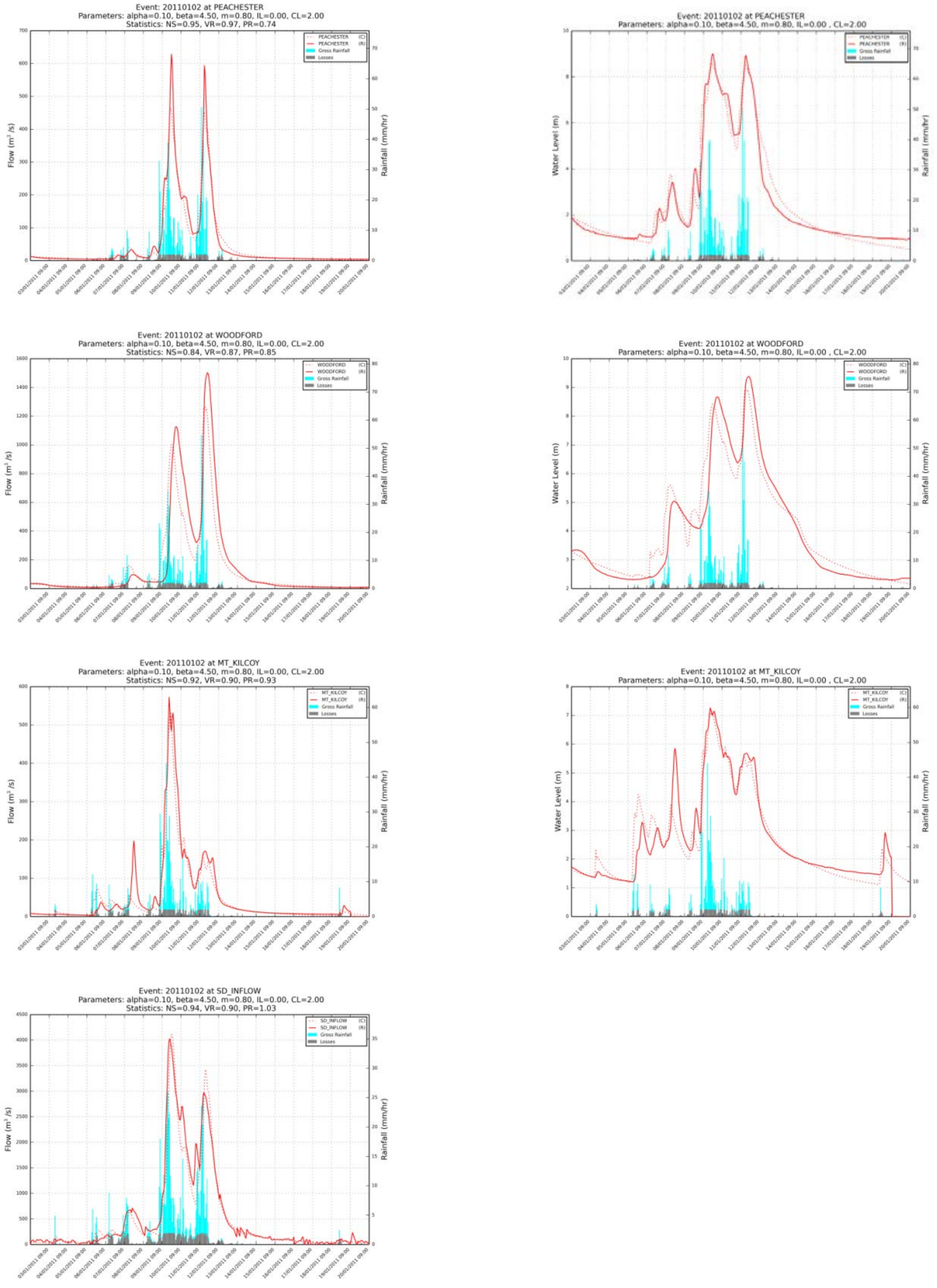


Figure 3-1 Stanley River calibration plots – January 2011 event

3.2.4 Calibration results summary

The calibration event results at the Somerset Dam inflow are summarised in Table 3-1.

Table 3-1 Stanley River model calibration statistics at Somerset Dam inflow

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	3,434	3,362	1.02	587,335	631,076	0.93	0.94
19960430	1,153	1,101	1.05	179,861	189,151	0.95	0.95
19990207	3,419	3,449	0.99	444,171	447,894	0.99	0.97
20110102	4,122	4,021	1.03	721,880	800,568	0.90	0.94
20130123	2,522	2,194	1.15	212,368	260,604	0.81	0.89

3.2.5 Calibration performance ranking

The calibration ranking at the Somerset Dam inflow are summarised in Table 3-2.

Table 3-2 Stanley River model calibration performance at Somerset Dam inflow

Event	Calibration parameters					Calibration performance ranking					
	IL	CL	α	β	m	PR	VR	NS	Magnitude	Rainfall	Total event weighting
19740124	0	2.70	0.19	4.5	0.8	5	5	4	5	3	0.18
19960430	120	1.80	0.12	10.0	0.8	5	5	5	2	4	0.12
19990207	0	2.50	0.05	6.0	0.8	5	5	5	5	4	0.30
20110102	0	2.00	0.10	4.5	0.8	5	5	4	5	5	0.30
20130123	150	4.00	0.18	5.00	0.8	4	4	3	4	5	0.11

3.2.6 Calibration comments

At the Woodford gauge, with the revised model setup and reporting location, the match to rated flows has been significantly improved over the initial Aurecon recalibration. The model typically predicts earlier timing of the event than the gauged data. At the Somerset gauge, the calibration has not been modified significantly.

The changes to the model setup in the Woodford area have required the alpha value to be increased in 3 of the 5 events and the beta value has been increased in all events.

3.2.7 Comparison to Seqwater calibration

In comparison to Seqwater's calibration, the revised calibration shows that at the Somerset Dam inflow:

- In the 1974 and 1996 events, the peak flow ratio is improved. The volume ratio and Nash-Sutcliffe value are worsened (1974: PR 1.06 → 1.02, VR 0.97 → 0.93, NS 0.95 → 0.94; 1996: PR 1.06 → 1.05, VR 0.99 → 0.95, NS 0.96 → 0.95)
- In the 1999 event, the peak flow ratio and Nash-Sutcliffe value are improved and the volume ratio is identical (PR 1.05 → 0.99, VR 0.99 → 0.99, NS 0.96 → 0.97)

- In the 2011 event calibration to all three parameters is worsened (PR 1.01 → 1.03, VR 0.99 → 0.90, NS 0.95 → 0.94)
- In the 2013 event, the peak flow ratio is improved and the volume ratio and Nash-Sutcliffe value are worsened (PR 1.22 → 1.15, VR 0.89 → 0.81, NS 0.92 → 0.89)
- For the 1974, 1996, 1999 and 2011 events the peak flow and volume ratios are classed as excellent and the for the 2013 event they are classed as good. The Nash-Sutcliffe value for the 1996 and 1999 events is classed excellent, for the 1974 and 2011 events is it classed good and for the 2013 event it is classed fair
- Overall the peak ratio comparisons were improved however the volume ratio and Nash-Sutcliffe comparisons show a worsening

3.2.8 Recommended parameters

The recommended parameters for the model were calculated based upon the values provided in Table 3-2. The recommended parameters are:

- Typical continuing loss = 2.5 mm/hr with a range between 1.8 and 4.0 mm/hr
- Alpha = 0.11 with a range of between 0.05 and 0.19
- Beta = 5.7 with a range of between 4.5 and 10.0
- Catchment non-linearity exponent m = 0.8
- Channel routing parameter n = 1.0

The recommended parameters have been compared to those recommended by Seqwater, as shown in Table 3-3. To assist in the comparison, an additional set of recommended parameters have been calculated based on Seqwater's calibration results for the only five adopted calibration events.

Table 3-3 Comparison of recommended parameters for Stanley River

Parameter	Revised recommended value	Seqwater recommended value	Recommended value from Seqwater results based on five calibration events only
Alpha	0.11	0.16	0.12
Beta	5.7	4.3	4.6
m	0.8	0.8	0.8
n	1.0	1.0	1.0

Table 3-3 shows that, as a result of the changes to the model in the Woodford area, the alpha value has been reduced from that recommended by Seqwater and the beta value has been increased. This table shows that whilst there would be a difference in Seqwater's recommended parameters if only the five calibration events had been used, these values are still considered to be similar to the recommended values. Therefore the approach of using only these five calibration events should provide reasonable set of recommended parameters.

The typical continuing loss rate of 2.5 mm/hr is increased above Seqwater's typical continuing loss rate of 2.0 mm/hr.

3.3 Upper Brisbane River

3.3.1 Calibration plots

Calibration plots for the Upper Brisbane River model in the January 2011 event are provided in Figure 3-2.

Flow **Height**

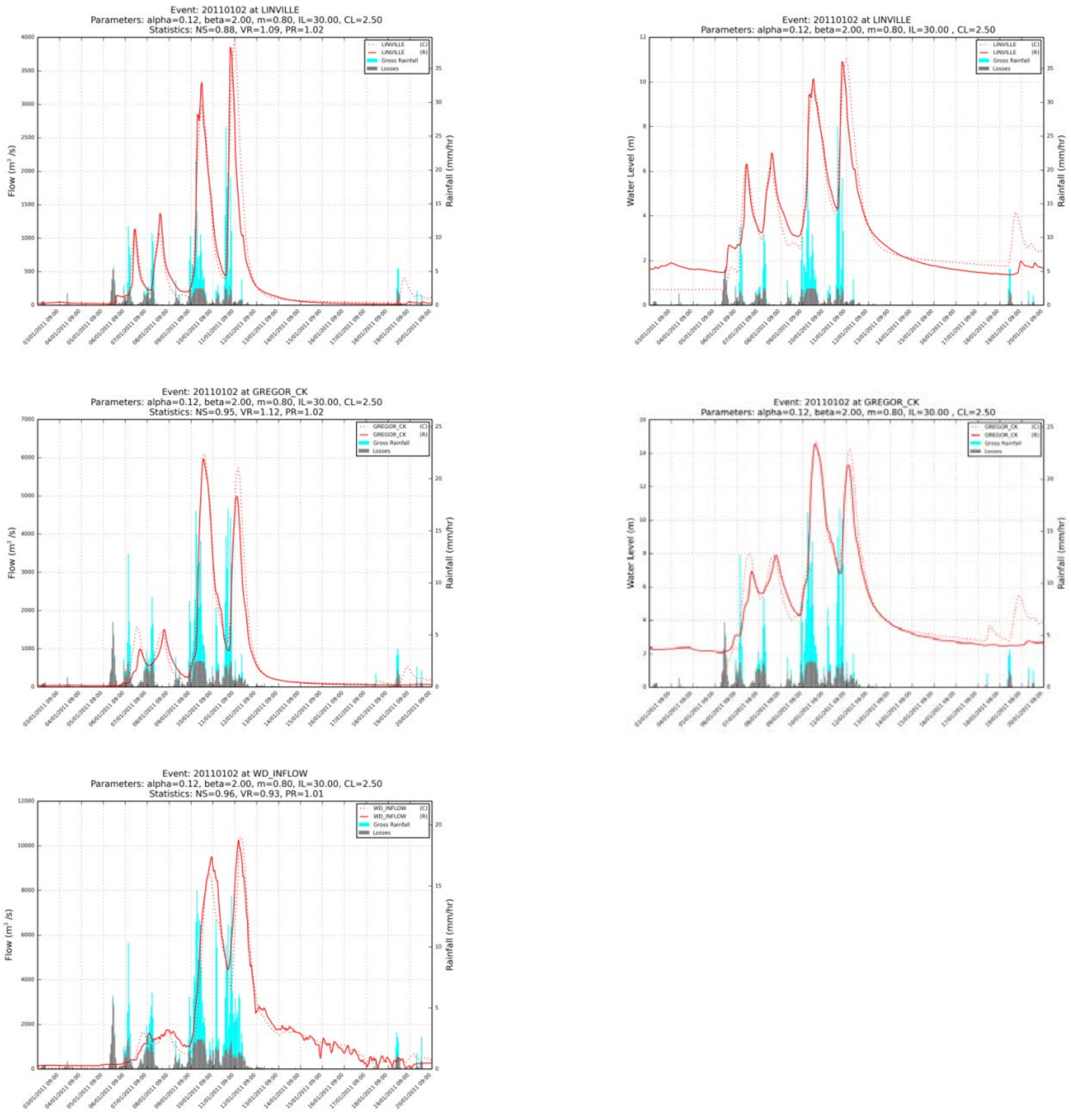


Figure 3-2 Upper Brisbane River calibration plots – January 2011 event

Additional plots overlaying the recalibration results, Seqwater's results and the rated flows are provided in Appendix B.

3.3.2 Calibration results summary

The calibration event results at the Somerset Dam inflow are summarised in Table 3-4 and Table 3-5.

Table 3-4 Upper Brisbane River model calibration statistics at Gregors Creek

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	4,950	5,118	0.97	759,242	809,309	0.94	0.98
19960430	801	502	1.60	79,639	74,965	1.06	0.56
19990207	5,880	5,910	1.00	573,269	596,412	0.96	0.98
20110102	6,089	5,959	1.02	1,067,072	951,432	1.12	0.95
20130123	3,893	3,469	1.12	383,032	219,391	1.75	0.74

Table 3-5 Upper Brisbane River model calibration statistics at Wivenhoe Dam inflow

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19960430	2,019	2,118	0.95	283,230	357,509	0.79	0.62
19990207	7,330	7,326	1.00	1,079,000	1,190,347	0.91	0.97
20110102	10,388	10,264	1.01	2,512,405	2,705,022	0.93	0.96
20130123	5,904	5,870	1.01	878,475	858,593	1.02	0.96

3.3.3 Calibration performance ranking

The calibration ranking at the Gregors Creek and Wivenhoe Dam Inflow are summarised in Table 3-6.

Table 3-6 Upper Brisbane River model calibration performance at Gregors Creek and Wivenhoe Dam inflow

Event	Calibration parameters					Calibration performance ranking					
	IL	CL	α	β	m	PR	VR	NS	Magnitude	Rainfall	Total event weighting
19740124 (Gregors Ck)	45	1.20	0.14	3.3	0.8	5	5	5	5	3	0.16
19960430	110	3.30	0.09	2.5	0.8	5	4	2	5	4	0.07
19990207	90	2.00	0.12	2.5	0.8	5	5	5	5	4	0.22
20110102	30	2.50	0.12	2.0	0.8	5	5	5	5	5	0.27
20130123	170	3.00	0.10	3.5	0.8	5	5	5	5	5	0.27

The event weightings are based upon the Gregors Creek model performance for the January 1974 flood event and Wivenhoe Dam inflow for the remaining events.

3.3.4 Comparison to Seqwater calibration

In comparison to Seqwater's calibration, the revised calibration shows:

- No change was made to the model parameters in the 1974 event; however as a result of the revised rating curve at Gregors Creek, the peak ratio is improved, the volume ratio is worsened and the Nash-Sutcliffe value is identical (Gregors: PR 0.96 → 0.97, VR 0.97 → 0.94, NS 0.98 → 0.98)
- In the 1996 event, the peak flow ratios at both locations are slightly worse, as is the Nash-Sutcliffe value at Gregors Creek. The volume ratio at both locations and the Nash-Sutcliffe value at the Wivenhoe Inflow are slightly improved (Gregors: PR 1.56 → 1.60, VR 0.93 → 1.06, NS 0.59 → 0.56; Wivenhoe: PR 0.95 → 0.98, VR 0.76 → 0.79, NS 0.57 → 0.62)
- In the 1999 event, the peak flow ratios at both locations are improved. The volume ratio and Nash-Sutcliffe values at Wivenhoe Inflow are identical and are slightly worsened at Gregors Creek (Gregors: PR 1.02 → 1.00, VR 0.97 → 0.96, NS 0.99 → 0.98; Wivenhoe: PR 1.05 → 1.00, VR 0.91 → 0.91, NS 0.97 → 0.97)
- In the 2011 event at Gregors Creek, the peak flow ratio is identical while the volume ratio and the Nash-Sutcliffe value are improved. For Wivenhoe Dam Inflow the peak flow ratio is improved whilst the volume ratio is correspondingly worsened and the Nash-Sutcliffe value is similar (Gregors: PR 1.02 → 1.02, VR 1.18 → 1.12, NS 0.93 → 0.95; Wivenhoe PR 1.03 → 1.01, VR 0.95 → 0.93, NS 0.96 → 0.96)
- In the 2013 event, the calibration performance is improved across all three parameters at both locations (Gregors: PR 1.27 → 1.12, VR 1.83 → 1.75, NS 0.54 → 0.74; Wivenhoe: PR 1.06 → 1.01, VR 1.02 → 1.02, NS 0.95 → 0.96)
- The peak flow ratios are classed as an excellent match for all events except the 1996 event at Gregors Creek which is considered in the range "no data" and the 2013 event at Gregors Creek which is classed as a good match
- The volume ratio at Gregors Creek in the 2013 event is classed in the range "no data". The volume ratio at the Wivenhoe Inflow in the 1996 event is classed as good and for all other events it is classed as excellent
- The Nash-Sutcliffe values are classed as poor in the 1996 event at both locations and in the 2013 event at Gregors Creek. For the remaining events the Nash-Sutcliffe values are classed as excellent
- Overall a similar ranked calibration was achieved for the volume ratio comparison with the peak ratio and Nash-Sutcliffe values marginally improved over the corresponding Seqwater values

3.3.5 Recommended parameters

The recommended parameters for the model were calculated based upon the values provided in Table 10. The recommended parameters are:

- Typical continuing loss = 2.4 mm/hr with a range between 1.2 and 3.3 mm/hr
- Alpha = 0.12 with a range of between 0.10 and 0.14
- Beta = 2.8 with a range of between 2.0 and 3.5
- Catchment non-linearity exponent m = 0.8
- Channel routing parameter n = 1.0

The recommended parameters have been compared to those recommended by Seqwater, as shown in Table 3-7. To assist in the comparison, an additional set of recommended parameters have been calculated based on Seqwater's calibration results for the only five adopted calibration events.

Table 3-7 Comparison of recommended parameters for Upper Brisbane River

Parameter	Revised recommended value	Seqwater recommended value	Recommended value from Seqwater results based on five calibration events only
Alpha	0.12	0.13	0.12
Beta	2.8	2.8	2.5
m	0.8	0.8	0.8
n	1.0	1.0	1.0

Table 3-7 shows that there is no significant change in the recommended model parameters for the Upper Brisbane River sub-catchment model due to the changes in rating curves. The typical continuing loss of 2.4 mm/hr also compares closely to Seqwater's typical loss rate of 2.5 mm/hr.

3.4 Lockyer Creek

3.4.1 Model schematisation

Following first pass recalibration and receipts of comments from Seqwater on the calibration performance of the lower Lockyer and its impacts on the Lower Brisbane recalibration, the schematisation of the lower Lockyer, below Glenore Grove, was reviewed. The lower Lockyer floodplain has unique characteristics. A deep channel with banks perched above the floodplain level runs through a wide, flat floodplain. At Glenore Grove the flow divides between main channel flow and floodplain flow. Breakout from the channel commences at approximately 600 m^3/s and increases rapidly as the flowrate increases. The maximum channel capacity peaks at under 1,000 m^3/s.

Although there are several opportunities for flow to transfer between the channel and floodplain where tributaries enter the channel, the elevated overbanks mean that the channel and floodplain flows act almost completely independently. The floodplain is several kilometres wide, but may average less than 0.6 m deep even during extreme events, and floodplain flow velocities would be expected to be significantly lower than the main channel. The URBS model has been modified to represent the main channel and floodplain separately between Glenore Grove and the junction with Buaraba Creek, as shown in Figure 3-3.

The DMT TUFLOW model suggests that low flows (main channel) have approximately 10 hour translation between Glenore Grove and Savages Crossing with relatively little attenuation. Peak flows (floodplain) have a much longer delay and significant attenuation. The floodplain is almost entirely used for agriculture, and the speed and attenuation characteristics are likely to vary depending on the current crop conditions. The floodplain area may also be subject to semi-permanent ponding and increased infiltration when inundated by floodwaters. These would apply to floodwaters separate to the initial and continuing loss applied to rainfall, and the effects are currently not represented in the URBS model.

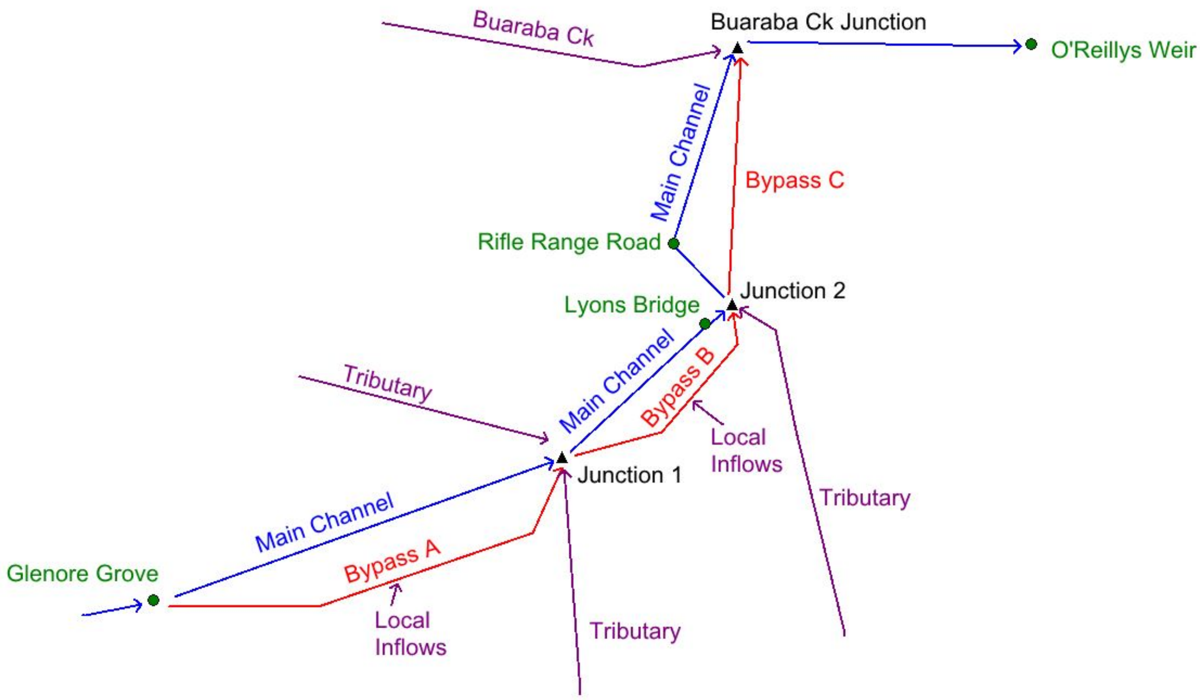


Figure 3-3 Lower Lockyer Creek schematisation

Key features of the revised model schematisation are as follows:

- Three separate bypass channels to represent the main channel and floodplain flows between junctions of the main channel and tributaries
- 100% of flow above 980 m^3/s routed through the bypasses
- A reach length factor of 2.5 on the main channel. This reach length factor gives approximately 10 hours of travel time in the main channel between Glenore Grove and O'Reillys Weir
- A reach length factor of 3.3 on the floodplain bypasses. This was selected as it gave the best overall calibration results at Savages Crossing
- Local inflows between Glenore Grove and the Buaraba Creek junction included in the bypass channel rather than the main channel

3.4.2 Calibration plots

Calibration plots for the Lockyer Creek model in the January 2011 event are provided in Figure 3-4. Additional plots overlaying the recalibration results with Seqwater's results and the rated flows are provided in Appendix B.

Flow **Height**

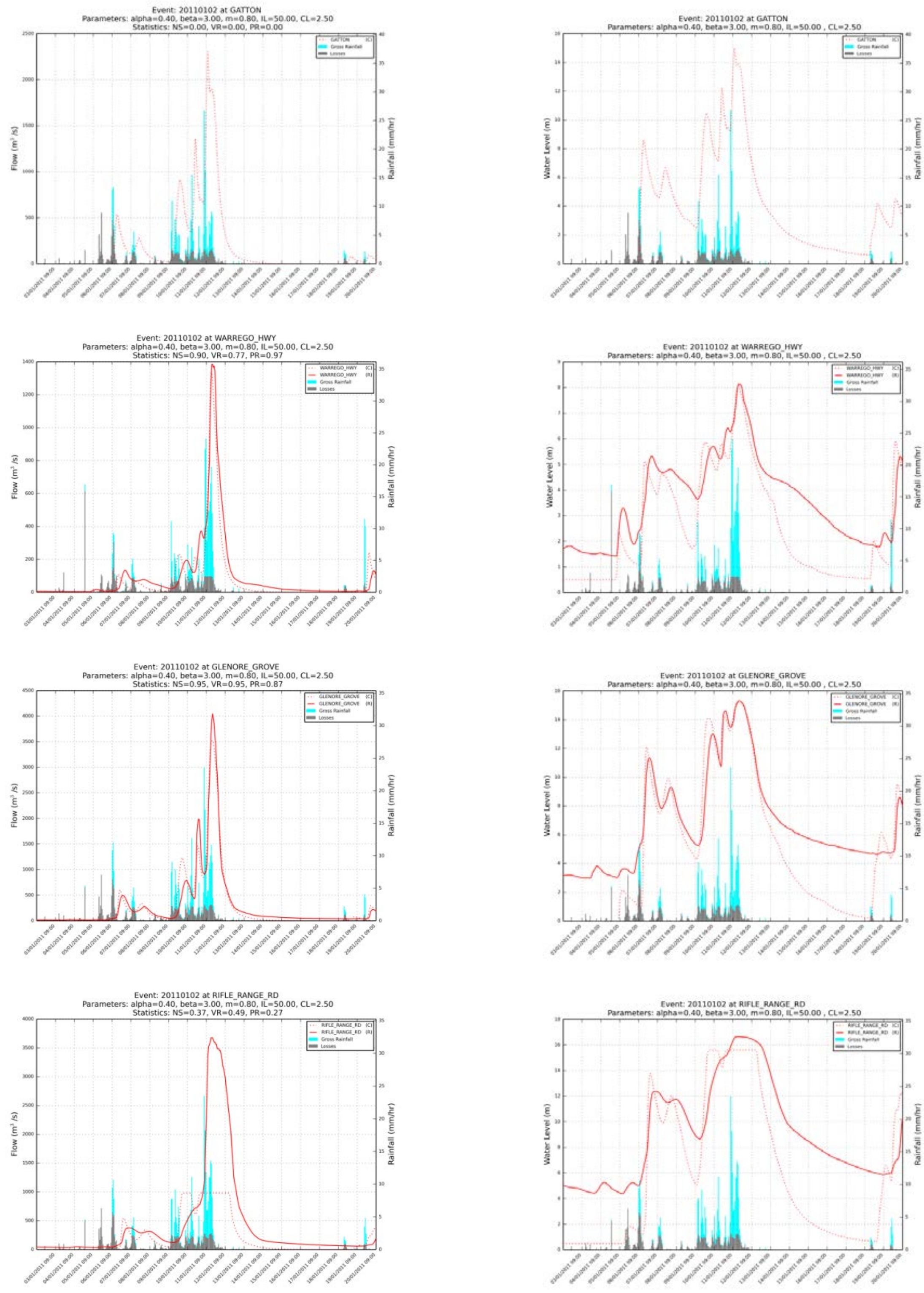


Figure 3-4 Lockyer Creek calibration plots – January 2011 event

3.4.3 Calibration results summary

The calibration event results at Glenore Grove are summarised in Table 3-8.

Table 3-8 Lockyer Creek model calibration statistics at Glenore Grove

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	2,918	2,739	1.07	267,440	261,016	1.02	0.78
19960430	1,599	1,531	1.04	349,066	317,301	1.10	0.79
19990207	415	421	0.99	36,445	37,611	0.97	0.99
20110102	3,522	4,048	0.87	416,601	439,424	0.95	0.95
20130123	2,752	3,115	0.88	264,629	267,360	0.99	0.98

3.4.4 Calibration performance ranking

The calibration rankings at Glenore Grove are summarised in Table 3-9.

Table 3-9 Lockyer Creek model calibration performance at Glenore Grove

Event	Calibration parameters					Calibration performance ranking					
	IL	CL	α	β	M	PR	VR	NS	Magnitude	Rainfall	Total event weighting
19740124	60	4.00	0.50	3.0	0.8	5	5	2	5	3	0.10
19960430	130	2.00	0.50	4.0	0.8	5	5	2	5	4	0.13
19990207	130	1.80	0.60	3.0	0.8	5	5	5	3	4	0.19
20110102	50	2.50	0.40	3.0	0.8	4	5	4	5	5	0.26
20130123	200	3.50	0.50	3.0	0.8	4	5	5	5	5	0.32

3.4.5 Comparison to Seqwater calibration

Seqwater summarised the performance of the Lockyer Creek sub-catchment model at Lyons Bridge and Rifle Range Road. However, as indicated from the rating curve review the rated flows at these sites for events with flow rates in excess of bankfull flow (800-900 m^3/s) are very uncertain and, apart from the February 1999 flood event, the other events considered in the recalibration are far in excess of this threshold. Therefore, the comparison with the Seqwater model performance has been performed using the Glenore Grove site which was adopted as a primary site during the rating curve review. Table 3-10 shows the Seqwater model performance for this location using the Seqwater recommended calibration parameters.

Table 3-10 Lockyer Creek model calibration statistics at Glenore Grove (Seqwater Recommended Parameters)

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	3,224	3,304	0.98	396,845	368,521	1.08	0.61
19960430	1,806	2,280	0.79	402,265	455,150	0.88	0.75
19990207	842	494	1.70	88,168	60,480	1.46	0.11

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20110102	2,975	4,126	0.72	382,407	612,382	0.62	0.65
20130123	2,556	3,598	0.71	272,297	382,476	0.71	0.75

In comparison to Seqwater's calibration, the revised calibration shows that at Glenore Grove:

- As a result of the revised rating curve at Glenore Grove, the 1974 rated flows have been reduced from those used by Seqwater and higher losses have been adopted to match these reduced flows. The peak ratio is worsened, the volume ratio is improved and the Nash-Sutcliffe value is improved (PR 0.98 → 1.07, VR 1.08 → 1.02, NS 0.61 → 0.78)
- In the 1996 event, all three parameters are improved (PR 0.79 → 1.04, VR 0.88 → 1.10, NS 0.75 → 0.79)
- In the 1999 event, all three parameters are significantly improved as a result of removal of the infiltration capacity limit which was previously applied to this event (PR 1.70 → 0.99, VR 1.46 → 0.97, NS 0.11 → 0.99)
- In the 2011 event all three parameters are once again improved (PR 0.72 → 0.87, VR 0.62 → 0.95, NS 0.65 → 0.95). A better calibration could have been achieved using a lower continuing loss value, however this would have adversely affected the calibration of the Lower Brisbane model, therefore a compromise was made and the overall calibration performance of the 2011 event at Glenore Grove was reduced
- Very similar characteristics were achieved in the 2013 event as for the 2011 event, with improvement in all three parameters. As with the 2011 event, a better calibration could have been achieved with lower continuing loss, however this would have adversely affected the calibration of the Lower Brisbane model (PR 0.71 → 0.88, VR 0.71 → 0.99, NS 0.75 → 0.98)
- The peak flow ratios are classed as an excellent match for the 1974, 1996 and 1999 events and a good match for the 2011 and 2013 events
- The volume ratios are classed as excellent for all five events
- The Nash-Sutcliffe values are classed as poor in the 1974 and 1996 events, good in the 2011 event and excellent for the 1999 and 2013 events
- Overall a better calibration was achieved, given that this was a primary calibration location for the recalibration and wasn't a primary calibration location for Seqwater this result would be expected
- It is difficult to assess the overall performance of the model calibration for the Lockyer Creek sub-catchment model given the uncertainty associated with the rating curves especially in the higher flow range for the stream gauges situated in the lower reaches of this catchment. Calibration performance of the lower reaches has been reviewed through the Lower Brisbane model calibration at Savages Crossing

3.4.6 Recommended parameters

The recommended parameters for the model were calculated based upon the values provided in Table 3-2. The recommended parameters are:

- Typical continuing loss = 2.8 mm/hr with a range between 1.8 and 4.0 mm/hr
- Alpha = 0.49 with a range of between 0.40 and 0.60
- Beta = 3.1 with a range of between 3.0 and 4.0

- Catchment non-linearity exponent m = 0.8
- Channel routing parameter n = 0.85

The recommended parameters have been compared to those recommended by Seqwater, as shown in Table 3-11. To assist in the comparison, an additional set of recommended parameters have been calculated based on Seqwater's calibration results for the only five adopted calibration events.

Table 3-11 Comparison of recommended parameters for Lockyer Creek

Parameter	Revised recommended value	Seqwater recommended value	Recommended value from Seqwater results based on five calibration events only
Alpha	0.49	0.30	0.20
Beta	3.1	3.0	3.0
m	0.8	0.8	0.8
n	0.85	1.0	1.0

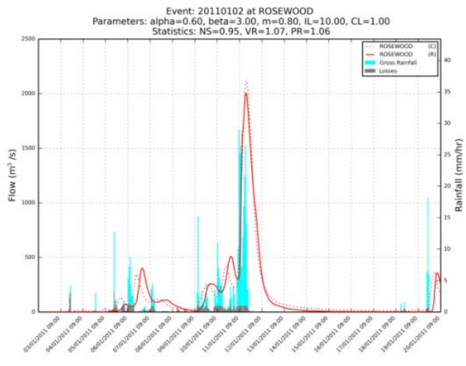
Table 3-11 shows that the recommended alpha value has increased significantly whilst the beta value remains similar. The changes for this catchment are brought about the modifications to the rating curves and also the introduction of non-linearity for the channel routing parameter, n. The typical continuing loss value of 2.8 mm/hr is slightly increased above Seqwater's typical value of 2.7 mm/hr.

3.5 Bremer River

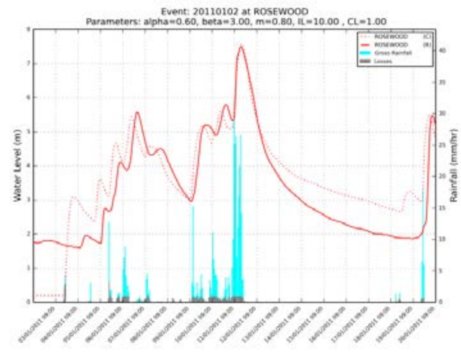
3.5.1 Calibration plots

Calibration plots for the Bremer River model in the January 2011 event are provided in Figure 3-5. Additional plots overlaying the recalibration results with Seqwater's results and the rated flows are provided in Appendix B.

Flow



Height



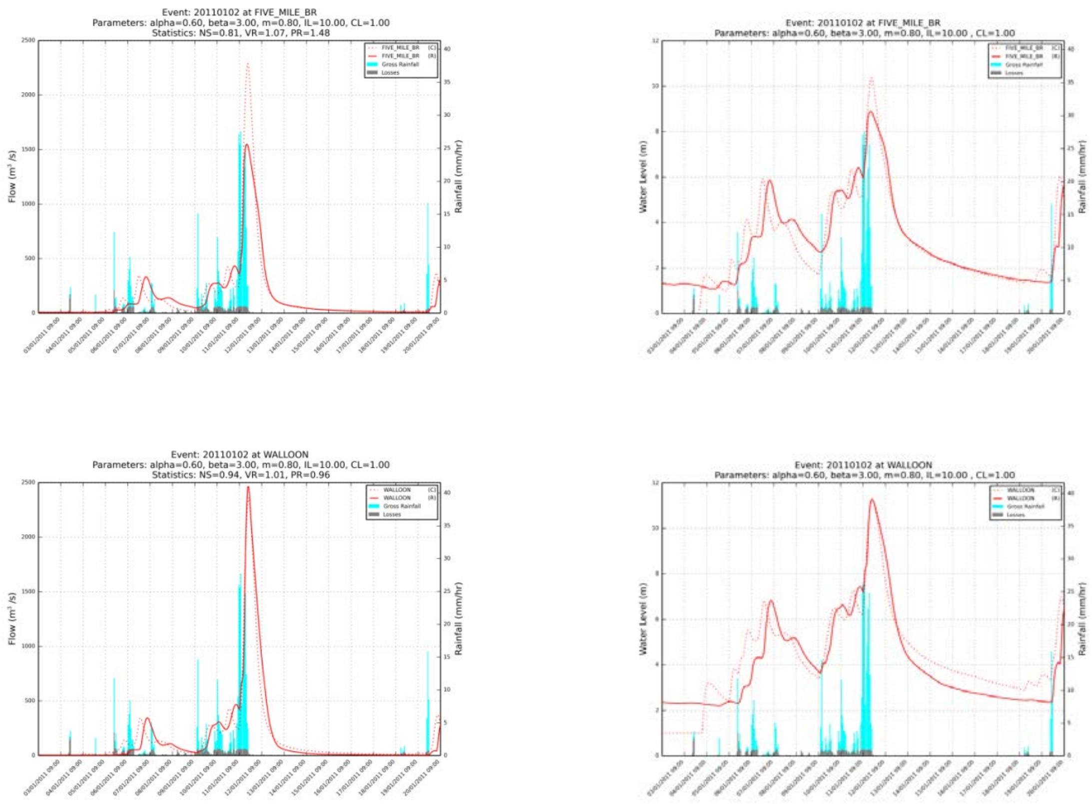


Figure 3-5 Bremer River calibration plots – January 2011 event

3.5.2 Calibration results summary

The calibration event results at Walloon are summarised in Table 3-12.

Table 3-12 Bremer River model calibration statistics at Walloon

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	1,875			222,983			
19960430	1,035	1,042	0.99	200,144	211,588	0.95	0.93
19990207	458	476	0.96	54,712	45,659	1.20	0.91
20110102	2,364	2,461	0.96	237,601	236,357	1.01	0.94
20130123	1,359	1,380	0.98	135,332	115,203	1.17	0.96

3.5.3 Calibration performance ranking

The calibration rankings at Walloon are summarised in Table 3-13.

Table 3-13 Bremer River model calibration performance at Walloon

Event	Calibration parameters					Calibration performance ranking					
	IL	CL	α	β	m	PR	VR	NS	Magnitude	Rainfall	Total event weighting
19740124	80	2.50	0.70	3.0	0.8					3	0.00
19960430	100	1.00	1.00	2.5	0.8	5	5	4	5	4	0.24
19990207	45	1.00	0.80	3.0	0.8	5	4	4	4	4	0.16
20110102	10	1.00	0.60	3.0	0.8	5	5	4	5	5	0.30
20130123	175	2.00	0.80	2.8	0.8	5	4	5	5	5	0.30

3.5.4 Comparison to Seqwater calibration

In comparison to Seqwater's calibration, the revised calibration shows:

- There is no recorded data for comparison of the 1974 event, however a similar relationship between the recalibrated hydrograph and Seqwater's hydrograph as that for the other events is evident, with the recalibrated hydrograph having a slightly higher peak and earlier timing
- In the 1996 event, the peak flow ratio value is similar whilst both the volume ratio and Nash-Sutcliffe values have improved (PR 1.01 → 0.99, VR 0.87 → 0.95, NS 0.92 → 0.93)
- In the 1999 event, the peak flow ratio has worsened, whilst the volume ratio and the Nash-Sutcliffe value have improved (PR 1.00 → 0.96, VR 1.23 → 1.20, NS 0.84 → 0.91)
- In the 2011 event, the peak flow ratio is similar and the volume ratio and Nash-Sutcliffe value have improved (PR 1.04 → 0.96, VR 0.97 → 1.01, NS 0.93 → 0.94)
- In the 2013 event, the comparison of peak flow ratios and volumes has worsened slightly whilst the Nash-Sutcliffe comparison has improved slightly (PR 1.00 → 0.98, VR 1.15 → 1.17, NS 0.95 → 0.96)
- The peak flow ratios are classed excellent for the four events with recorded data. The volume ratios are classed as excellent in the 1996 and 2011 events and good in the 1999 and 2013 events. The Nash-Sutcliffe values are classed good in the 1996, 1999 and 2011 events and excellent in the 2013 event
- Overall the ranked calibration is similar to the Seqwater calibration with a tendency to slightly underestimate peak flows but with a slight improvement on volume ratios and Nash-Sutcliffe values.

3.5.5 Recommended parameters

The recommended parameters for the model were calculated based upon the values provided in Table 3-2. The recommended parameters are:

- Typical continuing loss = 1.3 mm/hr with a range between 1.0 and 2.5 mm/hr
- Alpha = 0.79 with a range of between 0.70 and 1.00
- Beta = 2.8 with a range of between 2.5 and 3.0
- Catchment non-linearity exponent m = 0.8
- Channel routing parameter n = 0.85

The recommended parameters have been compared to those recommended by Seqwater, as shown in Table 3-14. To assist in the comparison, an additional set of recommended parameters have been calculated based on Seqwater's calibration results for the only five adopted calibration events.

Table 3-14 Comparison of recommended parameters for Bremer River

Parameter	Revised recommended value	Seqwater recommended value	Recommended value from Seqwater results based on five calibration events only
Alpha	0.79	0.35	0.30
Beta	2.8	3.0	3.0
m	0.8	0.8	0.8
n	0.85	1.0	1.0

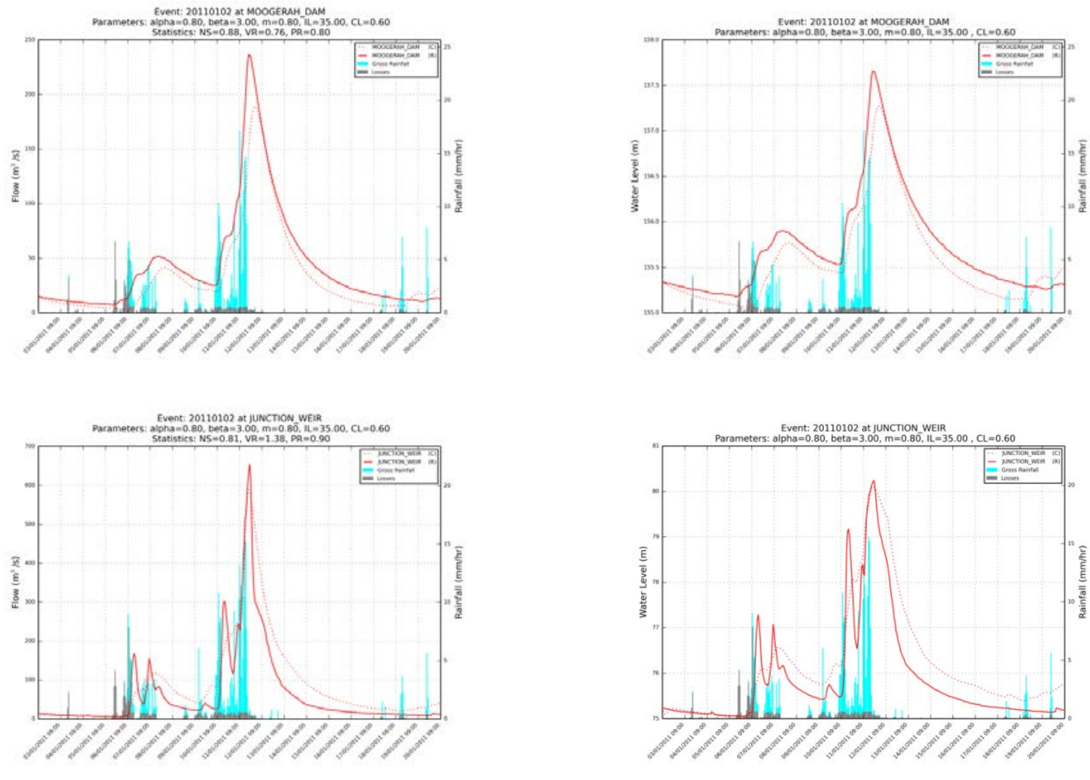
Table 3-14 shows that the changes to the rating curves and non-linearity parameter n, have resulted in a significant increase to the channel routing parameter alpha. The typical continuing loss rate of 1.3 mm/hr is reduced from Seqwater's typical value of 1.8 mm/hr.

3.6 Warrill Creek

3.6.1 Calibration plots

Calibration plots for the Warrill Creek model in the January 2011 event are provided in Figure 3-6. Additional plots overlaying the recalibration results with Seqwater's results and the rated flows are provided in Appendix B.

Flow **Height**



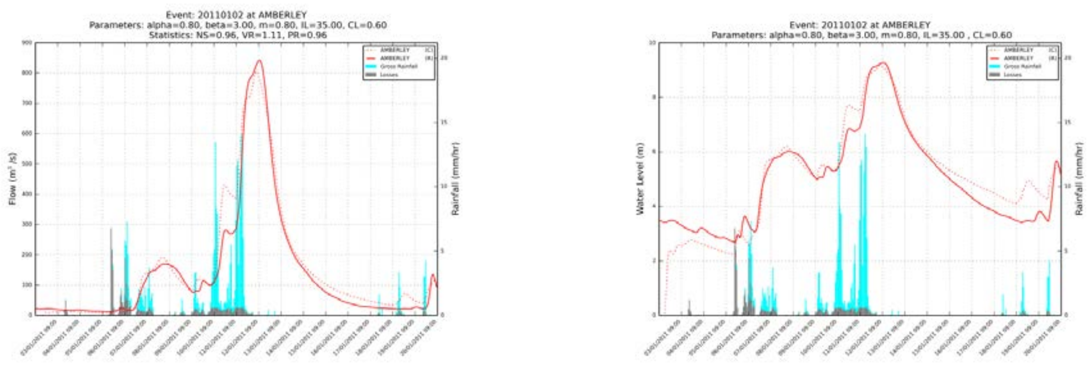


Figure 3-6 Warrill Creek calibration plots – January 2011 event

3.6.2 Calibration results summary

The calibration event results at Amberley are summarised in Table 3-15.

Table 3-15 Warrill Creek model calibration statistics at Amberley

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	1,990	2,533	0.79	326,258	312,940	1.04	0.96
19960430	441	400	1.10	116,642	127,742	0.91	0.90
19990207	200	196	1.02	29,206	28,065	1.04	0.97
20110102	806	841	0.96	240,558	217,075	1.11	0.96
20130123	1,127	1,309	0.86	199,450	177,401	1.12	0.96

3.6.3 Calibration performance ranking

The calibration rankings at Amberley are summarised in Table 3-16.

Table 3-16 Warrill Creek model calibration performance at Amberley

Event	Calibration parameters					Calibration performance ranking					
	IL	CL	α	β	m	PR	VR	NS	Magnitude	Rainfall	Total event weighting
19740124	90	1.20	0.70	2.0	0.80	2	5	5	5	3	0.08
19960430	80	1.50	0.90	4.0	0.80	4	5	4	5	4	0.16
19990207	50	0.70	0.70	2.0	0.80	5	5	5	4	4	0.20
20110102	35	0.60	0.80	3.0	0.80	5	5	5	5	5	0.31
20130123	150	5.00	0.80	1.5	0.80	4	5	5	5	5	0.25

3.6.4 Comparison to Seqwater calibration

In comparison to Seqwater's calibration, the revised calibration shows:

- In the 1974 event, the peak flow ratio and the Nash-Sutcliffe value have worsened whilst the volume ratio has improved (PR 0.99 → 0.79, VR 1.08 → 1.04, NS 0.98 → 0.96)
- In the 1996 event, the peak flow ratio has worsened, whilst the volume ratio and the Nash-Sutcliffe value are similar (PR 1.09 → 1.10, VR 0.91 → 0.91, NS 0.90 → 0.90)
- In the 1999 event, all three parameters are improved as a result of removal of the infiltration capacity limit which was previously applied to this event (PR 1.13 → 1.02, VR 1.28 → 1.04, NS 0.92 → 0.97)
- In the 2011 event, the peak flow ratio is similar whilst the volume ratio and the Nash-Sutcliffe value are worsened (PR 1.04 → 0.96, VR 1.09 → 1.11, NS 0.98 → 0.96)
- In the 2013 event, the peak flow and volume ratios are worsened, but Nash-Sutcliffe value is similar (PR 0.96 → 0.86, VR 1.11 → 1.12, NS 0.95 → 0.96)
- The peak flow ratios are classed as an excellent match in the 1999 and 2011 events, a good match in the 1996 and 2013 events and a poor match in the 1974 event. The volume ratios are classed as an excellent match in all events. The Nash-Sutcliffe values are classed as excellent in all events except the 1996 event in which it is classed "good"
- Overall the ranked calibration is similar to that of Seqwater, with a worsening in the peak flow ratios a slight improvement in the volume ratios and similar Nash-Sutcliffe values

3.6.5 Recommended parameters

The recommended parameters for the model were calculated based upon the values provided in Table 3-2. The recommended parameters are:

- Typical continuing loss = 2.0 mm/hr with a range between 0.7 and 5.0 mm/hr
- Alpha = 0.79 with a range of between 0.70 and 0.90
- Beta = 2.5 with a range of between 1.5 and 4.0
- Catchment non-linearity exponent m = 0.8
- Channel routing parameter n = 0.85

The recommended parameters have been compared to those recommended by Seqwater, as shown in Table 3-17. To assist in the comparison, an additional set of recommended parameters have been calculated based on Seqwater's calibration results for the only five adopted calibration events.

Table 3-17 Comparison of recommended parameters for Warrill Creek

Parameter	Revised recommended value	Seqwater recommended value	Recommended value from Seqwater results based on five calibration events only
Alpha	0.79	0.75	0.78
Beta	2.5	2.8	2.7
m	0.8	0.8	0.8
n	0.85	0.85	0.85

Table 3-17 shows that the channel routing parameters are similar, but the sub-catchment routing parameter, beta, has been slightly reduced as a result of the changes to the rating curves. The typical continuing loss value of 2.0 mm/hr is identical to that of Seqwater’s assessment.

3.7 Purga Creek

3.7.1 Calibration plots

Calibration plots for the Purga Creek model in the January 2011 event are provided in Figure 3-7. Additional plots overlaying the recalibration results with Seqwater’s results and the rated flows are provided in Appendix B.

Flow **Height**

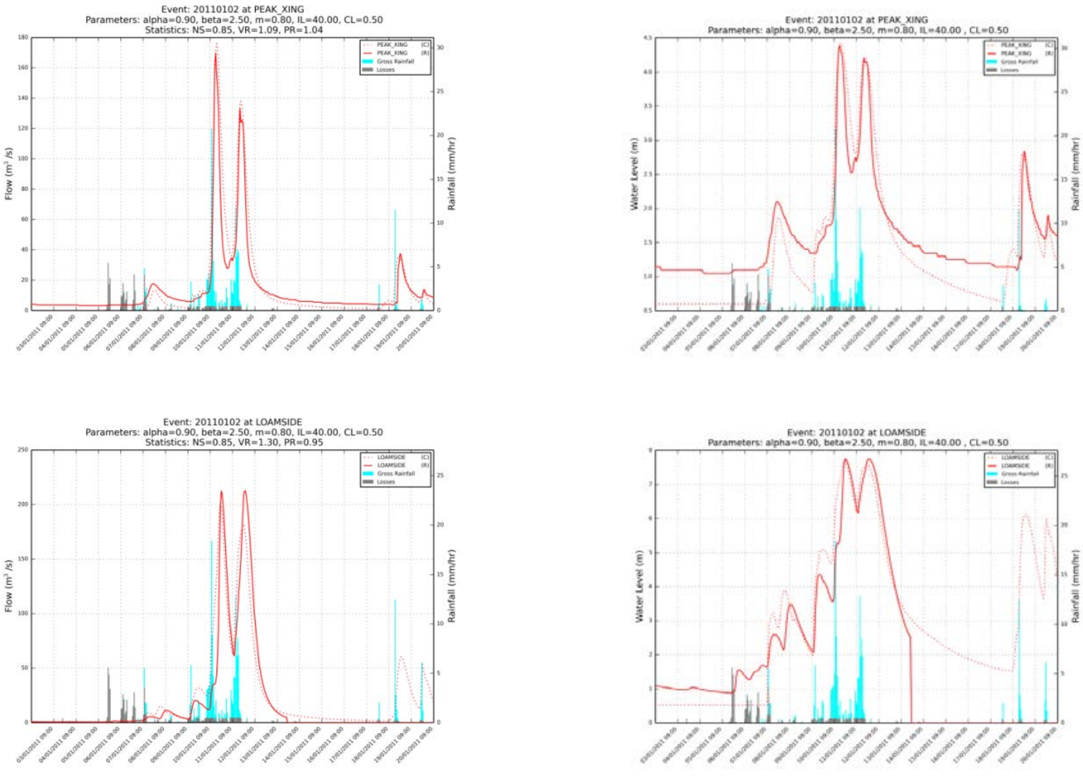


Figure 3-7 Purga Creek calibration plots – January 2011 event

3.7.2 Calibration results summary

The calibration event results at Loamside are summarised in Table 3-18.

Table 3-18 Purga Creek model calibration statistics at Loamside

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	753	751	1.00	74,993	87,556	0.86	0.89
19960430	282	291	0.97	48,669	49,688	0.98	0.97
19990207	66	69	0.96	9,046	7,376	1.23	0.95
20110102	201	212	0.95	34,946	26,960	1.30	0.85

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20130123	123	103	1.20	11,411	10,456	1.09	0.95

3.7.3 Calibration performance ranking

The calibration rankings at Loamside are summarised in Table 3-19.

Table 3-19 Purga Creek model calibration performance at Loamside

Event	Calibration parameters					Calibration performance ranking					
	IL	CL	α	β	m	PR	VR	NS	Magnitude	Rainfall	Total event weighting
19740124	80	2.10	0.40	4.0	80	5	5	3	5	3	0.167
19960430	90	0.50	0.90	3.0	90	5	5	5	5	4	0.372
19990207	30	1.20	1.50	4.0	30	5	4	5	4	4	0.238
20110102	40	0.50	0.90	2.5	40	5	2	2	5	5	0.074
20130123	165	8.00	0.70	6.0	165	2	5	4	5	5	0.149

3.7.4 Comparison to Seqwater calibration

In comparison to Seqwater's calibration, the revised calibration shows that the peak ratio, volume ratio and Nash-Sutcliffe values are improved across all events, resulting in an improved overall calibration.

- 1974: PR 0.99 → 1.00, VR 0.82 → 0.86, NS 0.88 → 0.89
- 1996: PR 1.10 → 0.97, VR 1.32 → 0.98, NS 0.70 → 0.97
- 1999: PR 1.11 → 0.96, VR 1.33 → 1.23, NS 0.91 → 0.95
- 2011: PR 1.14 → 0.95, VR 1.54 → 1.30, NS 0.82 → 0.85
- 2013: PR 1.68 → 1.20, VR 1.13 → 1.09, NS 0.73 → 0.95
- The peak flow ratio is classed excellent for the 1974, 1996, 1999 and 2011 events and is classed poor for the 2013 event. The volume ratio is classed excellent for the 1974, 1996 and 2013 events, good for the 1999 event and poor for the 2011 event. The Nash-Sutcliffe values are classed excellent for the 1996 and 1999 events, good for the 2013 event, fair for the 1974 event and poor for the 2011 event

3.7.5 Recommended parameters

The recommended parameters for the model were calculated based upon the values provided in Table 3-2. The recommended parameters are:

- Typical continuing loss = 2.0 mm/hr with a range between 0.5 and 8.0 mm/hr
- Alpha = 0.93 with a range of between 0.40 and 1.50
- Beta = 3.8 with a range of between 2.5 and 6.0
- Catchment non-linearity exponent m = 0.8
- Channel routing parameter n = 0.85

The recommended parameters have been compared to those recommended by Seqwater, as shown in Table 3-20. To assist in the comparison, an additional set of recommended parameters have been calculated based on Seqwater's calibration results for the only five adopted calibration events.

Table 3-20 Comparison of recommended parameters for Purga Creek

Parameter	Revised recommended value	Seqwater recommended value	Recommended value from Seqwater results based on five calibration events only
Alpha	0.93	0.40	0.39
Beta	3.8	3.4	3.8
m	0.8	0.8	0.8
n	0.85	1.0	1.0

Table 3-20 shows that the changes to non-linearity of the channel routing parameter 'n' and the rating curves for Purga Creek have resulted in an increase in both the alpha and beta parameters. The typical continuing loss of 2.0 mm/hr is reduced slightly from Seqwater's typical value of 2.2 mm/hr.

3.8 Lower Brisbane River

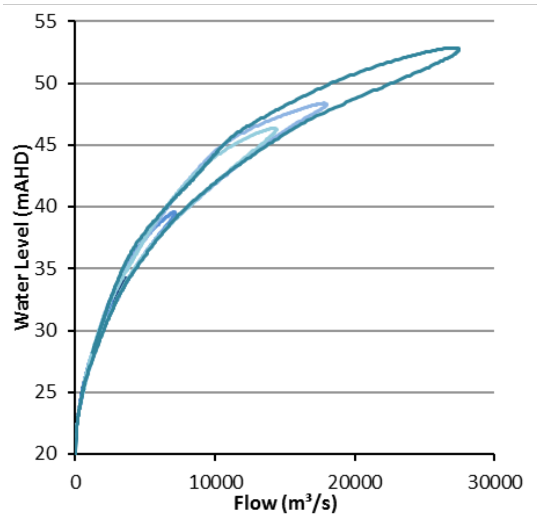
3.8.1 Dynamic hydrographs

Review of the DMT TUFLOW model results suggests that the lower Brisbane River is subject to noticeable dynamic effects (eg hysteresis – the delayed response between flow and water levels, see Figure 3-10) that become increasingly more pronounced with distance downstream. This means that there is not a singular steady-state relationship between flow and water level. The dynamic flow (Q) can often be related to a steady state rating flow (Qr) using the well-known Jones Formula:

$$Q = Q_r(\eta)\sqrt{1 + \frac{1}{cS}\frac{d\eta}{dt}} \qquad (1)$$

where $c = \frac{1}{B}\frac{dQ_r}{d\eta}$, η is the water surface level, *B* is the channel width, *S* is the channel slope.

Figure 3-8 shows the relationship between water level and flow at Savages Crossing from the DMT TUFLOW model for a range of flood events with and without correction using the Jones formula. This method was used to calculate a 'steady-state' rating curve at each of the five key gauges in the lower Brisbane River (Savages Crossing, Mt Crosby Weir, Moggill, Centenary Bridge and Brisbane City). URBS currently does not include dynamic correction, so the Jones Formula was also used to convert the recorded water levels into a dynamic flow. Note that in order for URBS to produce recorded flows for comparison with the calculated flows, these dynamic flows were then converted back to an equivalent water level. The water levels input and reported by the URBS model therefore do not match the recorded water levels, but rather a water level matched to the dynamic flow by the steady-state rating curve. The Seqwater analysis did not apply a dynamic correction to the lower Brisbane River ratings.



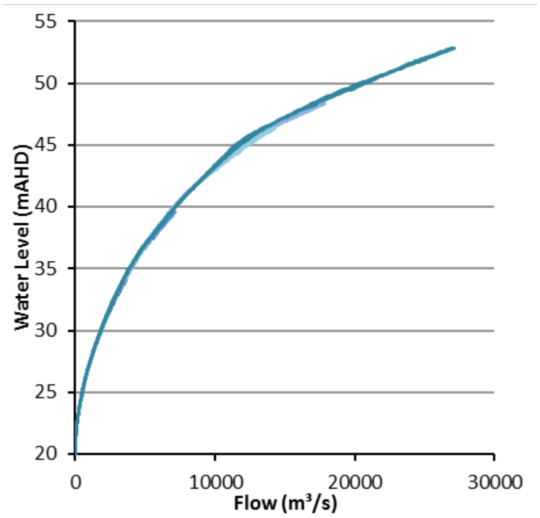


Figure 3-8 Flow and water level relationship at Savages Creek with and without Jones correction

3.8.2 River storage attenuation

The Lower Brisbane River model has a number of significant challenges. The river responds differently at different flowrates. For low flows the river is highly channelized and displays little dynamic effect. At higher flows, the river breaks out into certain areas while remaining channelized in others. As shown in Figure 3-9 (reproduced from the Seqwater report), these areas are often offline from the main river channel (eg Lower Lockyer Creek, Bremer River and Oxley Creek floodplains) and are of comparable surface area to Wivenhoe, and consequently represent potentially significant storage and flood attenuation.

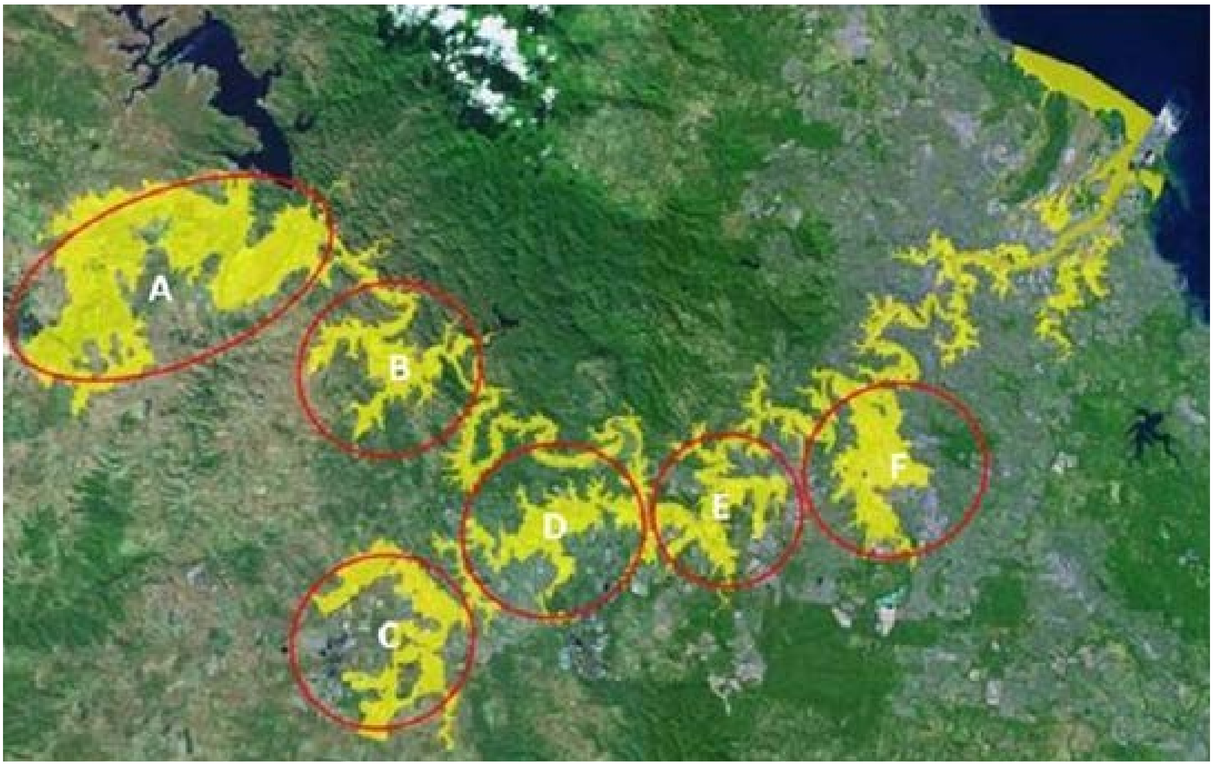


Figure 3-9 Seqwater Figure 7-95: Conceptual flood storages – Lower Brisbane River

The Seqwater models have attempted to account for these flow patterns by including additional storage volume within the models, relating a defined additional storage volume to a known flow rate in the river. A limitation of these storages is that they do not account for the dynamic response of the river. Figure 3-10 shows the flow and water level at Moggill for the 2011 calibration extracted from the DMT hydraulic model. During the rising limb of the hydrograph, the flow and water level increase simultaneously, however the water level continues to increase after the flow has peaked and the receding water level lags significantly behind the flow. This means that additional water continues to be stored/delayed upstream of Moggill for around 4 hours after the flood peak, and the stored flow does not release until 10 hours after the equivalent flow. The hydrologic model storage is linked to flow, not water level, and consequently the hydrologic model will release the stored volume much earlier than predicted by the hydraulic model.

The flow hydrograph at any location is a complex interaction dependent on both the magnitude and coincident timing of inflows from local catchments and a number of major tributaries (upper Brisbane/Wivenhoe, Lockyer Creek and Bremer River), as well as the travel time and storage attenuation within the river and floodplain. This means that the issues with the premature release of stored volume can have a significant bearing on the resulting flow hydrographs downstream, and that these issues will compound downstream of each storage and inflow.

To include offline storage areas and dynamic effects properly in the hydrologic model would require (as a minimum) the storage to be related to level rather than flow, but to determine level the model must be able to predict the dynamic response of the downstream system including influence of channel conveyance, storages, inflows and the like. This is theoretically possible by reversing the Jones Formula method used to determine the dynamic hydrographs discussed in Section 3.8.1, but this is currently outside the capabilities of URBS.

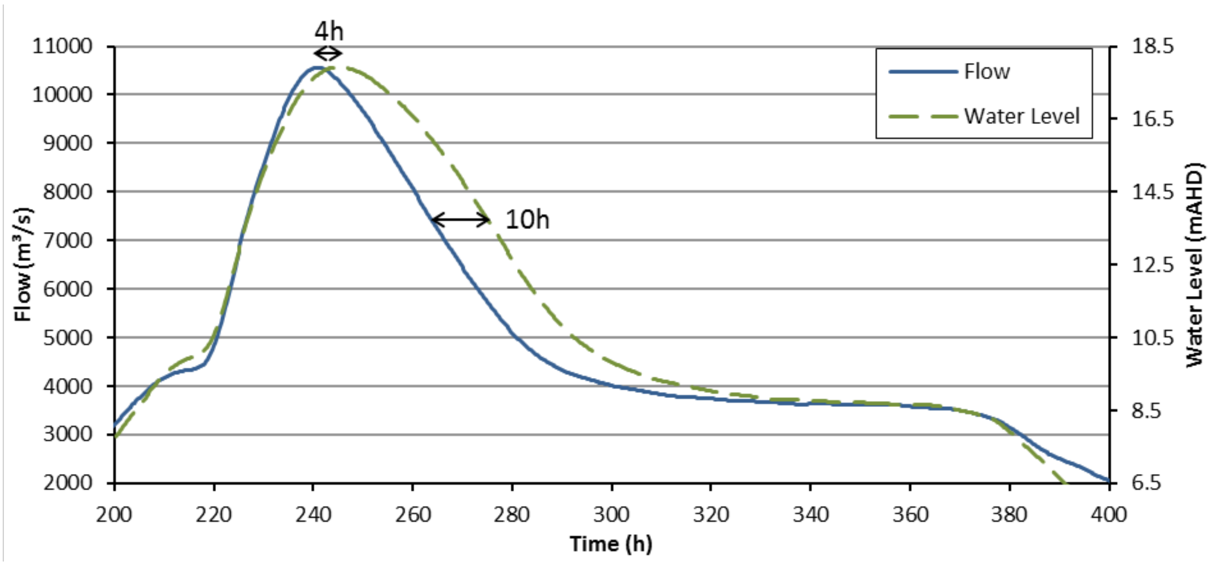


Figure 3-10 DMT TUFLOW model 2011 calibration – flow and water levels at Moggill

3.8.3 Adopted conceptual storages

As part of the *Hydrologic Model Calibration and Validation Review* it was recommended that the Seqwater relationships be modified by reducing the storage for flows above 10,000 m^3/s. It was found that with the changes to the upstream models, these relationships were no longer appropriate and modifications to the conceptual storages were required to improve the calibration. Initial efforts at calibrating the Lower Brisbane URBS model were focussed on using model parameters (alpha and beta) and conceptual storages similar to those developed by Seqwater. However, review of the model and results identified a number of issues with the implementation of the storages:

- The storage volumes had no 'physical' basis, being estimated by trial-and-error investigation of their effect on the hydrographs for the calibration events. They could therefore at best be considered 'reliable' only up to the 1974 flood magnitude (~12,000 m^3/s) with some confidence up to 1893 floods (17-18,000 m^3/s) but no basis for extrapolation above this
- Modelled travel time in the main river channel appeared to be slower than in reality, with modelled flows in the Brisbane River at Moggill lagging significantly (4 to 10 hours) behind what the stream gauges and TUFLOW hydraulic model indicated them to arrive at. This delay has potentially significant implications when assessing the coincidence of Bremer River flows

In order to address the latter issue the main channel routing speed has been increased to improve timing of flows through the system. Initially this was achieved by reducing the alpha routing parameter, however as this also affected local tributary flows, the method ultimately adopted was to reduce the main channel reach lengths. A consequence reducing alpha and/or reach length is removal of storage from the Muskingham channel routing in the URBS routing, placing greater emphasis on the conceptual storages placed along the main river channel. To improve confidence in the storage-discharge relationships used in the conceptual storages, they have been related directly to physical properties of the river and floodplain by combining level-volume relationships taken directly from a digital elevation model of the floodplain with level-flow relationships estimated from the main gauge rating curves.

Overall, these modifications appeared to noticeably improve the model's representation of hydrograph timing and shape in the calibration events while also providing a physical basis for extrapolation of the storages to larger flows. A number of limitations of the implementation still need to be noted:

- Level discharge relationships are based on currently adopted ratings at the major Brisbane River gauges, which are largely influenced by DMT TUFLOW model results. These will need to be confirmed as part of the hydraulics phase of the BRCFS, particularly extension of the ratings for extreme discharges
- As discussed further in this section and in Section 3.8.2 above, limitations of the hydrologic model framework mean that conceptual storages cannot fully represent the complexities of a fully dynamic system (eg hysteresis or backflow of Brisbane River flows up Lockyer Creek or Bremer River)
- As the bulk of the channel storage is lumped at discrete points in the system, the calibration has optimised hydrographs at the major gauges but intermediate points may not be as well represented

Conceptual storage A represents the storage around the confluence of Lockyer Creek and the Brisbane River. In the initial Seqwater modelling this storage also included areas and effects that are technically part of the lower Lockyer floodplain within the domain of the Lockyer URBS model. The revised schematisation of the lower Lockyer model and the increased reach length factors included in the floodplain bypass channels mean that these storage effects are now partly represented in the Lockyer Creek model, and the adopted storage volumes are therefore typically lower than those used by Seqwater, particularly for larger events as shown in Figure 3-11.

It should be cautioned that the behaviour of the floodplain storage areas in the lower Lockyer can be complicated depending on the magnitude and timing of Lockyer Creek and Brisbane River flows. The adopted storage profile appears to perform well under most of the examined calibration flood events, however large flows from the Upper Brisbane with little coincident flow in Lockyer Creek (eg releases from Wivenhoe) can flow back up Lockyer Creek. The URBS model cannot represent this type of flow behaviour and the storage volume would need to be increased to compensate.

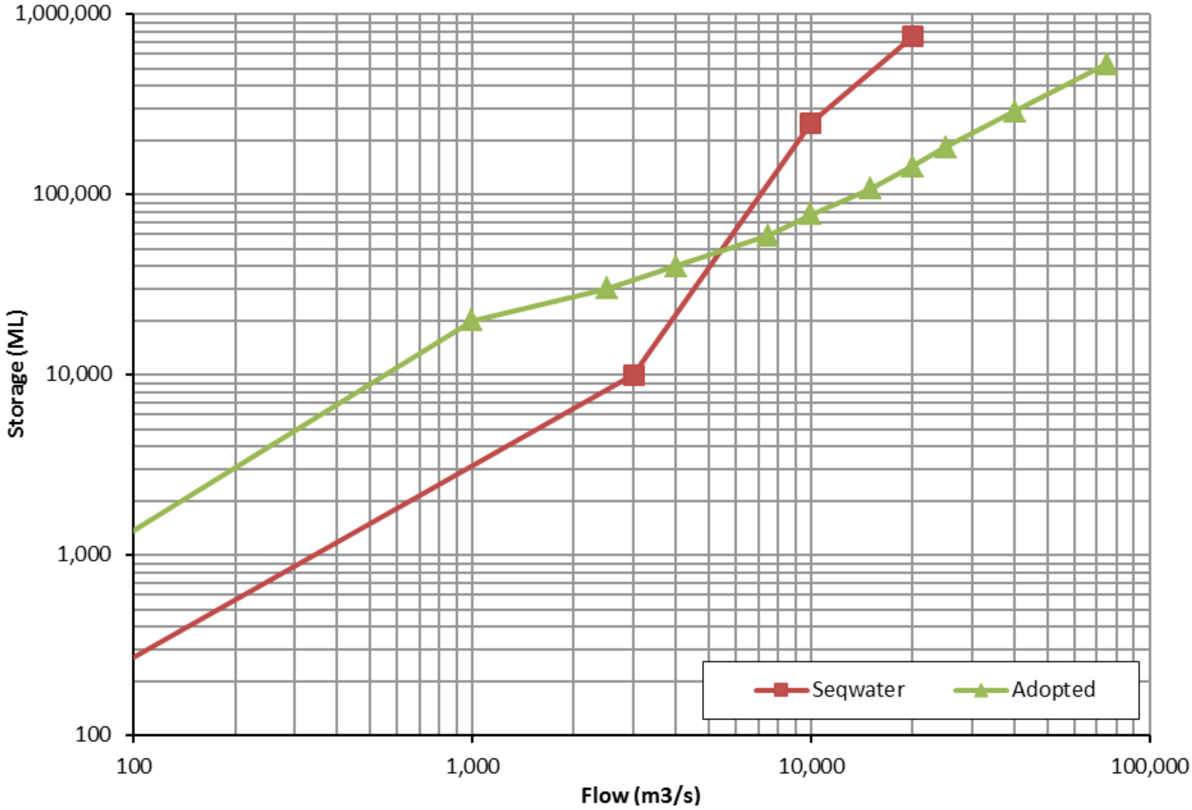


Figure 3-11 Area A conceptual storage

Conceptual storage B is intended to represent the storage between Savages Crossing and Mt Crosby Weir. Seqwater's storage relationship provides relatively little storage compared to the other storages, and the adopted relationship significantly increases the storage volume, as shown in Figure 3-12. The reason for this increase may be attributed to reduction in Muskingum storage in the main channel but also improved understanding of the attenuation between Savages Crossing and Mt Crosby Weir provided by the DMT TUFLOW model.

Conceptual Storage C covers the area of the lower Bremer River upstream of Ipswich. This area is hydraulically complicated because it is affected by both Bremer River flows and backwater from the Brisbane River. When calibrating the model a better match of timing of flows at Moggill was achieved by moving much of the storage volume from Area C to Area D. Physically, this can be justified in that Bremer River flows rise and fall, but water is retained within the storage by elevated Brisbane River levels. The URBS implementation does not allow for a multi-dependent storage. The Area C storage has been implemented as a relatively small storage volume, shown in Figure 3-13, with the remainder of the area included with Area D. Based on the calibration events, this is considered to be a reasonable approximation, but may not be appropriate for events significantly dominated by Bremer River flows.

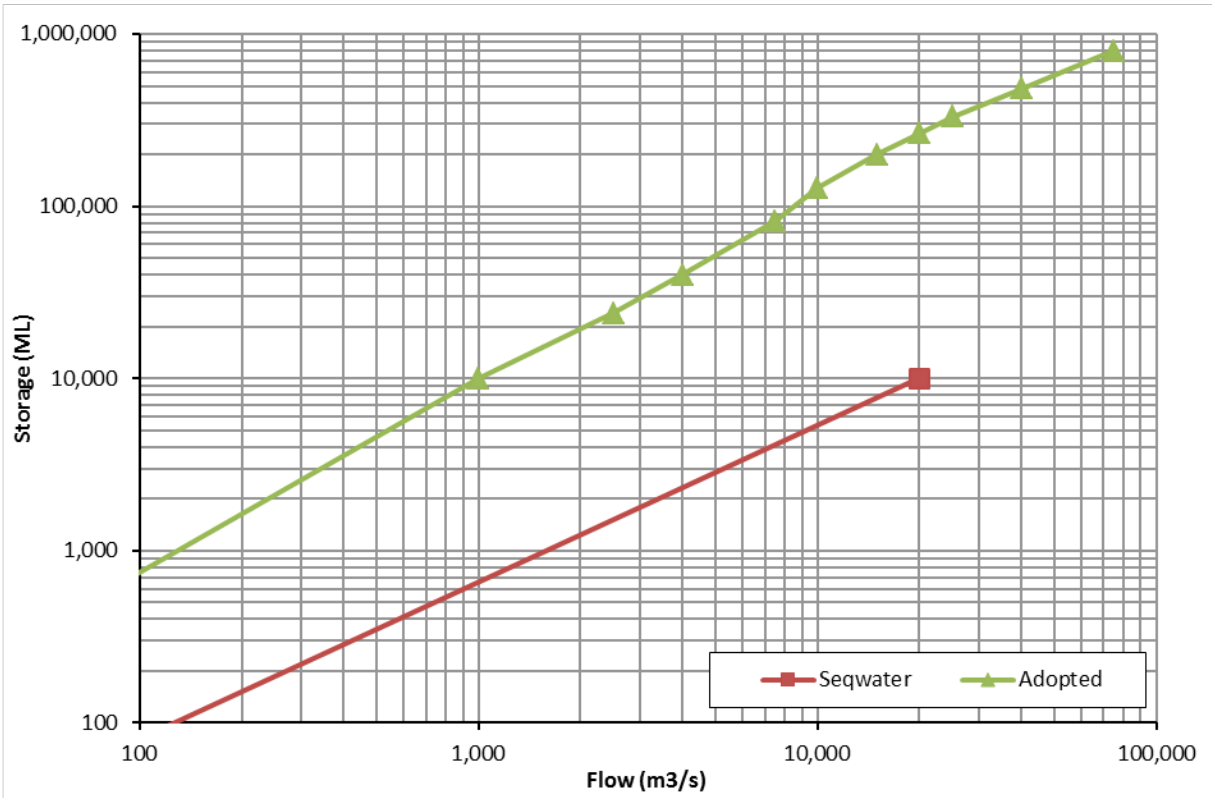


Figure 3-12 Area B conceptual storage

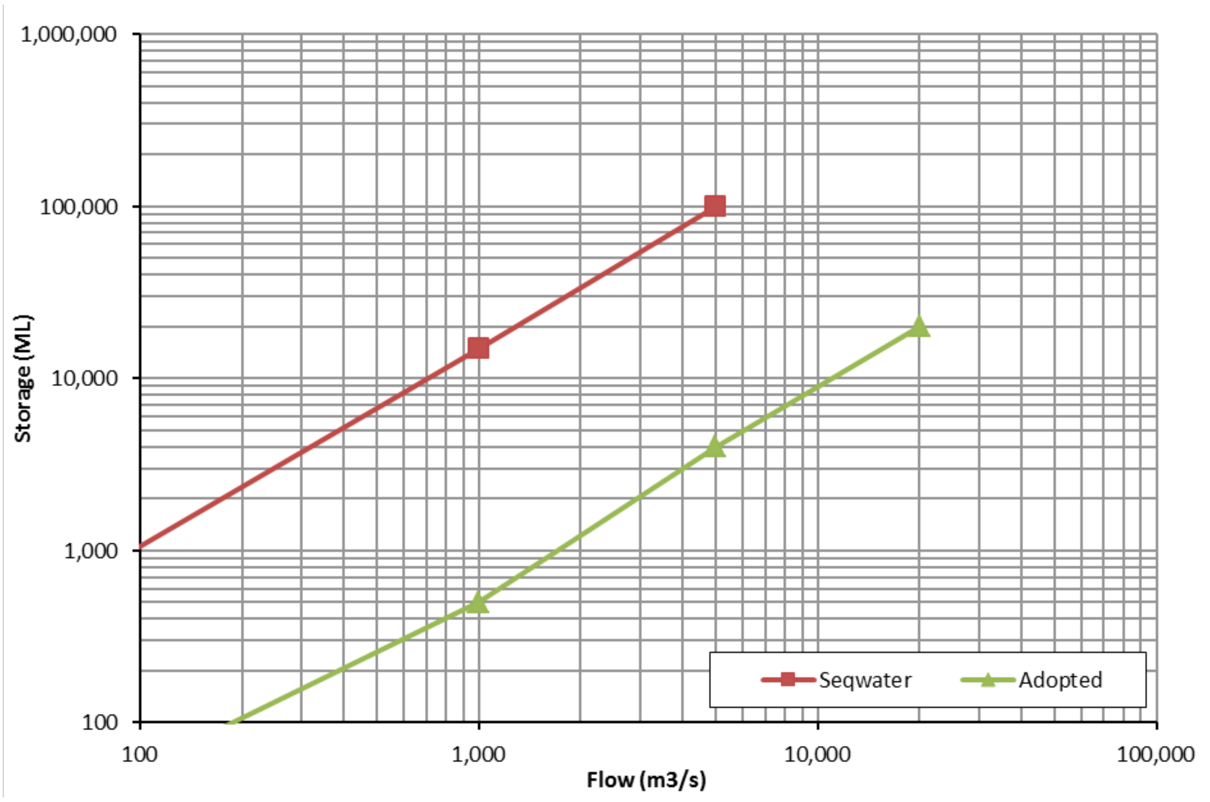


Figure 3-13 Area C conceptual storage

The storage in the Bremer River floodplain between Ipswich and Moggill is represented by conceptual storage D. Whilst it was previously recommended that the storage volumes for high flows be reduced, changes to the main channel reach lengths and inclusion of volume from Area C has resulted in an increased storage volume relationship being adopted, as shown in Figure 3-14.

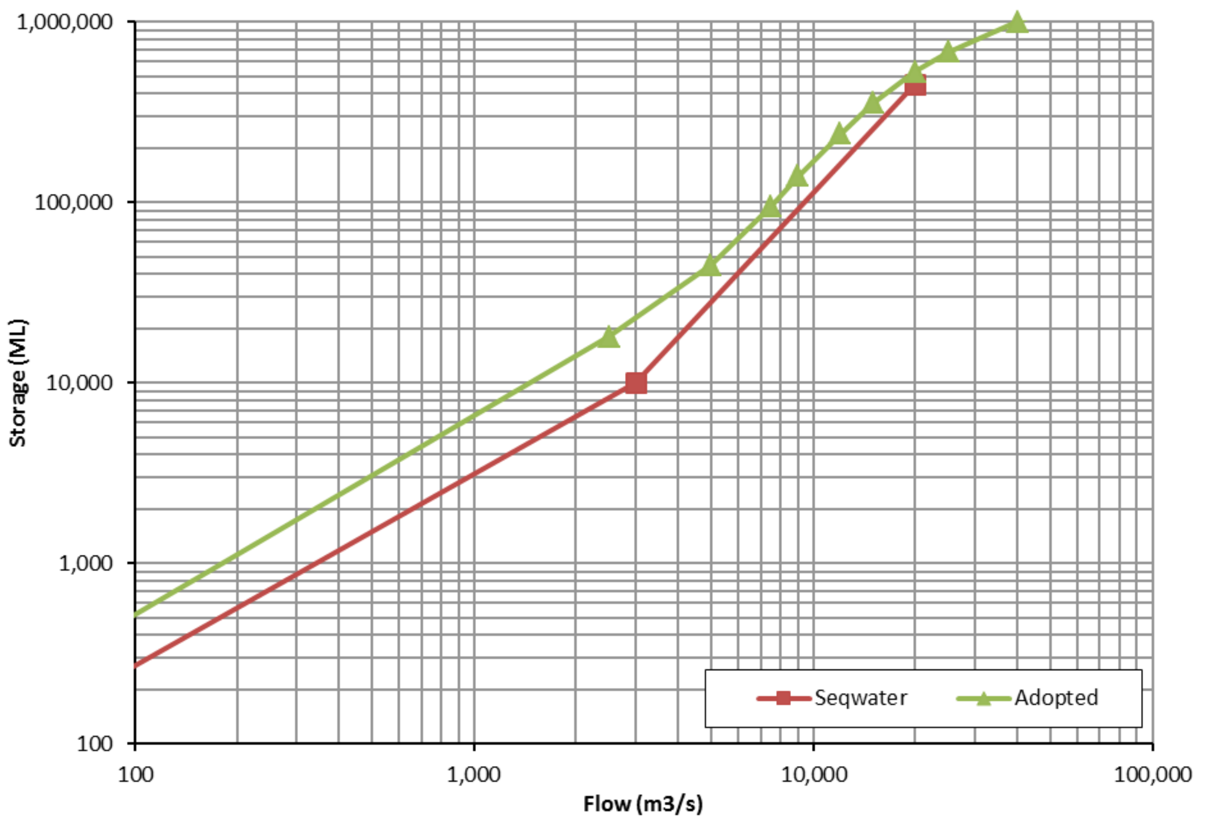


Figure 3-14 Area D conceptual storage

Conceptual storages E and F cover the areas between Moggill and Centenary Bridge and between Centenary Bridge and Brisbane City (primarily the Oxley Creek floodplain area) respectively. As with areas B and D, the revised storage relationships based on DTM level-volume and stream gauge level-flow relationships are typically larger than those used by Seqwater, offsetting the reduced Muskingham storage in the main channels.

3.8.4 Ipswich gauge

The Ipswich gauge was not considered for the recalibration process. The flow interactions at this location were considered too complex for it to be a suitable calibration location. The DMT TUFLOW model shows inconsistencies between the rated flows and the modelled flows at this location, giving low confidence in the gauge rating.

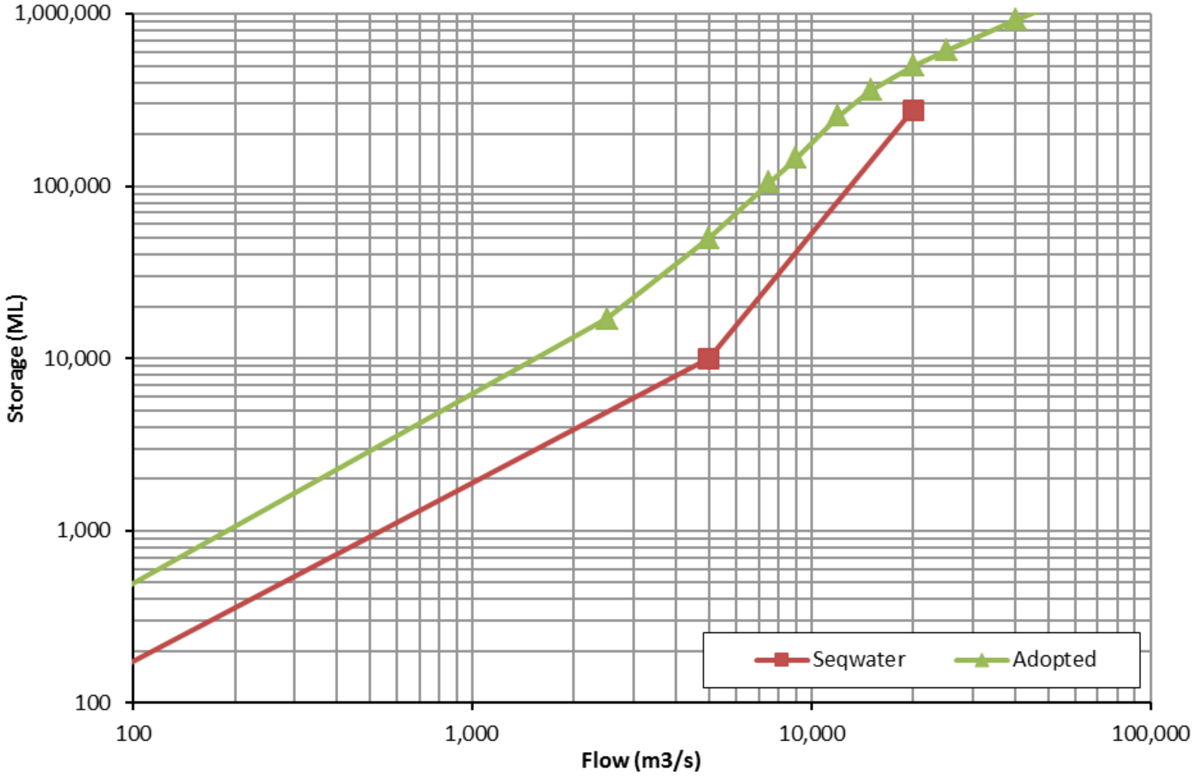


Figure 3-15 Area E conceptual storage

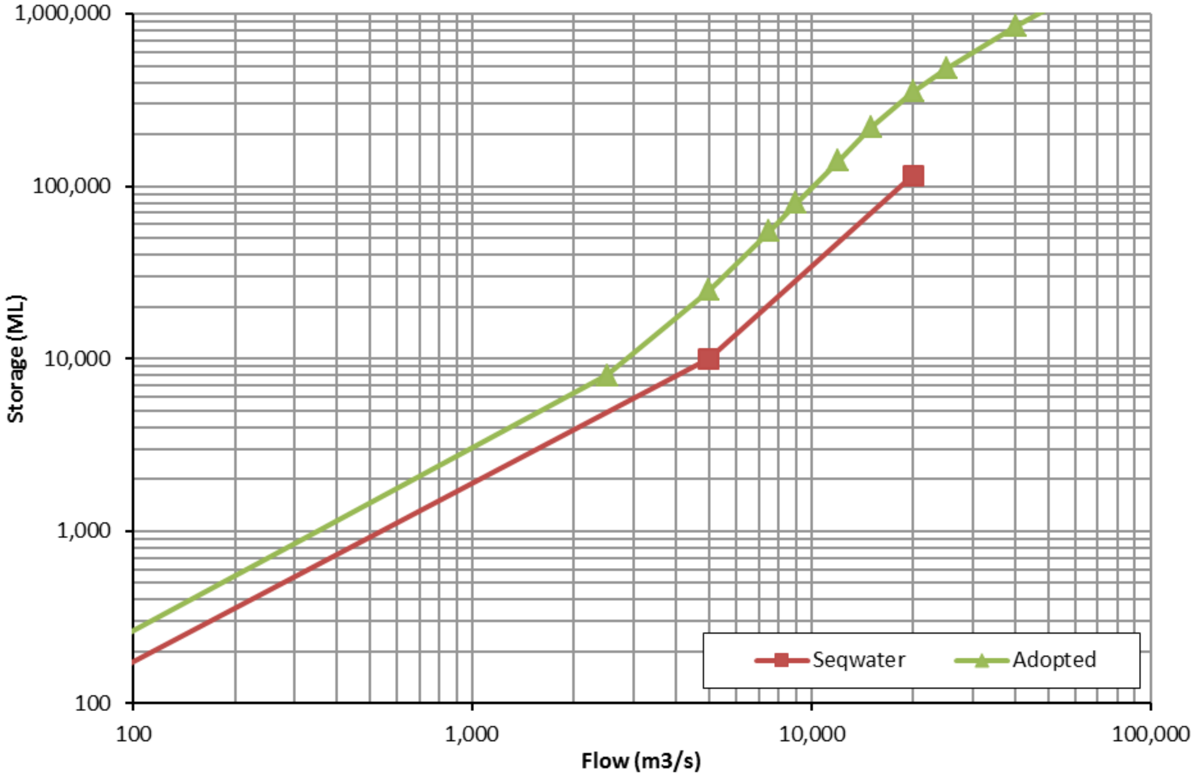


Figure 3-16 Area F conceptual storage

3.8.5 Calibration comments

The lower Brisbane River floodplain is a complex, dynamic system with multiple significant tributary inflows and backwater influences, and as discussed in the section above cannot be represented correctly (in pure technical terms) within the limitations of a hydrologic model network. During the calibration process it became apparent that, although the model generally provided a good estimate, it could not perfectly match every condition of every event, whether due to uncertainty in the rainfall and other data, or simply limitations of the model. The adopted parameters have therefore been selected as giving a good overall fit of the majority of calibration events, but recognising that some compromise is required in certain areas.

The 1974 and 2011 events, whilst having similar peak flows, exhibit different characteristics between Savages Crossing, Mt Crosby Weir and Moggill. The 2011 flood event actually caused higher water levels than the 1974 flood at Lowood and Savages Crossing, but lower levels at and downstream of Mt Crosby. A likely contributor to this effect is that the 2011 event hydrograph is strongly affected by Wivenhoe releases, with a sharper flood peak of similar magnitude but much shorter duration than 1974, resulting in lower volume and greater storage attenuation as the flood progresses downstream (within the peak; the 2011 event contained greater overall volume than 1974 but much of this occurred within the controlled Wivenhoe release following the main peak, see Figure 3-17). The hydrologic model exhibits similar trends but cannot perfectly match both events. The representation of storage at discrete locations and inability to dynamic river response (storage lags behind flow as discussed in Section 3.8.2) are key limitations in this respect.

The primary model calibration parameters are the channel and catchment lag parameters (alpha and beta respectively). As alpha affects both the main channel and local tributary inflows, alpha and beta have been selected based on their effect on local tributaries, with reach length factors applied to the main channel to adjust the routing time along the main river channel and lumped conceptual storages applied to represent the storage attenuation. However, the local tributary catchments are themselves highly diverse, varying from steep catchments of the D'Aguilar Ranges on the northern catchment boundary to the much flatter catchments such as Oxley Creek. Review of two local tributaries identified that an alpha of 0.15 and beta of 3 provided a relatively good match of hydrograph shape and timing for Cabbage Tree Creek (Lake Manchester), but produced a hydrograph that peaked too early for Oxley Creek where alpha of 0.4 and beta of 0.5 provided a better fit of hydrograph timing. The alpha, beta and main channel reach length scaling factor identified in Section 3.8.10 have therefore been recommended as giving a reasonable balance of overall catchment properties.

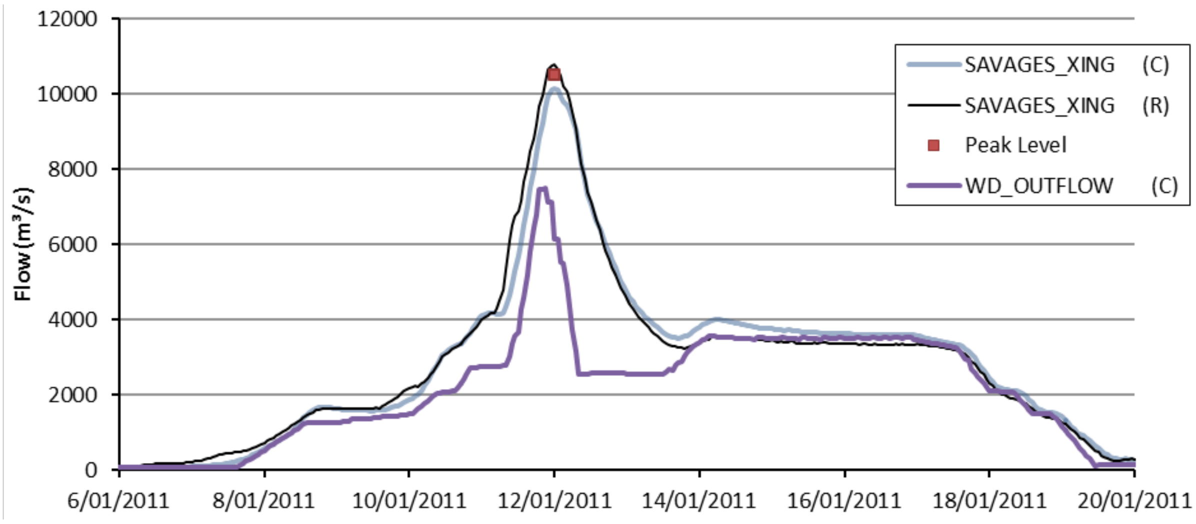
Initial calibration methods involved varying calibration parameters for each individual event and then determining a weighted composite value. Due to the number of potential calibration parameters (alpha, beta, reach length factor, conceptual storages etc), final fine-tuning was undertaken to determine a single set of parameters that provided a good fit for all events, but would not necessarily a perfect fit for any one event. The results presented in the following sections are based on this single parameter set. Differences to Seqwater's calibration results therefore include:

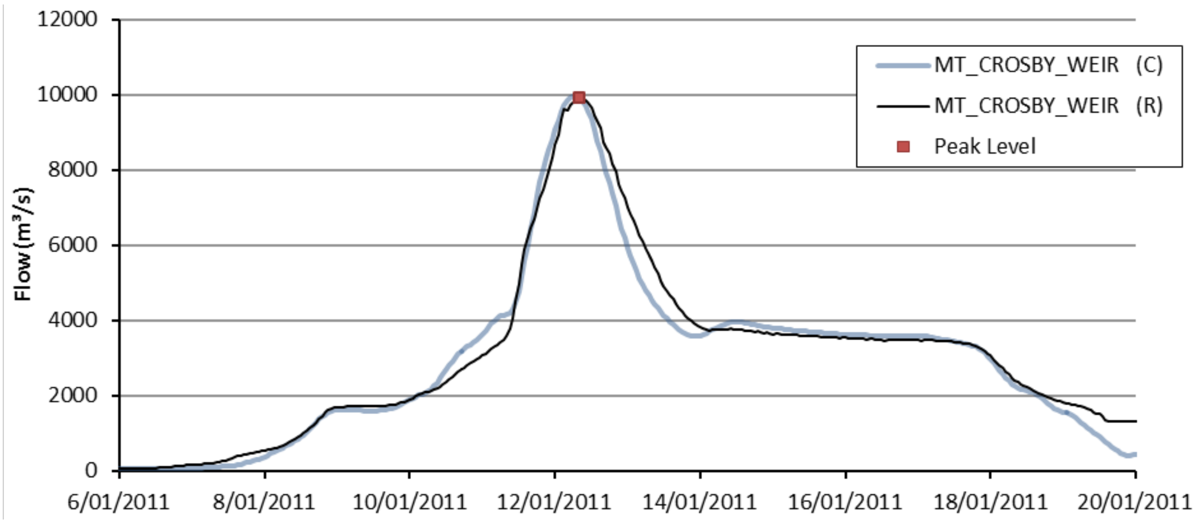
- Use a single consistent set of parameters for all events
- Emphasis on matching timing and shape of the hydrograph at all gauges throughout the system rather than peak flow at any particular gauge

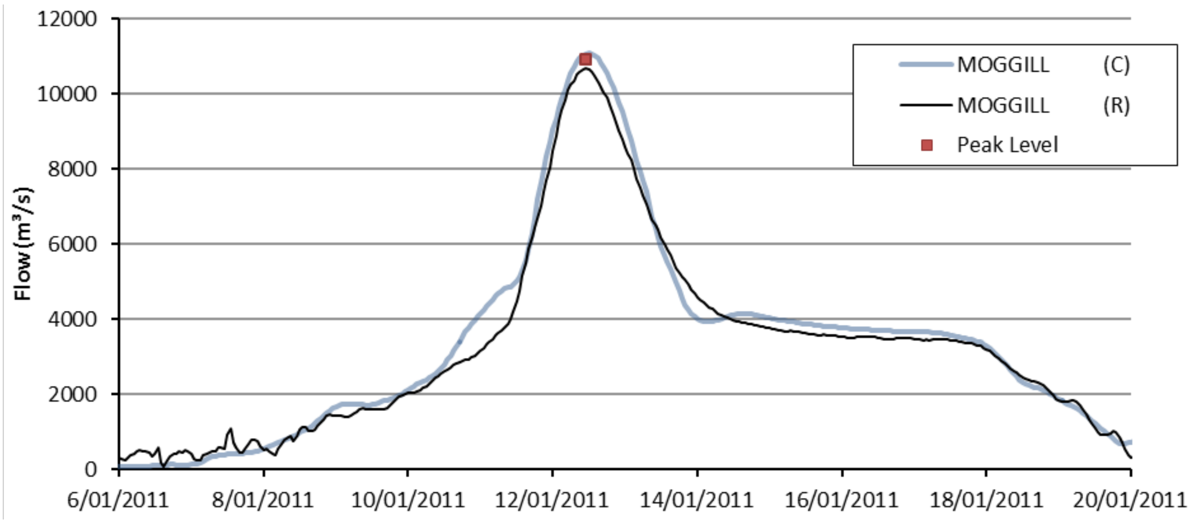
For the 1974 event calibration, inflows from the Lockyer and Upper Brisbane models did not match the timing of the hydrograph at Savages Crossing (and consequently further downstream). Although reasonable calibration was achieved at various points within these catchments (Gregors Creek, Somerset, Glenore Grove) there are large areas downstream of these gauges where reliable stream gauge data is not available. Recognising the level of uncertainty in the location and timing of rainfall across the lower Lockyer and Upper Brisbane catchments and as the focus of the calibration was to confirm routing through the Lower Brisbane model, Lockyer inflows into the Lower Brisbane model were adjusted using different losses to those used in in the Glenore Grove calibration and shifting the timing forward by 6 hours to improve consistency of the model results at Savages Crossing.

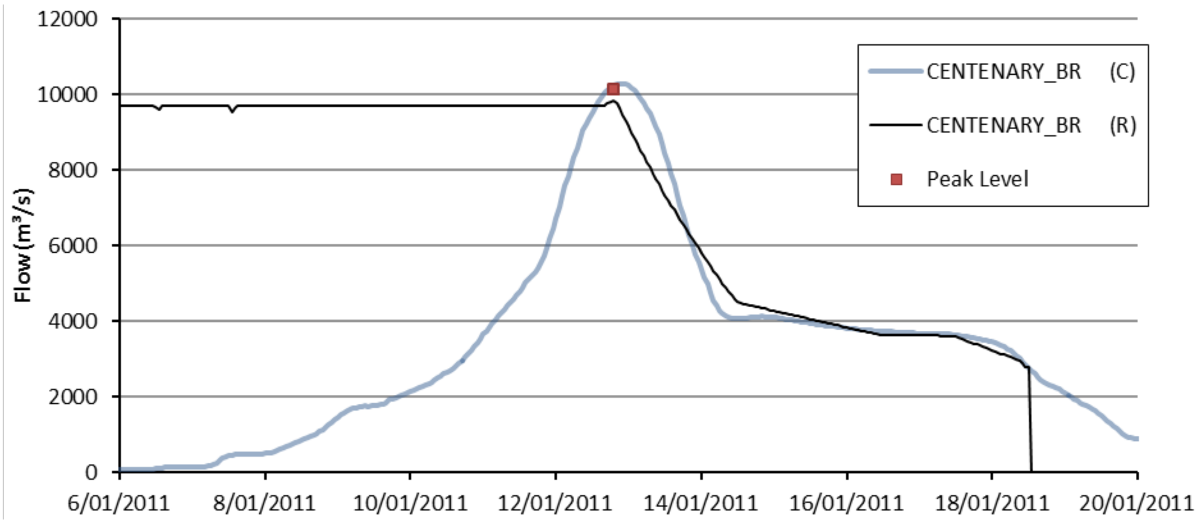
3.8.6 Calibration plots

Calibration plots for the Lower Brisbane River model in the January 2011 event are provided in Figure 3-17. Additional plots overlaying the recalibration results with Seqwater's results and the rated flows are provided in Appendix B.









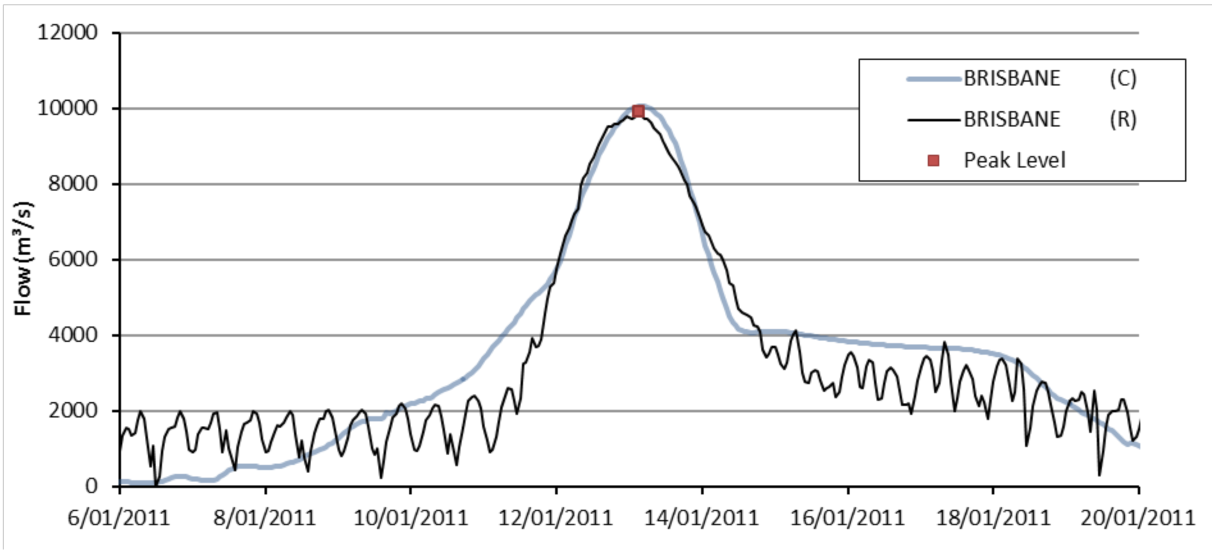


Figure 3-17 Lower Brisbane River calibration plots – January 2011 event

3.8.7 Calibration results summary

The calibration event results at Mt Crosby Weir and Moggill are summarised in Table 3-21 and Table 3-22. Values highlighted with an asterisk (*) are affected by incomplete or erroneous gauge record.

Table 3-21 Lower Brisbane River model calibration statistics at Mt Crosby Weir

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	9,938	10,247	0.97	2,423,172	2,747,706	0.88	0.92
19960430	2,544	2,447	1.04	820,135	1,254,070*	0.65*	-6.76*
19990207	1,891	1,822	1.04	913,768	1,070,808*	0.85*	0.67*
20110102	9,954	10,004	1.00	3,640,578	3,810,416	0.96	0.98
20130123	2,335	2,185	1.07	1,298,799	1,215,045	1.07	0.96

Table 3-22 Lower Brisbane River model calibration statistics at Moggill

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19740124	12,282	12,553	0.98	3,451,528	3,230,759*	1.07*	0.95*
19960430	3,512	3,313	1.06	1,284,821	1,362,018	0.94	0.96
19990207	2,135	2,026	1.05	1,024,227	782,345*	1.31*	0.83*
20110102	11,073	10,658	1.04	4,134,425	4,077,076	1.01	0.98
20130123	3,543	3,738	0.95	1,679,183	1,763,176	0.95	0.93

3.8.8 Calibration performance ranking

The calibration rankings at Mt Crosby Weir and Moggill are summarised in Table 3-23.

Table 3-23 Lower Brisbane River model calibration performance

Event	Calibration parameters					Calibration performance ranking at Mt Crosby			Calibration performance ranking at Moggill		
	IL	CL	α	β	m	PR	VR	NS	PR	VR	NS
19740124	30	0.3	0.3	4.0	0.8	5	5	4	5	5	5
19960430	170	0.25	0.3	4.0	0.8	5	2*	0*	5	5	5
19990207	120	0.5	0.3	4.0	0.8	5	5	2*	5	2*	2*
20110102	40	2.5	0.3	4.0	0.8	5	5	5	5	5	5
20130123	150	3.0	0.3	4.0	0.8	5	5	5	5	5	4

3.8.9 Comparison to Seqwater calibration

In comparison to Seqwater's calibration, the revised calibration of the Lower Brisbane River at Moggill shows:

- In the 1974 event, although the matching of the peak flow is slightly worse than Seqwater's calibration (which achieved a ratio of 1 at Moggill) the shape and timing of the hydrograph is better represented as indicated by the Nash-Sutcliffe parameter. Although the volume ratio appears to be worse, the rated hydrograph does not cover the full receding limb so the rated volume is underestimated and the revised calibration actually provides a better match of volume (PR 1.00 → 0.98, VR 1.03 → 1.07, NS 0.92 → 0.95)
- In the 1996 event, the shape of the hydrograph has been modified significantly as a result of the schematisation changes in the lower Lockyer model. The peak flow ratio is slightly worsened however the volume ratio and Nash-Sutcliffe values are both improved (PR 1.04 → 1.06, VR 0.91 → 0.94, NS 0.90 → 0.96)
- In the 1999 event, all three parameters are significantly improved (PR 1.52 → 1.05, VR 1.69 → 1.31, NS 0.42 → 0.83). The high peak which was previously evident in the model has been reduced, primarily as a result of the reduction in peak flows from the Lockyer and Warrill Creeks and the revised schematisation in the lower Lockyer
- In the 2011 event, the peak flow ratio and volume ratio have improved and the Nash-Sutcliffe value is slightly worsened (PR 1.08 → 1.04, VR 1.02 → 1.01, NS 0.99 → 0.98)
- In the 2013 event, the hydrograph shape is significantly modified as a result of the changes in the lower Lockyer. The peak flow ratio, volume ratio and the Nash-Sutcliffe value are all slightly worsened (PR 1.04 → 0.95, VR 0.98 → 0.95, NS 0.94 → 0.93)
- The peak flow ratios are classed excellent for all five events at both Mt Crosby and Moggill. The volume ratios are classed as excellent for all events except the 1996 event at Mt Crosby and 1999 event at Moggill, where the recorded levels being truncated prior to the end of the event and not a result of a poor volume match. The Nash-Sutcliffe values are generally excellent or good with the exception of the 1996 and 1999 events at Mt Crosby and 1999 event at Moggill, due primarily to issues with the recorded data
- Overall the ranked calibration is similar to that of Seqwater

3.8.10 Recommended parameters

Model parameters alpha and beta were selected as being 'typical' of lower Brisbane River sub-catchments but are not necessarily appropriate for any particular sub-catchment. These generally have relatively minor impact on main channel flows and are therefore considered appropriate for use modelling Brisbane River flood events. The model in its current configuration/calibration is not considered suitable for investigating specific local inflows.

The recommended parameters for the model are:

- Typical continuing loss = 1.9 mm/hr with a range between 0.0 and 3.0 mm/hr
- Alpha = 0.3
- Beta = 4.0
- Reach length factor of 0.2 applied to main channel
- Catchment non-linearity exponent m = 0.8
- Channel routing parameter n = 1.0

The recommended parameters have been compared to those recommended by Seqwater, as shown in Table 3-24. To assist in the comparison, an additional set of recommended parameters have been calculated based on Seqwater's calibration results for the only five adopted calibration events.

Table 3-24 Comparison of recommended parameters for Lower Brisbane River

Parameter	Revised recommended value	Seqwater recommended value	Recommended value from Seqwater results based on five calibration events only
Alpha	0.3	0.15	0.14
Beta	4.0	2.9	2.9
m	0.8	0.8	0.8
n	1.0	1.0	1.0

4 Verification results

4.1 Introduction

The purpose of this section is to summarise the performance of the recommended model parameters on all of the available historical flood events. The recommended model parameters for each of the sub-catchment models as outlined in Section 3 have been adopted for the purpose of this assessment.

Peak flow and volume comparisons for all of the events have been used to compare the overall performance of the recommended model parameters. It is noted that incomplete or inaccurate rainfall or stream gauge records may lead to inconsistencies between rated and modelled volumes.

4.2 Stanley River

4.2.1 Verification results summary

The verification event results at the Somerset Dam inflow are summarised in Table 4-1.

Table 4-1 Stanley River model verification statistics at Somerset Dam inflow

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	4,004	3,639	1.10	511,095	510,926	1.00	0.93
19560307	1,377	1,395	0.99	280,105	293,764	0.95	-0.29
19590215	597	579	1.03	87,869	99,209	0.89	0.46
19591108	1,449	1,221	1.19	243,375	242,316	1.00	0.68
19650718	1,087	1,303	0.83	96,379	96,682	1.00	0.91
19670607	1,858	1,578	1.18	206,257	211,054	0.98	0.91
19680107	1,734	1,841	0.94	461,279	441,814	1.04	0.84
19710216	1,068			280,293			
19711226	1,195			108,670			
19720201	3,436			389,736			
19730705	1,932			266,942			
19740124	3,358	3,362	1.00	586,661	631,076	0.93	0.96
19760119	1,254	1,161	1.08	177,082	180,000	0.98	0.95

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19760209	118			15,293			
19830620	2,549	2,183	1.17	265,250	278,640	0.95	0.95
19880401	1,335			169,432			
19890331	3,413	3,598	0.95	362,258	364,687	0.99	0.96
19890423	3,065	3,630	0.84	346,863	337,691	1.03	0.92
19910205	25			6,638			
19911210	993			106,001			
19920314	2,012			205,736			
19960430	1,499	1,101	1.36	183,547	189,151	0.97	0.90
19990207	3,633	3,449	1.05	496,408	447,894	1.11	0.97
20010130	531			88,176			
20040304	725	645	1.12	64,499	65,430	0.99	0.84
20081116	209	254	0.82	29,574	30,316	0.98	0.66
20090518	861	811	1.06	110,419	113,342	0.97	0.84
20100226	767	717	1.07	198,391	206,327	0.96	0.79
20101006	2,003	1,986	1.01	276,924	284,911	0.97	0.96
20101201	335	288	1.16	92,598	92,484	1.00	0.51
20101216	907	929	0.98	131,905	137,318	0.96	0.85
20101223	524	548	0.96	142,425	147,877	0.96	0.77
20110102	3,876	4,021	0.96	787,185	800,568	0.98	0.93
20120121	829	737	1.13	162,190	173,743	0.93	0.73
20120220	892	614	1.45	213,479	218,104	0.98	0.57
20120316	304	251	1.21	87,721	87,926	1.00	0.29
20130123	2,528	2,194	1.15	212,220	260,658	0.81	0.92
20130215	1,723	1,645	1.05	329,109	376,204	0.87	0.92

The results show that:

- For the peak flow ratio, 17 of the events are considered to have an “excellent” match to the recorded data, 3 are classed as having a “good” match and 8 are considered to have a “poor” match (the respective Seqwater values were 15, 4 and 8)
- For the volume ratio comparison 27 of the 28 events with recorded data are classed as having an “excellent” match and one event is considered to have a good match (the respective Seqwater values were identical)
- 6 of the Nash-Sutcliffe values are classed as excellent, 7 are classed as good and 12 are classed as poor (the respective Seqwater values were 13 excellent, 4 good and 8 poor)

Figure 4-1 shows the comparison between rated flow and flood volume for Somerset Dam inflows using the recommended parameters. Included in the rated flow comparison is the trend line obtained by Seqwater for their recommended parameters. Figure 4-2 shows the comparison between rated flow and flood volume for Woodford inflows using the recommended parameters.

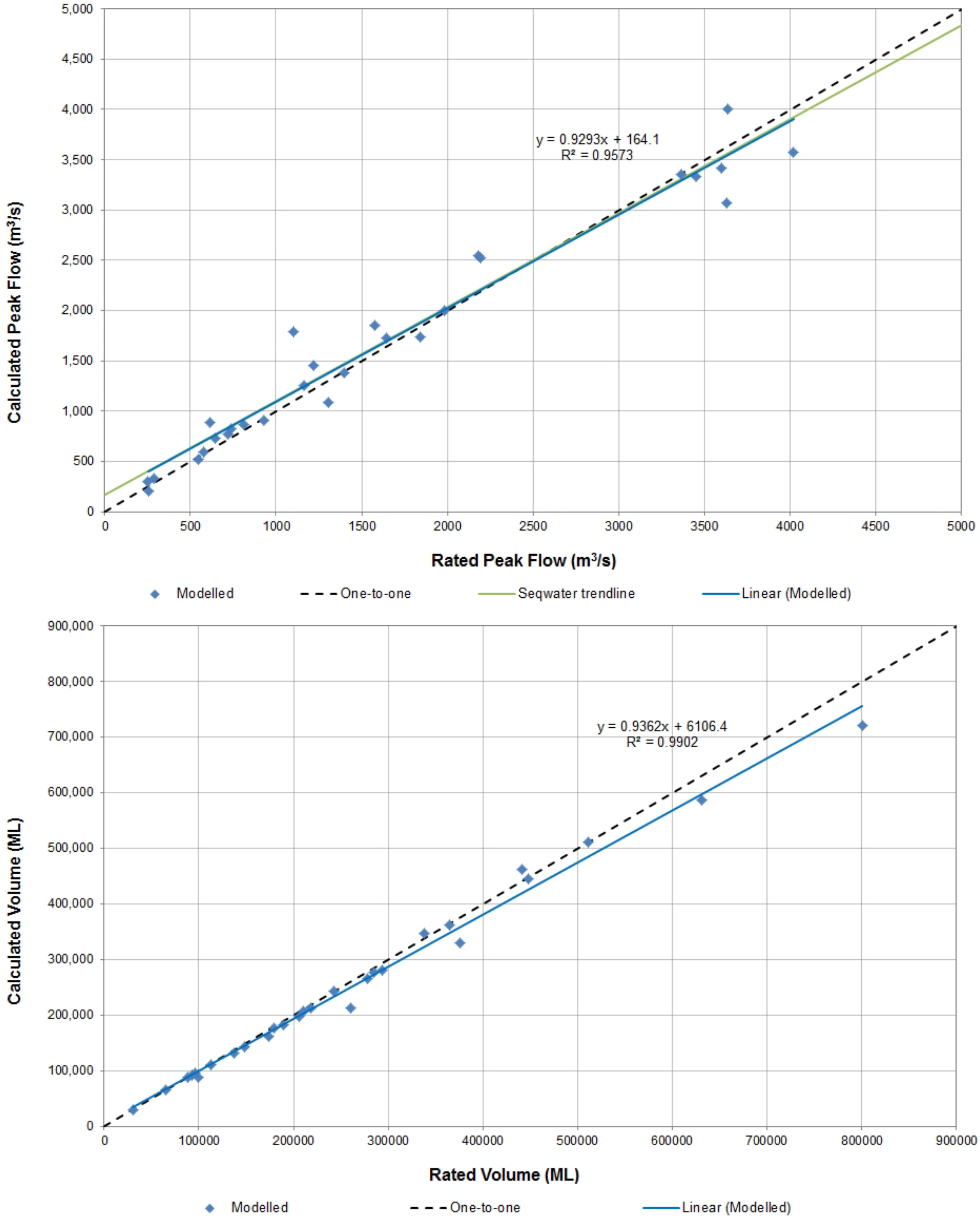


Figure 4-1 Model performance at Somerset Dam inflow for recommended parameters

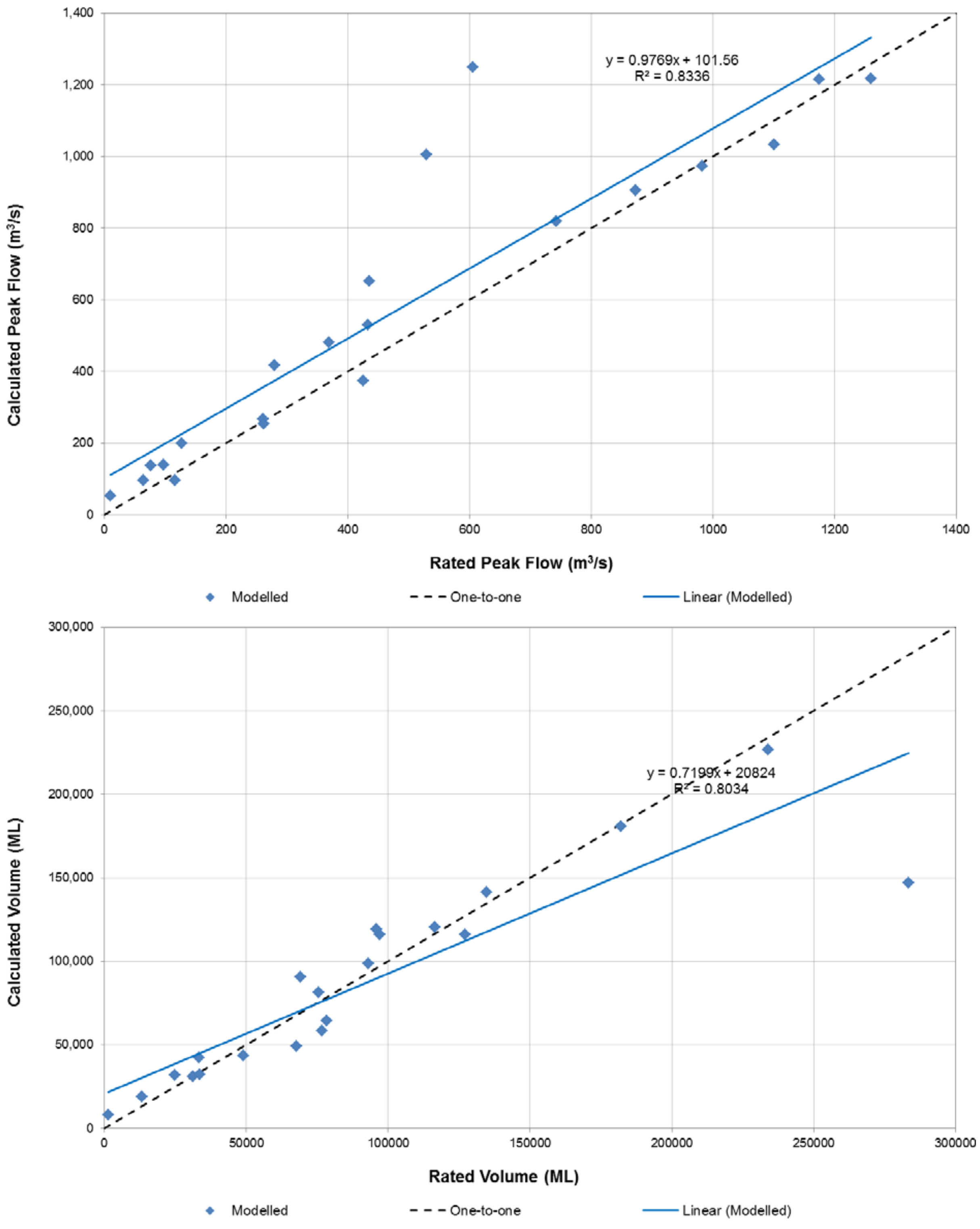


Figure 4-2 Model performance at Woodford inflow for recommended parameters

The comparison reveals that the Aurecon and Seqwater calibrations achieve virtually identical performance in terms of both correlation and scatter of the calculated and recorded flood peaks at Somerset. The flood volume comparison shows a reasonably good agreement with the calculated volumes, with the trend line being close to the one to one line. The peak flows and volumes at Woodford display greater scatter and contain a number of significant outliers but show a relatively consistent correlation free of bias. This scatter is to be expected considering the gauge records less than 20% of the catchment and the event calibrations have focussed on matching Somerset inflows.

4.3 Upper Brisbane River

4.3.1 Verification results summary

The verification event results at Gregors Creek are summarised in Table 4-2.

Table 4-2 Upper Brisbane River model verification statistics at Gregor Creek

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	4,192			442,919			
19560307	1,926			260,674			
19590215	113			17,714			
19591108	969			135,109			
19650718	851	849	1.00	72,536	77,684	0.93	1.00
19670607	2,101	734	2.86	254,370	105,856	2.40	2.86
19680107	1,154	887	1.30	247,951	202,049	1.23	1.30
19710216	2,569	4,195	0.61	318,094	377,987	0.84	0.61
19711226	630	842	0.75	57,474	77,318	0.74	0.75
19720201	1,481	801	1.85	168,789	93,769	1.80	1.85
19730705	3,235	3,597	0.90	277,027	296,027	0.94	0.90
19740124	5,083	5,118	0.99	695,482	809,309	0.86	0.99
19760119	610	524	1.16	82,489	75,198	1.10	1.16
19760209	273	282	0.97	28,754	35,628	0.81	0.97
19830620	4,998	5,349	0.93	410,385	419,315	0.98	0.93
19880401	635	470	1.35	66,890	57,286	1.17	1.35
19890331	2,047	2,243	0.91	170,569	165,451	1.03	0.91
19890423	3,944	4,452	0.89	288,142	341,401	0.84	0.89
19910205	70	59	1.20	8,258	13,118	0.63	1.20
19911210	294	289	1.02	27,538	29,799	0.92	1.02
19920314	1,886	2,299	0.82	200,337	200,711	1.00	0.82
19960430	837	502	1.67	106,757	74,965	1.42	1.67
19990207	6,014	5,910	1.02	635,356	596,412	1.07	1.02
20010130	462	567	0.81	48,751	84,869	0.57	0.81

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20040304	290	252	1.15	23,821	18,937	1.26	1.15
20081116	1	123	0.01	459	13,114	0.04	0.01
20090518	462	64	7.21	53,319	8,029	6.64	7.21
20100226	600	600	1.00	115,074	132,698	0.87	1.00
20101006	946	942	1.00	117,081	123,337	0.95	1.00
20101201	164	47	3.51	24,883	15,528	1.60	3.51
20101216	1,255	1,243	1.01	129,676	127,836	1.01	1.01
20101223	1,330	1,342	0.99	247,559	199,746	1.24	0.99
20110102	6,071	5,959	1.02	1,224,906	951,432	1.29	1.02
20120121	583	167	3.49	69,858	35,563	1.96	3.49
20120220	91	70	1.30	22,949	48,698	0.47	1.30
20120316	24	67	0.36	7,989	25,078	0.32	0.36
20130123	3,758	3,469	1.08	330,318	219,391	1.51	1.08
20130215	2,034	497	4.10	248,170	162,366	1.53	4.10

These results were classified as follows:

- For the peak flow ratios 13 are excellent, 2 are good, 10 are poor and the remainder are classed as “no data” (the respective Seqwater values are 16, 3 and 7)
- For the volume ratios 12 are excellent, 6 are good, 6 are poor and the remainder are classed as “no data” (the respective Seqwater values are 21, 6 and 3)
- For the Nash-Sutcliffe values 5 are excellent, 5 are good, 4 are fair, 7 are poor and the remainder are classed as “no data” (the respective Seqwater values are 6 excellent, 5 good, 6 fair and 7 poor)

Figure 4-3 shows the comparison between rated flow and flood volume for the Brisbane River at Gregors Creek using the recommended parameters. Included in the rated flow comparison is the trend line obtained by Seqwater for their recommended parameters.

The comparison indicates a good agreement between the adopted Aurecon model parameters and the trend line derived by Seqwater for the rated peak flows. Likewise, there appears to be good agreement for the range of events for the estimated flood volumes.

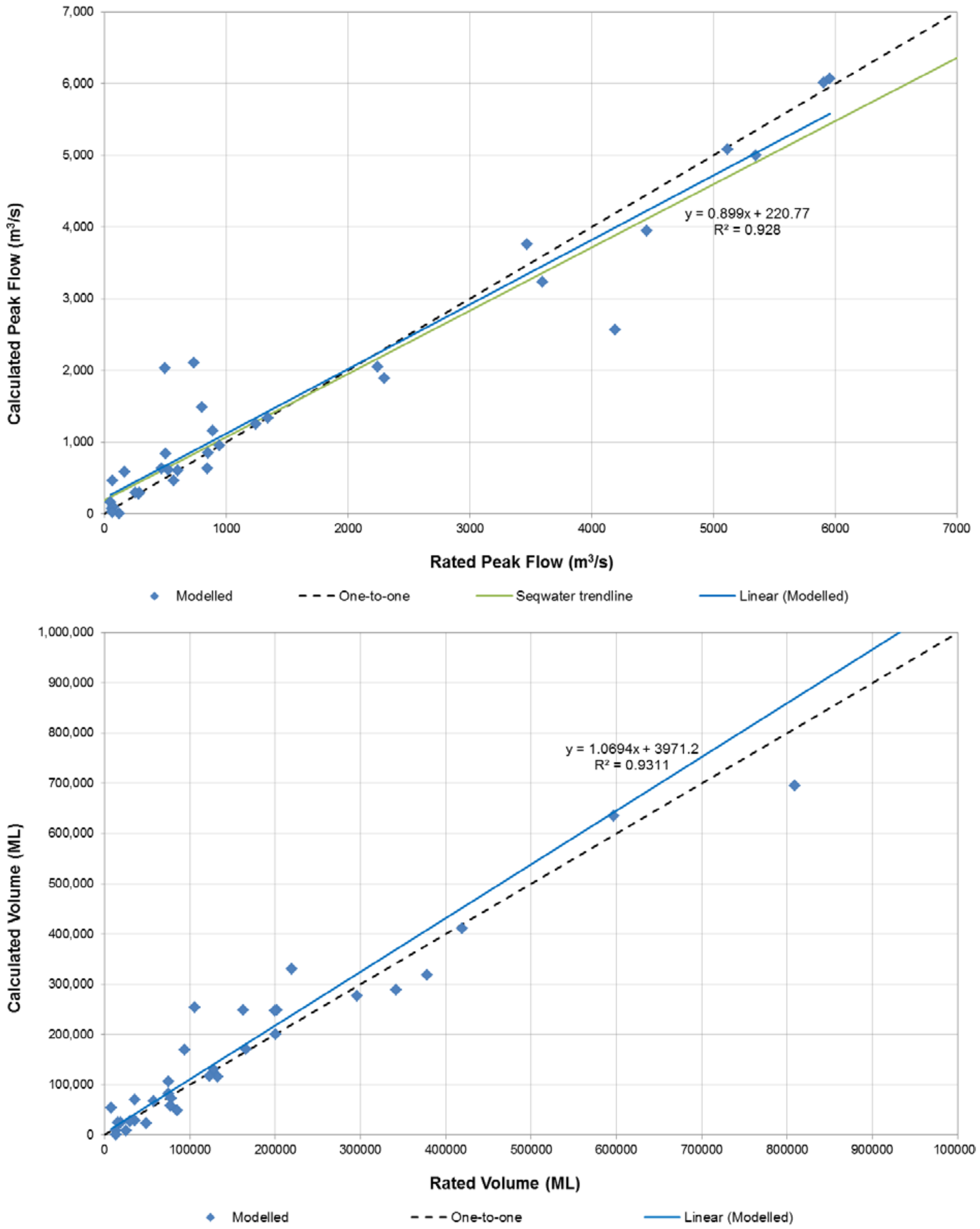


Figure 4-3 Model performance at Gregors Creek for recommended parameters

The verification event results at the Wivenhoe Dam inflow are summarised in Table 4-3.

Table 4-3 Upper Brisbane River model verification statistics at Wivenhoe Dam inflow

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	5,767			1,122,657			
19560307	2,216			860,371			
19590215	360			82,362			
19591108	1,500			437,836			
19650718	1,257			195,198			
19670607	2,730			505,409			
19680107	3,177			1,005,513			
19710216	2,905			455,586			
19711226	586			88,935			
19720201	2,168			361,262			
19730705	3,428			439,268			
19740124	7,115			1,506,374			
19760119	1,469			345,177			
19760209	362			72,076			
19830620	7,331	5,900	1.24	895,047	792,312	1.13	1.24
19880401	1,581			234,210			
19890331	3,745	3,188	1.17	685,972	677,578	1.01	1.17
19890423	5,209	5,234	1.00	761,536	879,354	0.87	1.00
19910205	156			30,052			
19911210	1,664			128,255			
19920314	3,169			340,353			
19960430	2,064	2,118	0.97	347,112	357,509	0.97	0.97
19990207	7,535	7,326	1.03	1,169,763	1,190,347	0.98	1.03
20010130	688	635	1.08	127,572	107,824	1.18	1.08
20040304	563	631	0.89	57,114	72,943	0.78	0.89
20081116	484	521	0.93	80,476	70,790	1.14	0.93
20090518	1,340	1,563	0.86	233,231	227,264	1.03	0.86
20100226	1,499	1,268	1.18	350,331	397,786	0.88	1.18
20101006	2,724	2,392	1.14	556,915	541,213	1.03	1.14
20101201	333	325	1.02	184,100	192,550	0.96	1.02
20101216	1,677	1,578	1.06	347,556	372,553	0.93	1.06
20101223	1,816	1,620	1.12	475,887	525,355	0.91	1.12
20110102	10,295	10,264	1.00	2,744,499	2,705,022	1.01	1.00
20120121	1,047	860	1.22	233,972	267,559	0.87	1.22

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20120220	451	512	0.88	262,009	273,535	0.96	0.88
20120316	219	364	0.60	83,350	169,470	0.49	0.60
20130123	5,616	5,870	0.96	795,671	858,593	0.93	0.96
20130215	3,159	3,412	0.93	831,477	1,068,354	0.78	0.93

These results were classed as follows:

- Peak flow ratios: 10 are excellent, 5 are good and 5 are poor (Seqwater's respective values were 7, 3 and 9)
- Volume ratios: 16 are excellent, 3 are good with 0 poor (Seqwater's respective values were 12, 3 and 4)
- Nash-Sutcliffe values: 2 is excellent, 5 are good, 5 are fair and 4 are poor (Seqwater's respective values were 0, 7, 2 and 7)

Figure 4-4 shows the comparison between the rated flow and flood volume for the Brisbane River at Wivenhoe Dam Inflow. The comparison between the Seqwater and Aurecon trend lines is quite close, and both lines are near the one to one line. The scatter of the points around the trend line is similar to the outcomes achieved by Seqwater.

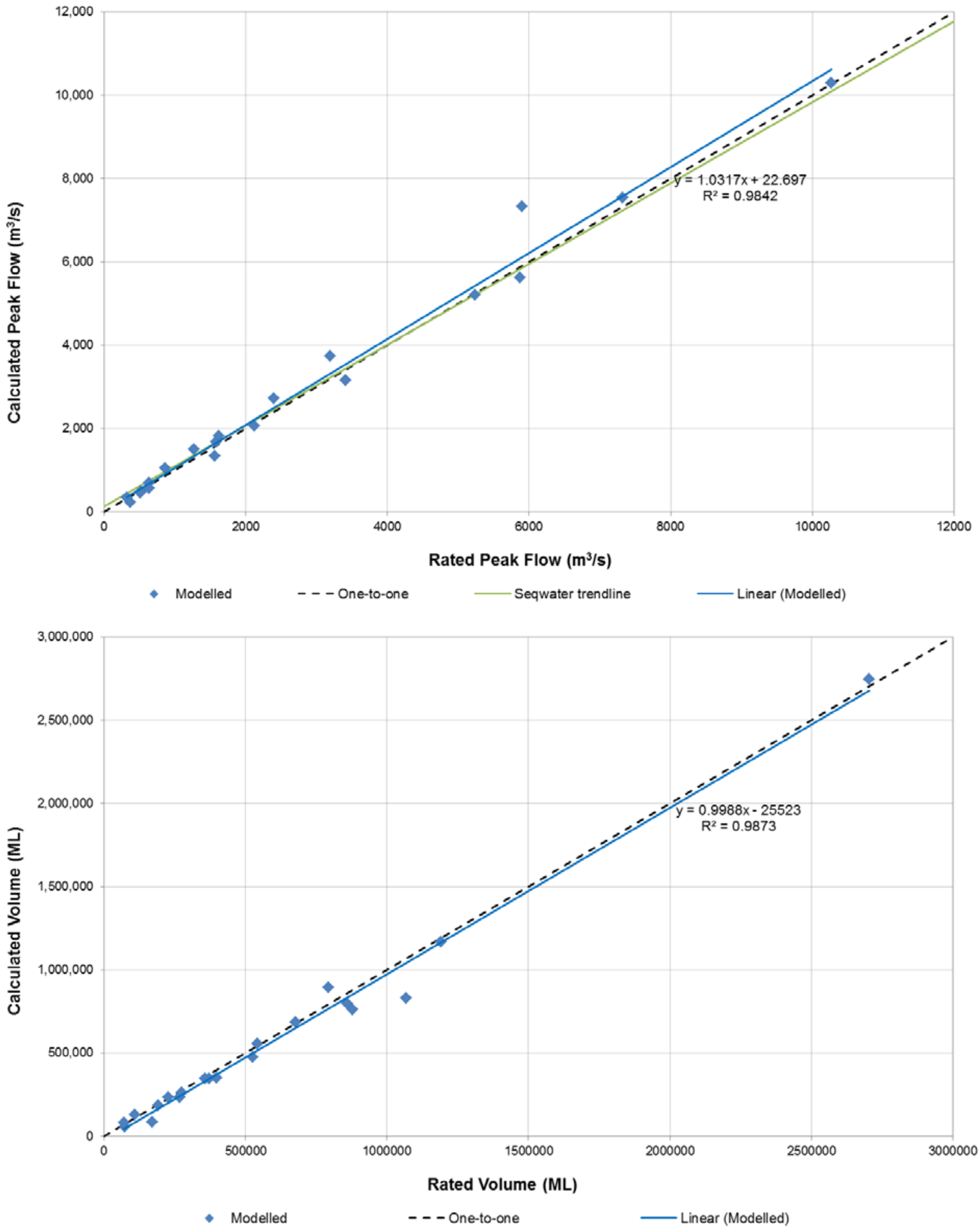


Figure 4-4 Model performance at Wivenhoe Dam inflow for recommended parameters

4.4 Lockyer Creek

4.4.1 Verification results summary

The verification event results at Glenore Grove are summarised in Table 4-4.

Table 4-4 Lockyer Creek model verification statistics at Glenore Grove

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	659	651	1.01	43,232			
19560307	178	175	1.02	11,246			
19590215	3,189	3,707	0.86	151,819			
19591108	254	237	1.07	21,276			
19650718	330	572	0.58	37,211			
19670607	604	572	1.06	96,455			
19680107	784	765	1.03	103,538			
19710216	582	572	1.02	55,317			
19711226	32			2,535			
19720201	23			7,068			
19730705	94			10,971			
19740124	2,988	2,739	1.09	286,654	261,824	1.09	0.74
19760119	528	487	1.08	67,419			
19760209	879	898	0.98	94,386			
19830620	1,881	1,142	1.65	115,719	128,309	0.90	0.40
19880401	844	824	1.02	147,865	121,218	1.22	0.14
19890331	89	67	1.32	12,378	17,215	0.72	-0.65
19890423	534	414	1.29	41,037	43,928	0.93	0.91
19910205	219	220	0.99	26,267			
19911210	279	202	1.39	31,890			
19920314	777			59,985			
19960430	2,295	1,531	1.50	418,208	316,101	1.32	0.42
19990207	432	421	1.03	37,176	37,614	0.99	0.95
20010130	556			61,714			
20040304	90	94	0.96	5,966	5,406	1.10	-0.57
20081116	342	332	1.03	31,413	22,445	1.40	0.76
20090518	149	26	5.73	14,425	4,536	3.18	-82.44
20100226	194	97	2.01	25,639	21,648	1.18	-1.77
20101006	479	47	10.23	61,676	7,960	7.75	-99.00
20101201	254	206	1.23	40,196	28,627	1.40	0.26

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20101216	327	309	1.06	51,167	44,494	1.15	0.38
20101223	1,734	1,813	0.96	137,529	135,285	1.02	0.98
20110102	4,030	4,048	1.00	510,901	438,875	1.16	0.90
20120121	44	40	1.09	6,635	17,398	0.38	-1.18
20120220	47	48	0.98	12,019	19,417	0.62	-0.67
20120316	8	15	0.57	1,073	5,968	0.18	-18.27
20130123	2,977	3,115	0.96	296,983	267,383	1.11	0.97
20130215	500	480	1.04	87,551	123,247	0.71	0.82

These results were classified as follows:

- For the peak flow ratios 21 are excellent, 1 is good, 7 are poor and the remainder are classed as “no data” (the respective Seqwater values are 5, 1 and 10)
- For the volume ratios 8 are excellent, 3 are good, 6 are poor and the remainder are classed as “no data” (the respective Seqwater values are 4, 2 and 9)
- For the Nash-Sutcliffe values 4 are excellent, 1 is good, 1 is fair, 3 are poor and the remainder are classed as “no data” (the respective Seqwater values are 0 excellent, 1 good, 0 fair and 7 poor)

Figure 4-5 shows the comparison between rated flow and flood volume for the Lockyer Creek at Glenore Grove using the recommended parameters. The comparison for Glenore Grove shows that there is an excellent correlation with to the one-to-one line for rated flows and a relatively good correlation for flood volumes.

Figure 4-6 shows a similar comparison between rated flow and flood volume for the Lockyer Creek at Gatton using the recommended parameters. The comparison of rated flows and volumes shows reasonable distribution about the one-to-one line, but with greater scatter than the Glenore Grove comparison, which is to be expected as the calibration has focussed on Glenore Grove as the primary calibration point.

Figure 4-7 shows the comparison between calculated and rated flows for the Lockyer Creek at Lyons Bridge and Rifle Range Road using the recommended parameters. Included in the rated flow comparison is the trend line obtained by Seqwater for their recommended parameters. At both of these locations the schematisation of the URBS model only reports main channel flows. Rated flows were calculated using Seqwater rating curves. The methodology used to derive these ratings related modelled flows inclusive of overbank flows with main channel water levels, and is considered unreliable where overbank flows are significant (above 800 to 900 m^3/s). Nevertheless, the comparison suggests a good correlation for low flows and supports the implementation of bypass flows downstream of Glenore Grove.

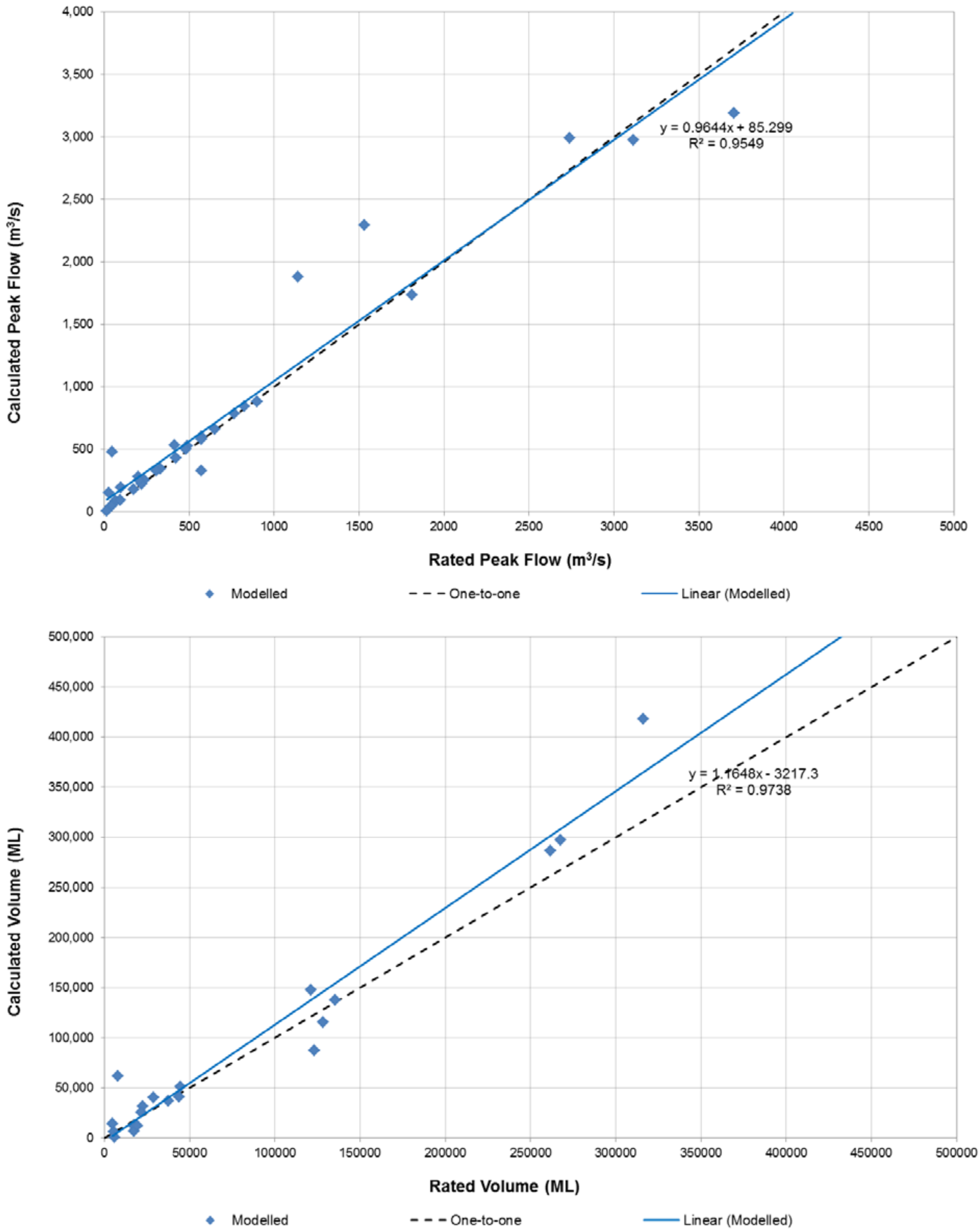


Figure 4-5 Model performance at Glenore Grove for recommended parameters

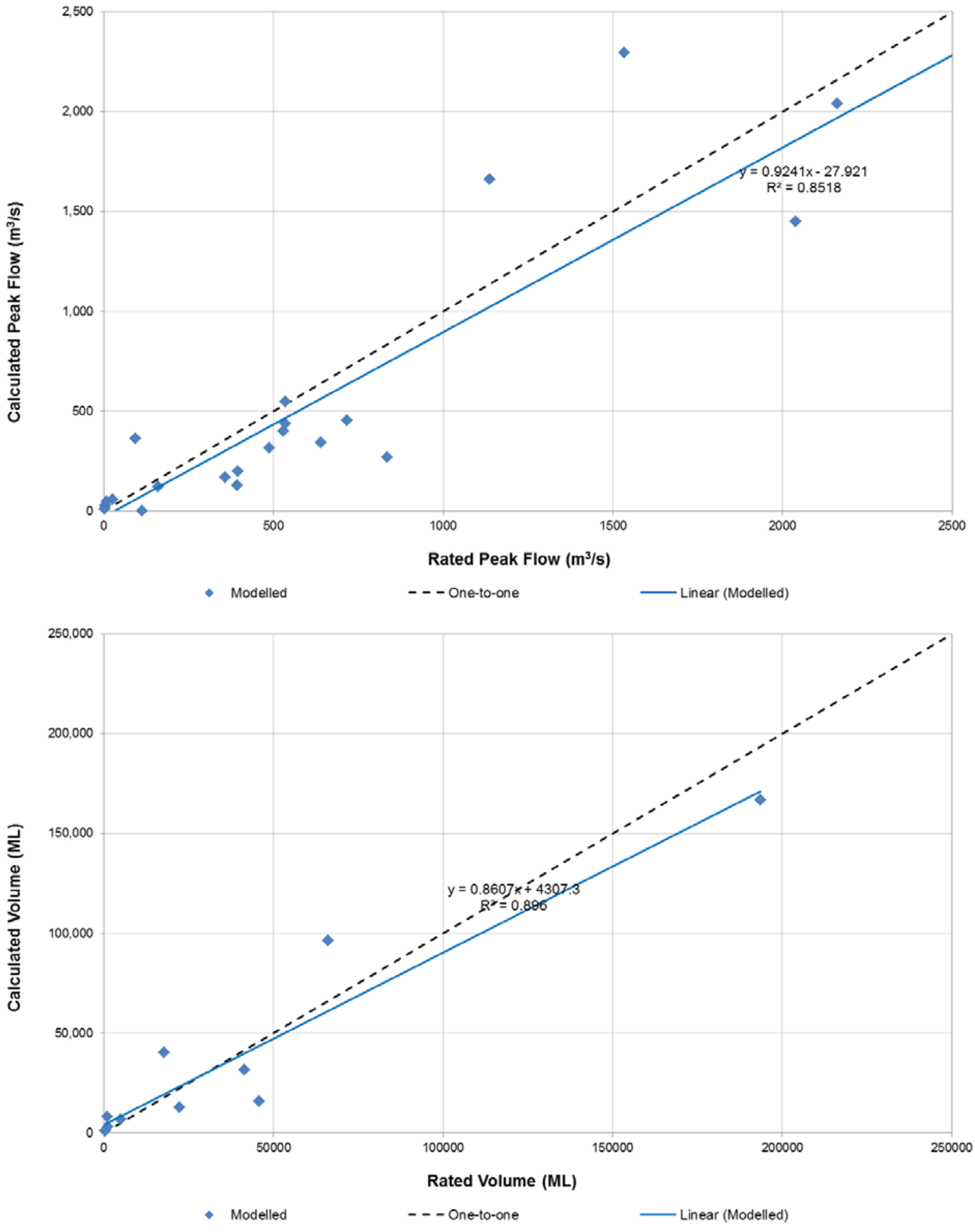


Figure 4-6 Model performance at Gatton for recommended parameters

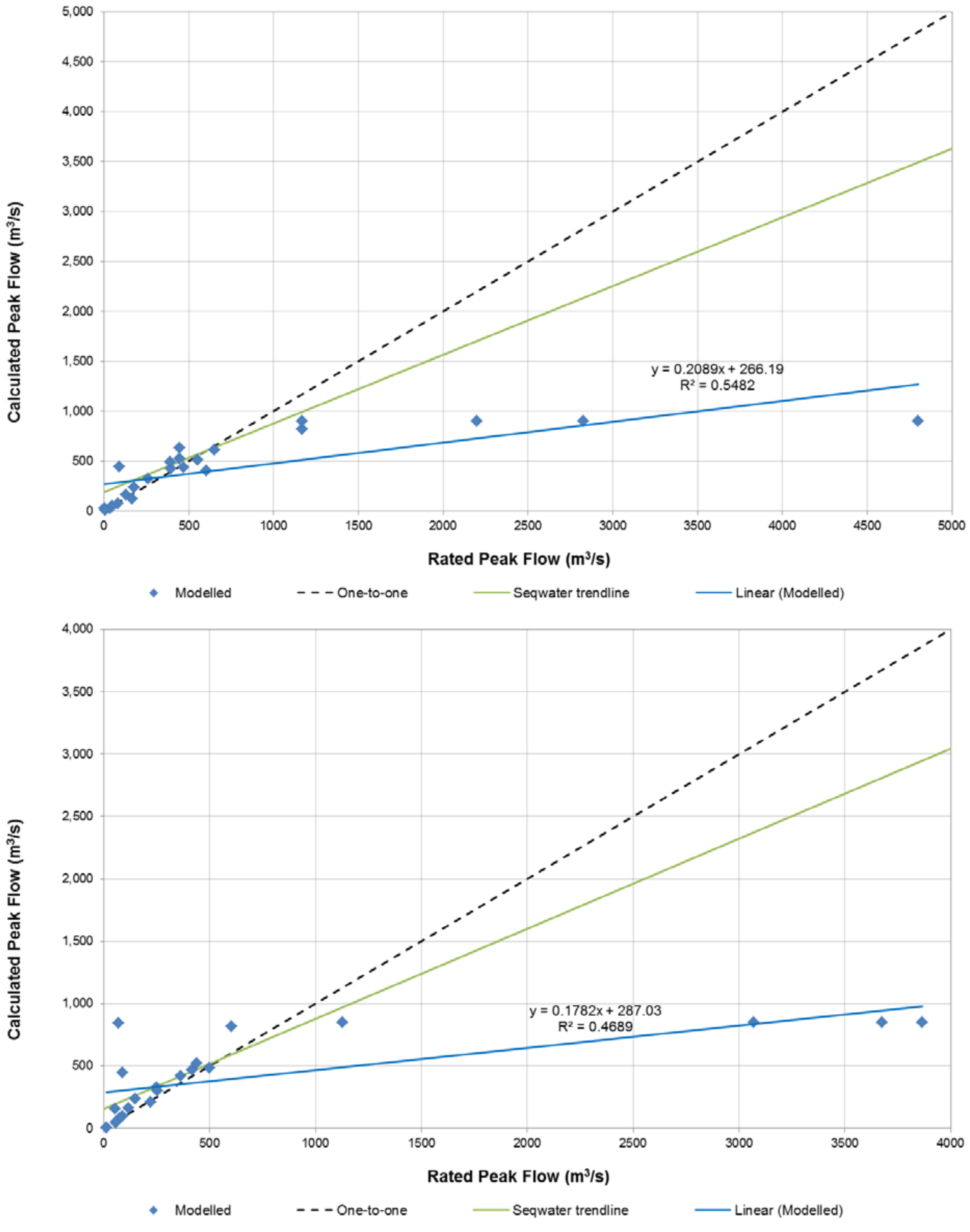


Figure 4-7 Model performance at Lyons Bridge and Rifle Range Road for recommended parameters

4.5 Bremer River

4.5.1 Verification results summary

The verification event results at Walloon are summarised in Table 4-5.

Table 4-5 Bremer River model verification statistics at Walloon

Event	Flow			Volume			Hydrograph
	Model peak flow (m³/s)	Rated peak flow (m³/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	466			31,782			
19560307	284			20,511			
19590215	1,209			64,257			
19591108	576			69,629			
19650718	508	506	1.00	49,470	28,911	1.71	0.58
19670607	477	488	0.98	76,500	69,474	1.10	0.95
19680107	496	527	0.94	100,543	101,830	0.99	0.80
19710216	602	577	1.04	46,473	45,089	1.03	0.80
19711226	11	8	1.41	1,007	810	1.24	-0.54
19720201	32	31	1.04	3,874	3,625	1.07	0.77
19730705	35	35	0.99	4,192	4,236	0.99	0.88
19740124	2,276	2,810	0.81	348,135			
19760119	400	438	0.91	34,223	22,489	1.52	0.86
19760209	914	919	0.99	83,040	74,284	1.12	0.98
19830620	584	686	0.85	67,384	57,375	1.17	0.71
19880401	1,103	1,160	0.95	114,385	141,744	0.81	0.64
19890331	216	274	0.79	47,230	42,043	1.12	0.82
19890423	393	400	0.98	39,891	32,162	1.24	0.08
19910205	265	271	0.98	21,831	18,580	1.18	0.80
19911210	941	977	0.96	66,339	62,597	1.06	0.89
19920314	53			4,680			
19960430	1,093	1,042	1.05	200,145	211,588	0.95	0.91
19990207	460	476	0.97	54,983	45,659	1.20	0.92
20010130	331	377	0.88	41,011	38,129	1.08	0.97
20040304	125	127	0.98	9,661	8,861	1.09	0.45
20081116	1,086	1,061	1.02	68,612	56,864	1.21	0.96
20090518	558	550	1.01	47,596	50,492	0.94	0.82
20100226	156	148	1.05	33,102	33,559	0.99	0.44
20101006	305	298	1.02	28,156	26,290	1.07	0.93
20101201	265	203	1.30	47,061	40,010	1.18	0.09

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20101216	276	277	1.00	43,187	34,111	1.27	0.51
20101223	649	619	1.05	100,209	93,911	1.07	0.91
20110102	2,092	2,461	0.85	200,783	235,842	0.85	0.94
20120121	208	205	1.02	34,302	27,377	1.25	0.41
20120220	195	202	0.96	22,229	15,378	1.45	0.20
20120316	2	3	0.93	440	923	0.48	-4.18
20130123	1,214	1,380	0.88	118,981	115,204	1.03	0.95
20130215	553	553	1.00	87,113	90,961	0.96	0.93

The model results show that:

- For the peak flow ratios, 25 are classed as an excellent match to the rated values, 4 are classed as a good match and 4 are classed as a poor match (the corresponding Seqwater values are 15,4 and 13)
- For the volume ratios, 18 are classed as an excellent match, 8 are classed as a good match and 3 are classed as a poor match (the corresponding Seqwater values are 19, 7 and 4)
- For the Nash-Sutcliffe values, 3 are classed as excellent, 8 as good, 3 as fair and 10 as poor (the corresponding Seqwater values are 3, 7, 6 and 7)

Figure 4-8 shows the comparison between rated flow and flood volume for the Bremer River at Walloon using the recommended parameters. Included in the rated flow comparison is the trend line obtained by Seqwater for their recommended parameters.

The comparison between the peak flow trend lines suggests that the revised model achieves an excellent correlation between modelled and rated flow peaks with the exception of the two largest events. This could suggest an issue with the gauge rating curve, which was derived was derived using an independent hydraulic model, however it is worth noting that:

- The flow for the largest event (1974) is derived from a level described as a “flood mark” rather an instrument level and the difference between the modelled level and recorded mark is less than 0.5 m
- Review of the DMT TUFLOW model results suggest that there may be some influence at the Walloon Gauge site from elevated Brisbane River levels during large flood events

Given the limited data sample, no modification of the independently derived rating has been undertaken. It is recommended that Brisbane River backwater influence is investigated during the hydraulics phase of the BRCFS.

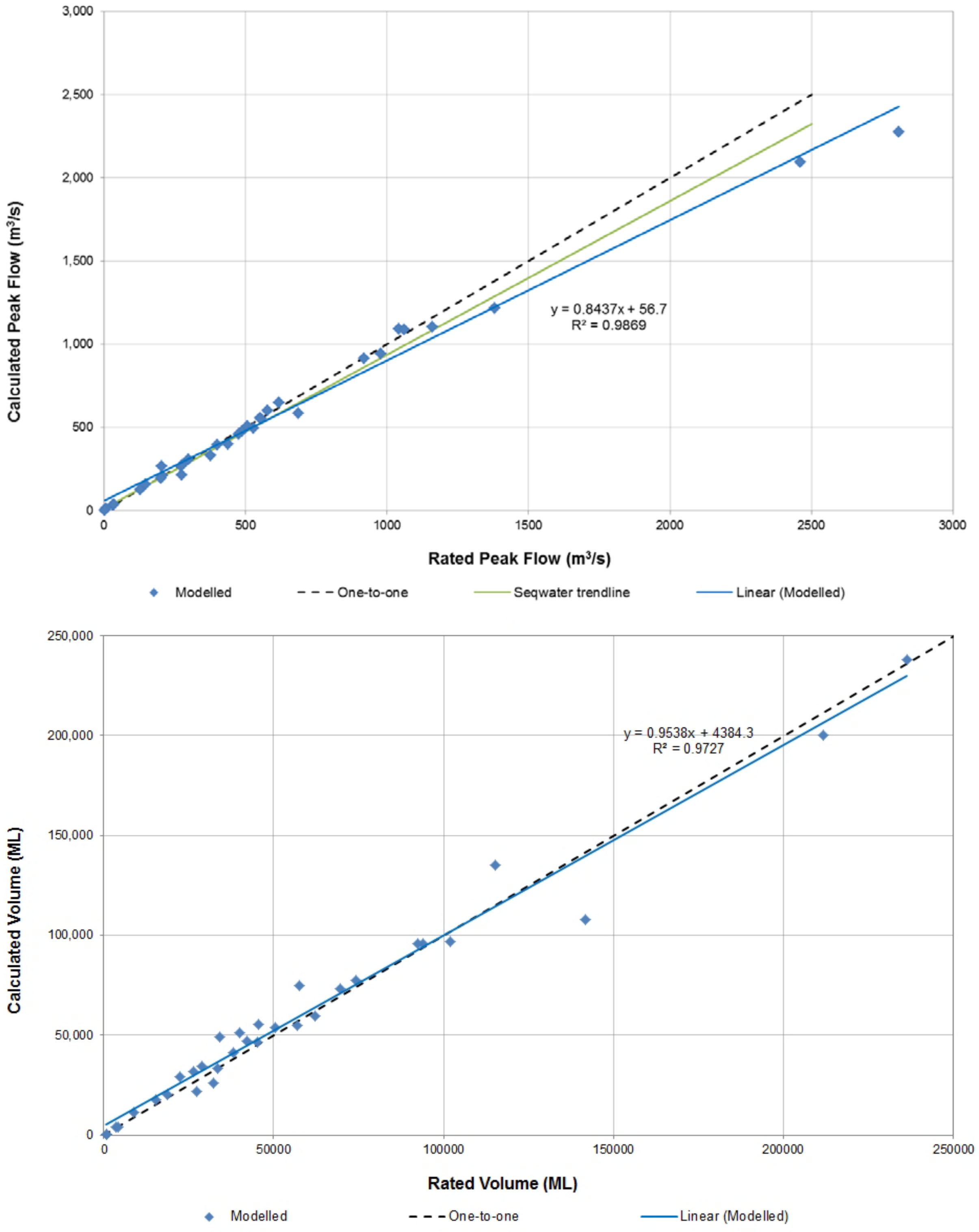


Figure 4-8 Model performance at Walloon for recommended parameters

4.6 Warrill Creek

4.6.1 Verification results summary

The verification event results at Amberley are summarised in Table 4-6.

Table 4-6 Warrill Creek model verification statistics at Amberley

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	308			30,126			
19560307	187			23,184			
19590215	917			85,998			
19591108	358			63,896			
19650718	523			88,907			
19670607	320	310	1.03	65,736	58,218	1.13	0.92
19680107	369	363	1.02	99,775	97,371	1.02	0.85
19710216	286	279	1.03	46,848	50,517	0.93	0.95
19711226	9	10	0.89	782	1,461	0.54	0.00
19720201	16	15	1.05	1,435	1,707	0.84	0.36
19730705	10	9	1.09	1,251	1,869	0.67	0.78
19740124	2,171	2,280	0.95	410,809	290,487	1.41	0.83
19760119	152	120	1.26	25,440	26,712	0.95	0.90
19760209	980	971	1.01	147,296	126,576	1.16	0.97
19830620	395	391	1.01	59,842	54,630	1.10	0.95
19880401	510	472	1.08	86,303	94,857	0.91	0.90
19890331	231	227	1.02	36,394	36,359	1.00	0.95
19890423	178	163	1.09	30,550	26,159	1.17	0.95
19910205	544	561	0.97	88,009	75,938	1.16	0.90
19911210	626	638	0.98	80,080	69,057	1.16	0.91
19920314	29	26	1.11	2,084	2,944	0.71	0.64
19960430	411	400	1.03	99,435	127,574	0.78	0.73
19990207	190	196	0.97	32,916	28,062	1.17	0.95
20010130	115	108	1.06	13,285	20,154	0.66	0.82
20040304	50	51	0.97	7,487	6,526	1.15	0.41
20081116	279	256	1.09	36,068	28,115	1.28	0.89
20090518	341	358	0.95	41,261	44,130	0.93	0.94
20100226	80	87	0.91	23,159	24,800	0.93	0.67
20101006	88	95	0.92	19,529	14,796	1.32	0.92
20101201	180	127	1.43	54,040	56,460	0.96	1.43

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20101216	173	176	0.98	47,483	45,228	1.05	0.98
20101223	515	535	0.96	143,628	144,132	1.00	0.96
20110102	773	774	1.00	219,233	211,512	1.04	1.00
20120121	163	159	1.02	47,645	38,897	1.22	1.02
20120220	300	269	1.12	48,743	47,596	1.02	1.12
20120316	11	13	0.85	4,894	7,497	0.65	0.85
20130123	1,134	1,178	0.96	209,478	169,398	1.24	0.96
20130215	315	306	1.03	89,440	80,896	1.11	1.03

These results were classed as follows:

- Peak flow ratios: 27 are excellent, 3 are good and 3 are poor (Seqwater's respective values were 20, 7 and 6)
- Volume ratios: 16 are excellent, 9 are good and 8 are poor (Seqwater's respective values were 25, 3 and 2)
- Nash-Sutcliffe values: 13 are excellent, 7 are good, 3 are fair and 8 are poor (Seqwater's respective values were 8, 6, 5 and 11)

Figure 4-9 shows the comparison between rated flow and flood volume for the Warrill Creek at Amberley using the recommended parameters. Included in the rated flow comparison is the trend line obtained by Seqwater for their recommended parameters.

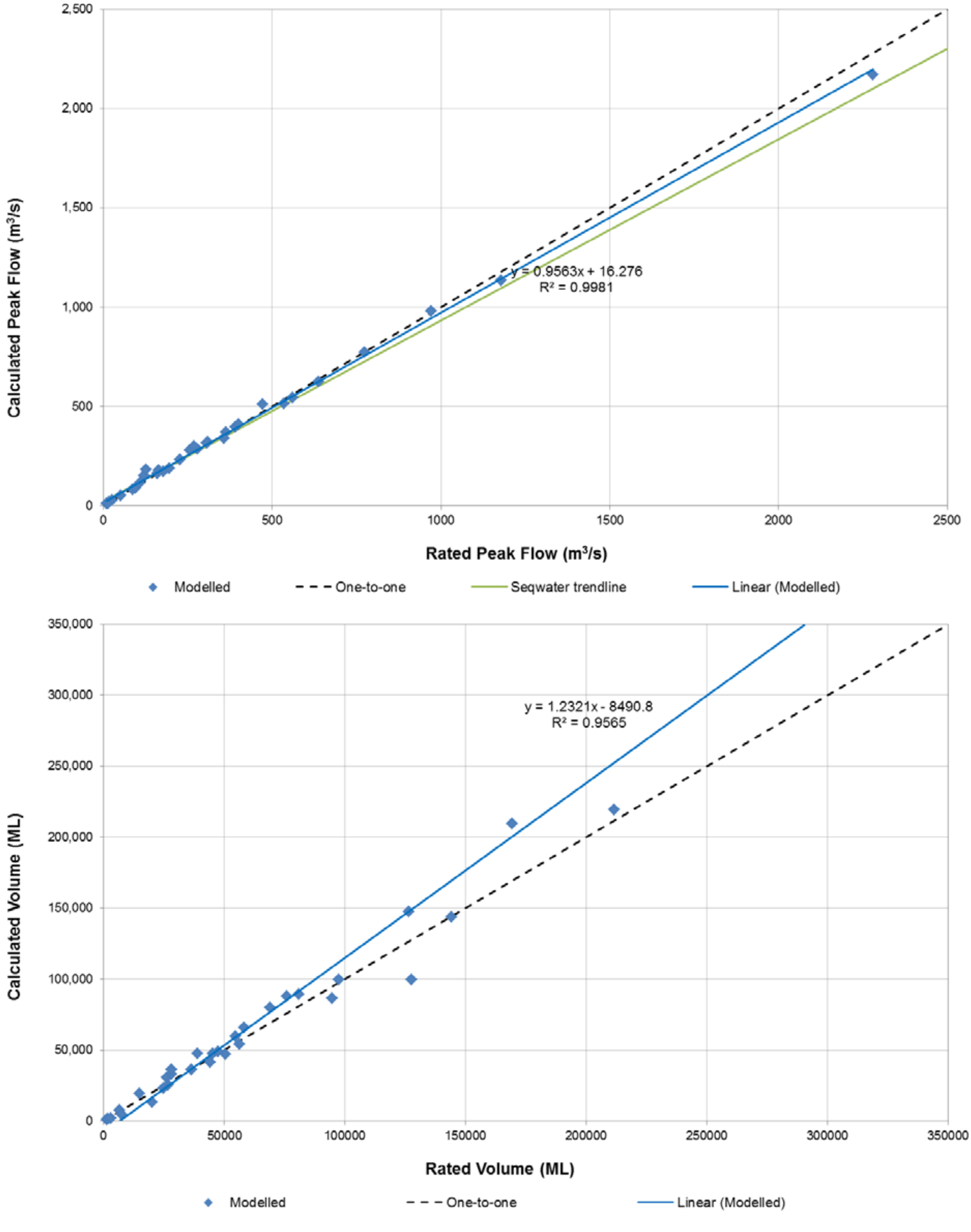


Figure 4-9 Model performance at Amberley for recommended parameters

4.7 Purga Creek

4.7.1 Verification results summary

The verification event results at Loamside are summarised in Table 4-7.

Table 4-7 Purga Creek model verification statistics at Loamside

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	70			5,933			
19560307	49			4,681			
19590215	88			6,342			
19591108	96			12,947			
19650718	203			22,247			
19670607	104			17,855			
19680107	86			17,486			
19710216	86			17,486			
19711226	4			394			
19720201	89			9,690			
19730705	1			205			
19740124	814	751	1.08	98,294	87,595	1.12	0.82
19760119	30	31	0.97	2,701	2,655	1.02	0.94
19760209	270	280	0.96	23,548	17,938	1.31	0.89
19830620	199	199	1.00	18,154	12,920	1.41	0.84
19880401	172	172	1.00	20,257	22,888	0.89	0.64
19890331	137	147	0.93	15,142	10,536	1.44	0.80
19890423	143	148	0.96	14,261	11,327	1.26	0.96
19910205	36	44	0.82	4,254	4,056	1.05	0.70
19911210	244	241	1.01	18,408	14,374	1.28	0.72
19920314	14	13	1.09	1,209	1,199	1.01	0.97
19960430	276	291	0.95	53,796	49,688	1.08	0.96
19990207	69	69	1.01	8,623	7,368	1.17	0.96
20010130	3	3	1.08	390	489	0.80	0.70
20040304	100	103	0.97	8,271	4,859	1.70	0.43
20081116	127	124	1.02	11,350	7,604	1.49	0.86
20090518	334	341	0.98	23,023	19,024	1.21	0.97
20100226	20	20	0.97	2,677	2,307	1.16	0.92
20101006	10	9	1.16	1,154	1,507	0.77	0.42
20101201	7	0	14.10	383	0	0	0.00

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20101216	9	9	1.07	1,081	677	1.60	0.67
20101223	133	1	130.47	19,420	840	23.12	-99.00
20110102	169	212	0.80	34,655	26,960	1.29	0.91
20120121	10	10	0.99	1,746	2,026	0.86	0.48
20120220	46	44	1.03	5,440	3,771	1.44	0.75
20120316	0	0	0.00	0	0	0	0.00
20130123	120	103	1.17	8,702	10,428	0.83	0.79
20130215	53	55	0.97	9,342	10,194	0.92	0.84

These results were classed as follows:

- Peak flow ratios: 20 are excellent, 0 are good and 4 are poor (Seqwater's respective values were 8, 3 and 11)
- Volume ratios: 8 are excellent, 6 are good and 8 are poor (Seqwater's respective values were 10, 5 and 5)
- Nash-Sutcliffe values: 9 are excellent, 3 are good, 2 are fair and 11 are poor (Seqwater's respective values were 3, 5, 1 and 8)

Figure 4-10 shows the comparison between rated flow and flood volume for the Purga Creek at Loamside using the recommended parameters. Included in the rated flow comparison is the trend line obtained by Seqwater for their recommended parameters.

The comparison shows that there is reasonable agreement between the Seqwater trend line and the Aurecon derived trend line for the peak flows. The Aurecon trend line is in close agreement with the one to one line indicating a good agreement between modelled and rated peak flows.

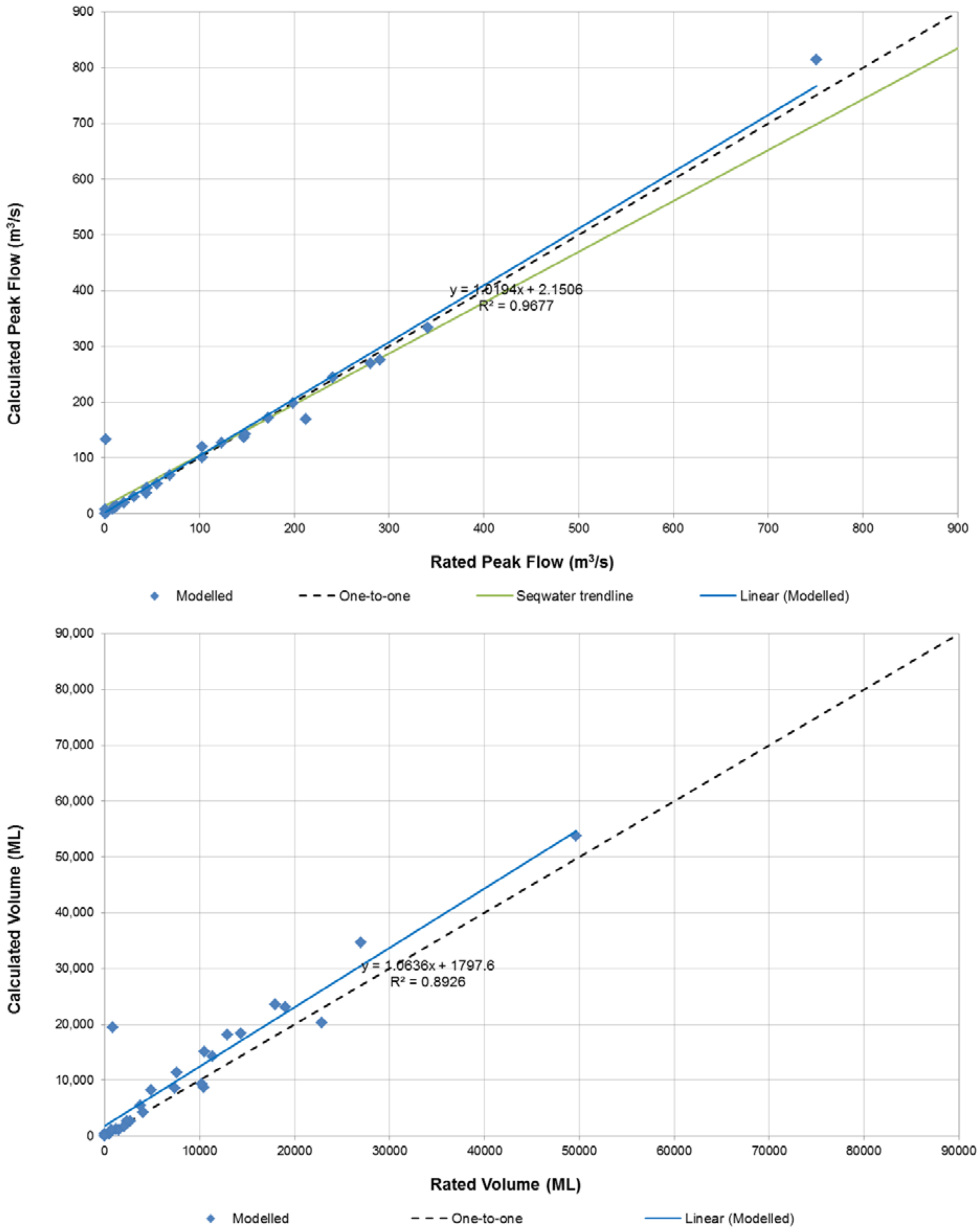


Figure 4-10 Model performance at Loamside for recommended parameters

4.8 Lower Brisbane River

4.8.1 Verification results summary

The verification event results at Mount Crosby Weir and Moggill are summarised in Table 4-8 and Figure 4-11 respectively.

Table 4-8 Lower Brisbane River model verification statistics at Mt Crosby Weir

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	6,137	5,998	1.02	1,201,216	1,405,285	0.85	0.93
19560307	2,131	2,219	0.96	872,409	932,569	0.94	0.50
19590215	1,908	1,900	1.00	265,346	352,543	0.75	0.84
19591108	1,757	1,935	0.91	543,647	763,153	0.71	0.78
19650718	1,827	1,840	0.99	339,753	357,781	0.95	0.87
19670607	2,984	3,087	0.97	718,378	793,158	0.91	0.83
19680107	4,031	3,920	1.03	1,305,326	1,440,876	0.91	0.86
19710216	3,280	338	9.71	552,290	19,006	29.06	-99.00
19711226	540	565	0.96	100,907			
19720201	2,273	2,034	1.12	482,987	701,842	0.69	0.40
19730705	3,411	2,687	1.27	512,906	858,079	0.60	0.28
19740124	9,938	10,247	0.97	2,423,172	2,747,706	0.88	0.92
19760119	1,851	1,894	0.98	464,102	339,196	1.37	0.95
19760209	1,078	1,186	0.91	214,083	138,346	1.55	0.95
19830620	1,937	1,905	1.02	654,564	727,743	0.90	0.88
19880401	1,143	1,647	0.69	327,966			
19890331	1,719	1,773	0.97	777,380	716,233	1.09	0.89
19890423	1,633	1,734	0.94	952,585	1,146,460	0.83	0.81
19910205	198			41,555			
19911210	616			88,969			
19920314	1,030	1,084	0.95	186,275			
19960430	2,544	2,447	1.04	820,135	1,254,070	0.65	-6.76
19990207	1,891	1,822	1.04	913,768	1,070,808	0.85	0.67
20010130	458	474	0.97	183,731	199,062	0.92	0.91
20040304	493	360	1.37	43,771	38,768	1.13	0.66
20081116	573	360	1.59	100,716	38,243	2.63	-3.27
20090518	999	1	999.07	123,630	17	7272.35	-99.00
20100226	208	52	3.99	62,619	35,568	1.76	-17.68
20101006	1,602	1,730	0.93	731,308	734,563	1.00	0.95
20101201	340	311	1.09	175,827	115,046	1.53	0.73

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20101216	1,524	1,712	0.89	410,284	433,111	0.95	0.91
20101223	1,709	1,762	0.97	730,489	847,548	0.86	0.85
20110102	9,954	10,004	1.00	3,640,578	3,810,416	0.96	0.98
20120121	502	503	1.00	278,907	285,686	0.98	0.97
20120220	440	444	0.99	326,087	329,901	0.99	0.93
20120316	130	138	0.95	109,635	110,111	1.00	0.85
20130123	2,335	2,185	1.07	1,298,799	1,215,045	1.07	0.96
20130215	1,911	1,745	1.09	1,214,144	1,225,209	0.99	0.98

These results were classed as follows:

- Peak flow ratios: 27 are excellent, 2 are good and 3 are poor (Seqwater's respective values were 12, 2 and 13)
- Volume ratios: 20 are excellent, 2 are good and 5 are poor (Seqwater's respective values were 17, 6 and 5)
- Nash-Sutcliffe values: 6 are excellent, 2 are good, 4 are fair and 10 are poor (Seqwater's respective values were 1, 2, 3 and 17)

Figure 4-11 shows the comparison between rated flow and flood volume for the Brisbane River at Mount Crosby Weir using the recommended parameters. Included in the rated flow comparison is the trend line obtained by Seqwater for their recommended parameters.

The comparison of trend lines shows that the Aurecon model achieves a very good correlation between calculated and rated flows over the full range of events with little evidence of bias whereas Seqwater's model tends to underestimate the larger flows. The comparison of volumes suggests a reasonable match although the calculated hydrographs tend to underestimate the rated flood volumes for the larger events although this is based on a limited sample size.

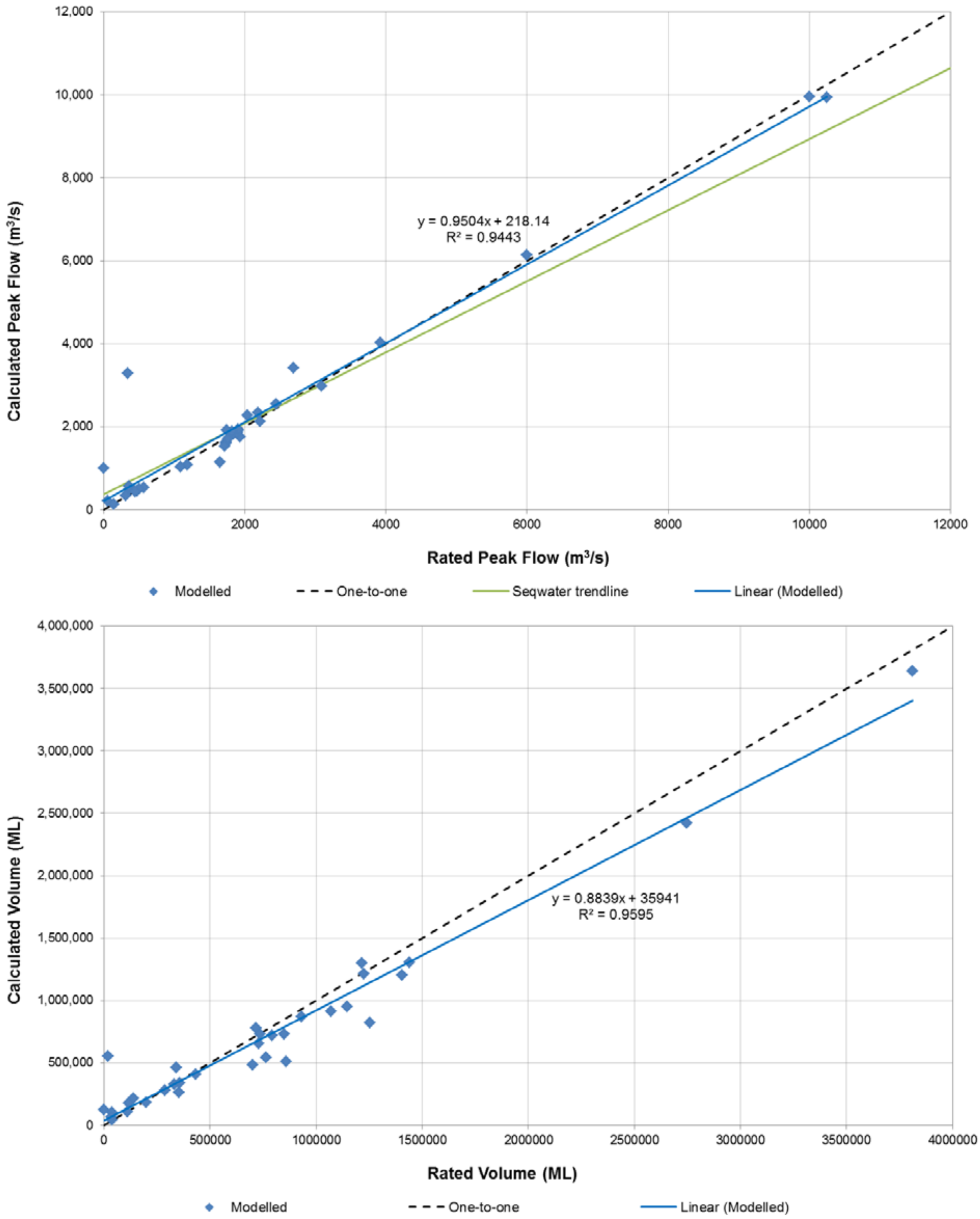


Figure 4-11 Model performance at Mt Crosby Weir for recommended parameters

Table 4-9 Lower Brisbane River model verification statistics at Moggill

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
19550325	6,181	6,865	0.90	1,277,317			
19560307	2,103			930,326			
19590215	2,403			431,688			
19591108	1,962			721,638			
19650718	2,712	2,763	0.98	534,081			
19670607	3,806	3,726	1.02	920,399			
19680107	4,290	5,230	0.82	1,561,634	2,558,224	0.61	-12.33
19710216	3,371	3,519	0.96	665,553			
19711226	539			108,800			
19720201	2,327	2,504	0.93	530,542			
19730705	3,318	2,999	1.11	534,622	1,381,995	0.39	-6.18
19740124	12,282	12,553	0.98	3,451,528	3,230,759	1.07	0.95
19760119	2,004			529,991			
19760209	2,581	2,751	0.94	494,167	496,913	0.99	-5.16
19830620	2,305	2,587	0.89	836,455	885,580	0.94	0.77
19880401	2,360			591,216			
19890331	2,104	2,061	1.02	920,547	859,478	1.07	-0.10
19890423	1,909	2,104	0.91	1,064,086	1,477,753	0.72	0.02
19910205	801			160,661			
19911210	2,508	2,529	0.99	286,802			
19920314	1,213	1,166	1.04	224,085			
19960430	3,512	3,313	1.06	1,284,821	1,362,018	0.94	0.96
19990207	2,135	2,026	1.05	1,024,227	782,345	1.31	0.83
20010130	628	1,250	0.50	251,884	1,117,160	0.23	-17.45
20040304	692	1,264	0.55	79,972	378,229	0.21	-17.78
20081116	2,344	2,357	0.99	266,689	1,004,748	0.27	-14.56
20090518	2,727	1,895	1.44	306,971	723,669	0.42	-4.88
20100226	592	798	0.74	138,496	551,280	0.25	-4.90
20101006	1,619	1,795	0.90	787,192	1,273,340	0.62	-0.73
20101201	541	1,282	0.42	290,273	593,022	0.49	-0.45
20101216	1,579	1,947	0.81	511,449	834,801	0.61	-1.08
20101223	1,853	2,045	0.91	1,018,506	1,546,045	0.66	-1.05
20110102	11,073	10,658	1.04	4,134,425	4,077,076	1.01	0.98
20120121	872	1,586	0.55	374,586	1,328,900	0.28	-5.18

Event	Flow			Volume			Hydrograph
	Model peak flow (m^3/s)	Rated peak flow (m^3/s)	Peak ratio	Model volume (ML)	Rated volume (ML)	Volume ratio	Nash-Sutcliffe
20120220	630	651	0.97	412,018	850,756	0.48	-4.49
20120316	138	644	0.21	116,562	432,908	0.27	-9.90
20130123	3,543	3,738	0.95	1,679,183	1,763,176	0.95	0.93
20130215	2,277	2,480	0.92	1,433,234	1,792,744	0.80	0.89

These results were classed as follows:

- Peak flow ratios: 20 are excellent, 2 are good and 7 are poor (Seqwater's respective values were 12, 1 and 8)
- Volume ratios: 7 are excellent, 1 is good and 6 are poor (Seqwater's respective values were 7, 5 and 3)
- Nash-Sutcliffe values: 3 are excellent, 1 is good, 1 is fair and 2 are poor (Seqwater's respective values were 1, 1, 1 and 3)

Figure 4-12 shows the comparison between rated flow and flood volume for the Brisbane River at Moggill using the recommended parameters. Included in the rated flow comparison is the trend line obtained by Seqwater for their recommended parameters. It should be noted that the Moggill stream gauge is tidally affected, and although attempts were made to develop a co-dependent rating linked to Brisbane Bar levels, this does could not entirely remove tidal effects. The rated low flows are highly unreliable, which affects volume ratio and Nash Sutcliffe value comparisons.

The comparison of trend lines at Moggill shows a very good correlation between calculated and rated peak flow with negligible evidence of bias with flow rate. This represents a slight improvement over the Seqwater results. The comparison of volumes shows that calculated flow volumes tend to be lower than the rated volumes, particularly for smaller events. Examination of rated vs calculated hydrographs suggests that incomplete gauge records and the low-flow rating in the tidally affected range significantly influence this trend.

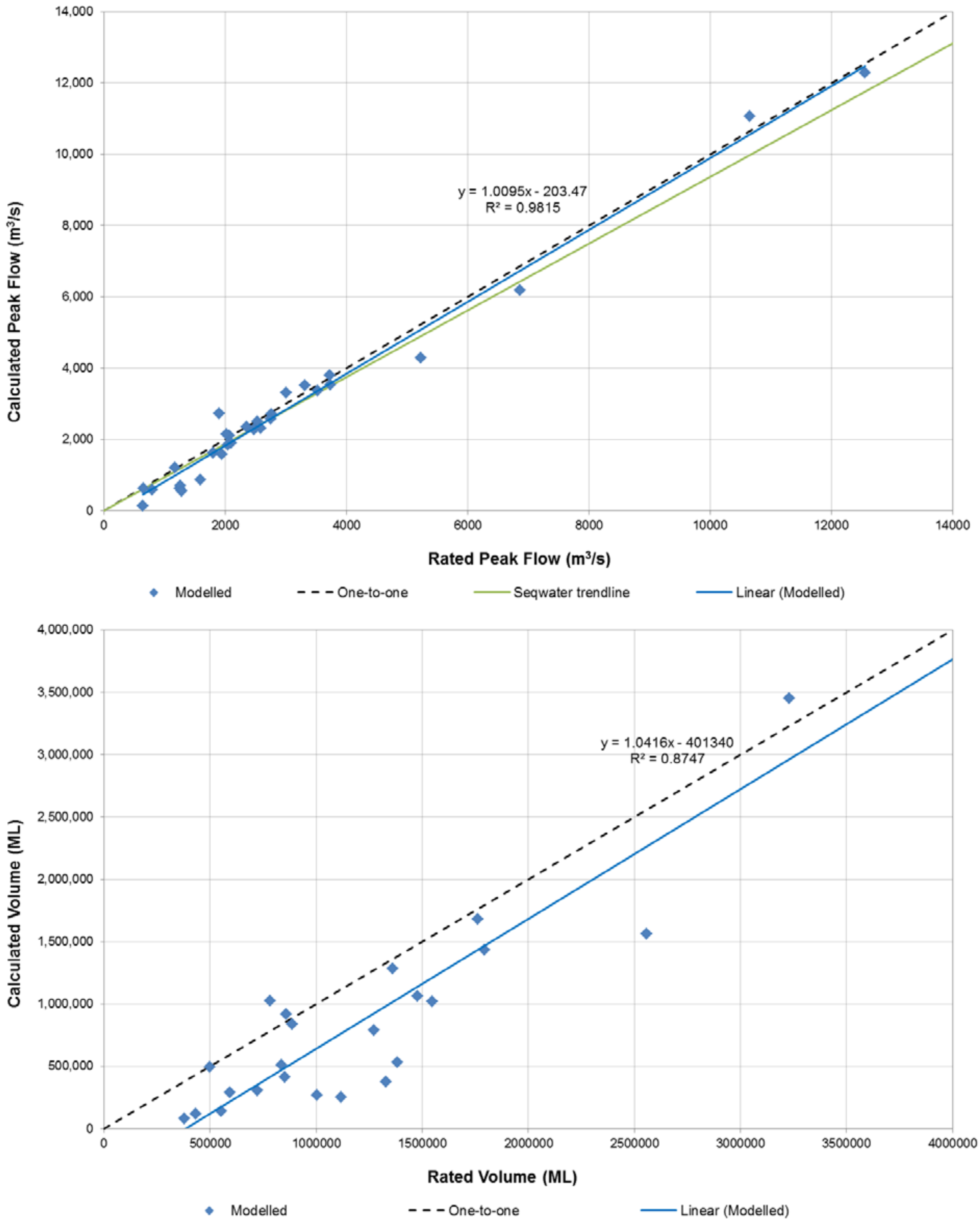


Figure 4-12 Model performance at Moggill for recommended parameters

5 Summary

The recalibration process has been carried out following a similar methodology to the Seqwater calibration process wherever possible. Due to time and budget constraints, the recalibration process has focussed on five key events: January 1974, May 1996, February 1999, January 2011 and January 2013. A revised set of recommended parameters has been calculated from the results for these five events and has been applied to all 38 of Seqwater's calibration events. A comparison of the model results was performed using the recommended parameters.

A number of changes to the models were recommended as part of the *Hydrologic Model Calibration and Validation Review*, listed in Table 5-1. The recalibration process has seen further modifications to a number of the models as follows:

- Stanley River model: the reporting location for the Woodford gauge was moved to the downstream junction to represent total flows through this area, as the hydraulic model of this area indicated that this was a more appropriate location
- Lockyer Creek model: the schematisation of the lower Lockyer Creek was modified to include the main channel and three separate bypass locations. This was felt to be an appropriate schematisation for this reach where the main channel is perched and the breakout flows travel slowly through the floodplain
- Lower Brisbane model: Calibration parameters alpha and beta were set to typical values for the local tributaries. Main channel routing time was reduced by applying a reach length scaling factor. Storage-discharge relationships used in the conceptual storages have been related directly to physical properties of the river and floodplain by combining level-volume relationships taken from DTM with level-flow relationships estimated from the main gauge rating curves

Table 5-1 Adopted URBS model changes

	Stanley	**Upper Brisbane**	**Lockyer**	**Bremer**	**Warill**	**Purga**	**Lower Brisbane**
Include revised rating curves	✓	✓	✓	✓	✓	✓	✓
Include channel routing non-linearity (n = 0.85)			✓	✓		✓	
Remove Kedron Brook catchment (Seqwater subareas 111, 113, 97, 99 and105)							✓
Include impervious fractions, urbanised areas and reduced reach length factors							✓
Modification of conceptual storage volumes (based on physical storage characteristics)		✓					✓

The recalibration process has generally seen either an improved or equivalent quality of calibration for all catchments when compared to the Seqwater results. Calibration results were similar in the Stanley River subcatchment and were slightly improved in the Upper Brisbane subcatchment, especially for the 1999, 2011 and 2013 events. Calibration in the Lockyer Creek subcatchment is difficult to assess given the uncertainty associated with the rating curves, especially in the higher flow range for the stream gauges situated in the lower reaches of this catchment, however the calibration at Glenore Grove is improved across all events. Overall, calibration in the Bremer River and Warrill Creek subcatchments was similar and a slight improvement in calibration was achieved in the Purga Creek subcatchment. Calibration in the Lower Brisbane model was notably improved for most events, particularly with respect to the timing of flow routing along the river.

The recalibration process has further strengthened the justification for review of the models, particularly the lower Lockyer Creek floodplain and Lower Brisbane, to be carried out once a calibrated hydraulic model is available. However it must be acknowledged that due to limitations of the hydrologic routing implicit in the URBS models it may not be possible to fully replicate complex dynamic or hydraulic phenomena (eg backwater effects).

The recommended alpha and beta parameters remain similar for the Upper Brisbane river subcatchment where the only changes to the model were to rating curves and the conceptual storages in the lower reaches (for the pre-Wivenhoe conditions). In the Stanley River where the model was modified around the Woodford gauge, the alpha value was reduced and the beta value was increased. In the models where channel routing non-linearity was introduced (Lockyer, Bremer and Purga), alpha values were increased to obtain a reasonable calibration and beta values were modified as required. In the Warrill Creek model, where only the rating curves were modified, the alpha value was slightly increased and the beta value was decreased. In the Lower Brisbane, alpha and beta were increased slightly to provide a typical representation of local tributaries but do not necessarily represent any individual tributary. A reach length factor was applied to main channel to match routing times observed between stream gauges along the Brisbane River.

The recommended model parameters for each sub-catchment model are shown in Table 5-2.

Table 5-2 Recommended model parameters

Sub-catchment	Alpha	Beta	m	n
Stanley River	0.11	5.7	0.8	1.0
Upper Brisbane River	0.12	2.8	0.8	1.0
Lockyer Creek	0.49	3.1	0.8	0.85
Bremer River	0.79	2.8	0.8	0.85
Warrill Creek	0.79	2.5	0.8	0.85
Purga Creek	0.93	3.8	0.8	0.85
Lower Brisbane River	0.30[a]	4.0	0.8	1.0

Notes: a Reach length factor of 0.2 applied to main channel reach lengths

When comparing model results from the recommended parameters runs across the full range of verification events, all of the examined flow gauges generally show a good correlation between calculated and rated peak flow rates and event volumes with no obvious flowrate related bias.

6 Glossary

6.1 Hydrologic terms

AEP: Annual Exceedance Probability – is a measure of the likelihood (expressed as a probability) of a flood event reaching or exceeding a particular magnitude in any one year. A 1% (AEP) flood has a 1% (or 1 in 100) chance of occurring or being exceeded at a location in any year

AHD: Australian Height Datum (m), the standard reference level in Australia

AR&R: Australian Rainfall and Runoff (AR&R) is a national guideline document for the estimation of design flood characteristics in Australia. It is published by Engineers Australia. The current 2003 edition is now being revised. The revision process includes 21 research projects, which have been designed to fill knowledge gaps that have arisen since the 1987 edition

CHA: Comprehensive Hydrologic Assessment

CL: Continuing Loss (mm/hour). The amount of rainfall during the later stages of the event that infiltrates into the soil and is not converted to surface runoff in the hydrologic model

CRC-CH: Cooperative Research Centre – Catchment Hydrology. In this report, CRCH-CH usually refers to a Monte Carlo sampling method that was developed by the CRC-CH

CSS: Complete Storm Simulation. This is one of the proposed Monte Carlo sampling methods

Cumulative probability: The probability of an event occurring over a period of time, any time in that period. This probability increases over time

DEA: Design Event Approach. A semi-probabilistic approach to establish flood levels, which only accounts for the variability of the rainfall intensity

Design flood event: Hypothetical flood events based on a design rainfall event of a given probability of occurrence (ie AEP). The probability of occurrence for a design flood event is assumed to be the same as the probability of rainfall event upon which it is based (EA, 2003)

DTM: Digital Terrain Model

EL (m AHD): Elevation (in metres) above the Australian Height Datum

FFA: Flood Frequency Analysis – a direct statistical assessment of flood characteristics

Flood mitigation manual (Flood Manual): A flood mitigation manual approved under section 371E(1)(a) or 372(3) of the Water Supply (Safety and Reliability) Act 2008 (QLD)

FOSM: Flood Operations Simulation Model (refer Seqwater 2014)

Floodplain: Area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by the PMF (CSIRO, 2000)

FSL: Full Supply Level - maximum normal water supply storage level of a reservoir behind a dam

FSV: Full Supply Volume – volume of the reservoir at FSL

GEV: Generalised Extreme Value statistical distribution

GIS: Geographic Information System

GL: Gigalitres This is a unit of volume used in reservoir studies. A Gigalitre = 1,000,000,000 litres or equivalently 1,000,000 m^3

IFD-curves: Intensity-Frequency-Duration curves, describing the point- or area-rainfall statistics. In the current report rainfall depth is generally used as an alternative to rainfall intensity. Rainfall depth is the product of duration and intensity. It was decided to maintain the term “IFD” as this is the terminology that the reader is most likely to be familiar with

IL: Initial Loss (mm). The amount of rainfall that is intercepted by vegetation or absorbed by the ground and is therefore not converted to runoff during the initial stages of the rainfall event

LOC: Loss of Communications dam operating procedure, refer Flood Manual (Seqwater 2013)

LPIII: Log-Pearson Type III statistical distribution

IQQM: Integrated Quantity and Quality Model for water resources planning

JPA: Joint Probability Approach. A general term for probabilistic methods to establish design flood levels

MCS: Monte Carlo Simulation

MHWS: Mean High Water Spring Tide level

ML: Megalitre. This is a unit of volume used in reservoir studies. A megalitre is equal to 1,000,000 litres or, equivalently, 1,000 m^3

m^3/s: Cubic metre per second – unit of measurement for instantaneous flow or discharge

PMF: Probable Maximum Flood – the largest flood that could conceivably occur at a particular location, resulting from the PMP (CSIRO, 2000) and Australia Rainfall and Runoff, 2003 (EA, 2003)

PMP: Probable Maximum Precipitation – the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of year, with no allowance made for long-term climatic trends (CSIRO, 2000; EA 2003)

PMP DF: Probable Maximum Precipitation Design Flood – the flood event that results from the PMP event.

Stochastic flood event: Statistically generated synthetic flood event. Stochastic flood events include variability in flood input parameters (eg temporal and spatial rainfall patterns) compared to design flood events. Stochastic flood events by their method of generation exhibit a greater degree of variability and randomness compared to design flood events (See also Design flood event)

Synthetic flood event: See Stochastic flood event

TPT: Total Probability Theorem. This is one of the fundamental theorems in statistics. In this report, TPT refers to a Monte Carlo sampling method that is based on stratified sampling and, hence, makes use of the total probability theorem

URBS: Unified River Basin Simulator. A rainfall runoff routing hydrologic model (Carroll, 2012)

6.2 Study related terms

BCC: Brisbane City Council

BoM: Australian Bureau of Meteorology

BRCFS: Brisbane River Catchment Flood Study

BRCFM: Brisbane River Catchment Floodplain Management Study

BRCFMP: Brisbane River Catchment Floodplain Management Plan

Delft-FEWS: Flood Early Warning Systems, a software package developed by Deltares, initially for the purpose of real-time flood forecasting. Delft-FEWS is used all over the world, including by the Environment Agency (UK) and the National Weather Service (US). Currently, it is also being implemented by Deltares and BoM for flood forecasting in Australia. The Monte Carlo framework for the BRCFS-Hydrology Phase will be implemented in Delft-FEWS

DEWS: Department of Energy and Water Supply

DIG: Dams Implementation Group

DNRM: Department of Natural Resources and Mines

DSITIA: Department of Science Information Technology, Innovation and the Arts

DSDIP: Department of State Development and Infrastructure Planning

EA: Engineers Australia formally known as The Institute of Engineers, Australia

GA: General Adapter, an interface between the Delft-FEWS environment and an external module

ICC: Ipswich City Council

IPE: Independent panel of experts to the BRCFS

LVRC: Lockyer Valley Regional Council

ND: No-dams condition. This scenario represents the catchment condition without the influence of the dams and reservoirs. The reservoir reaches have effectively been returned to their natural condition

NPDOS: North Pine Dam Optimisation Study conducted in response to the QFCOI Final Report

PIG: Planning Implementation Group

QFCOI: Queensland Floods Commission of Inquiry

RTC: Real-Time Control. A software package for simulations of reservoir operation. RTC tools is used for the simulation of Wivenhoe and Somerset reservoirs

SRC: Somerset Regional Council

TWG: Technical Working Group

WD: With-dams condition. This scenario represents the catchment condition with the influence of the dams and reservoirs represented in their current (2013) configuration

WSDOS: Wivenhoe and Somerset Dam Optimisation Study conducted in response to the QFCOI Final report

Appendices

Appendix A
Calibration plots

Stanley River calibration plots

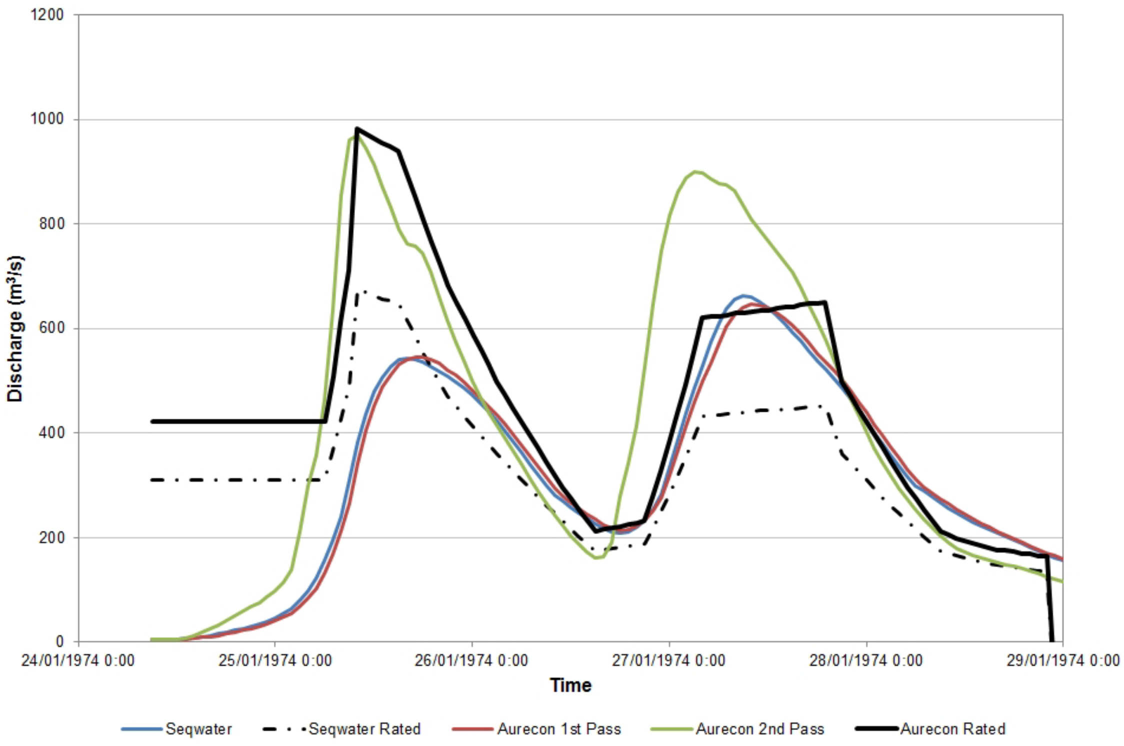


Figure A1 Woodford 1974 event

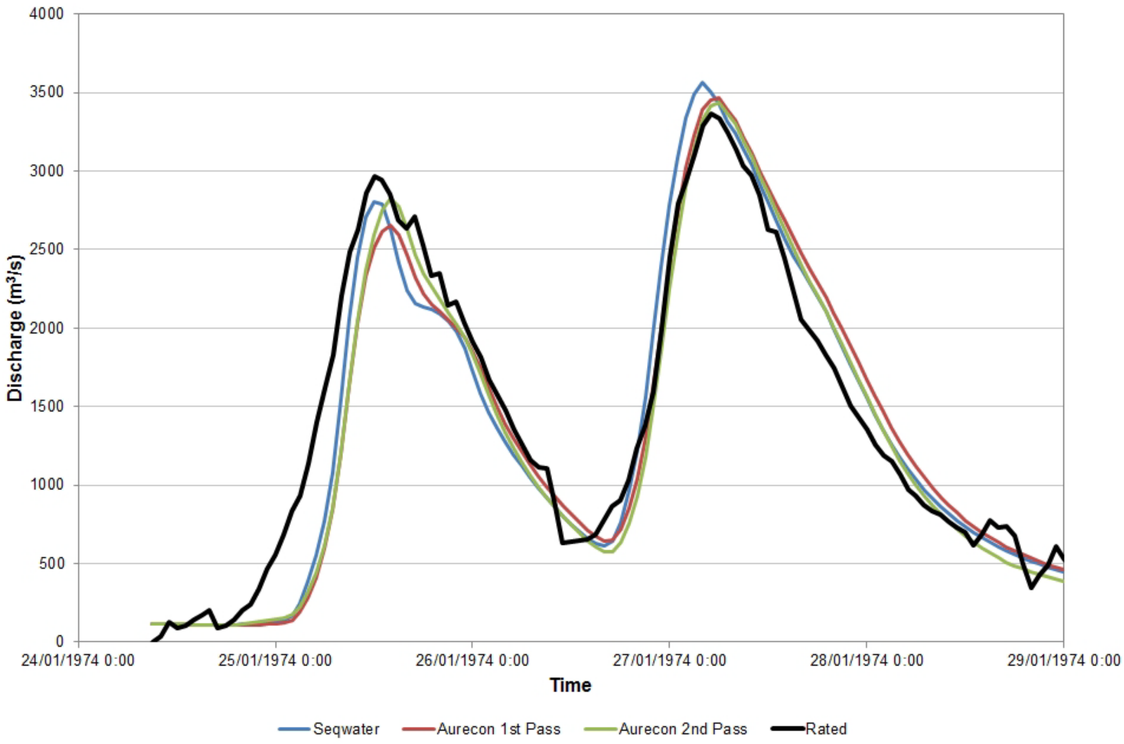


Figure A2 Somerset inflow 1974 event

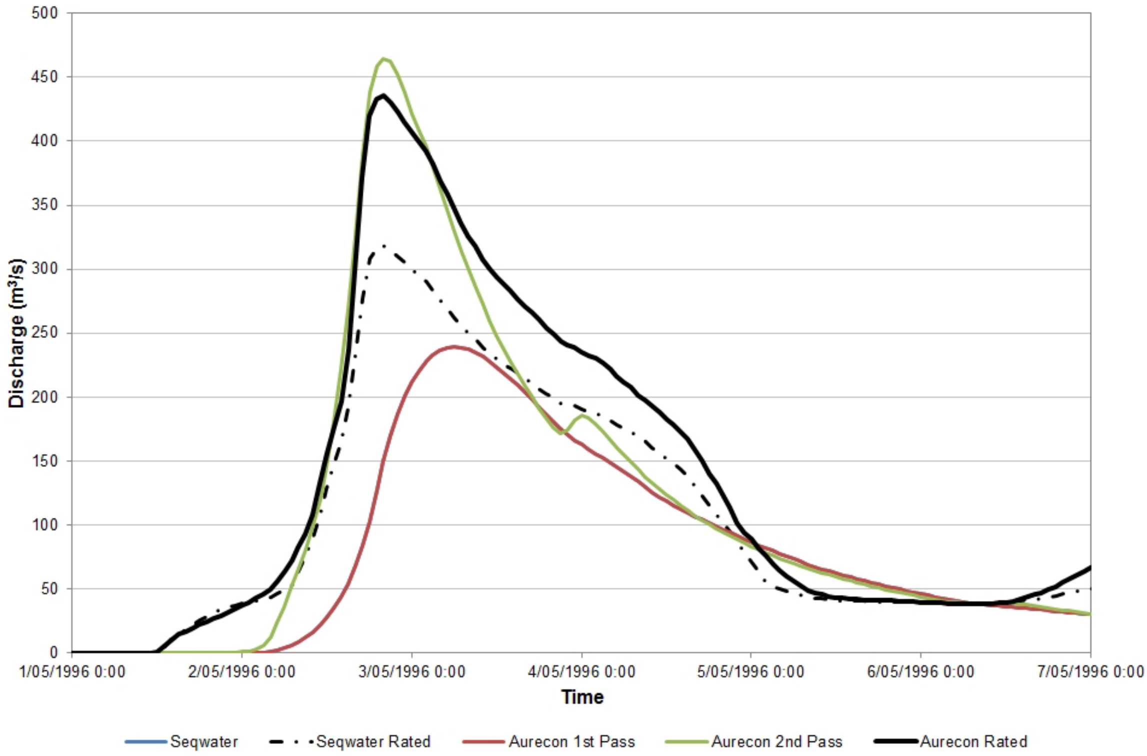


Figure A3 Woodford 1996 event

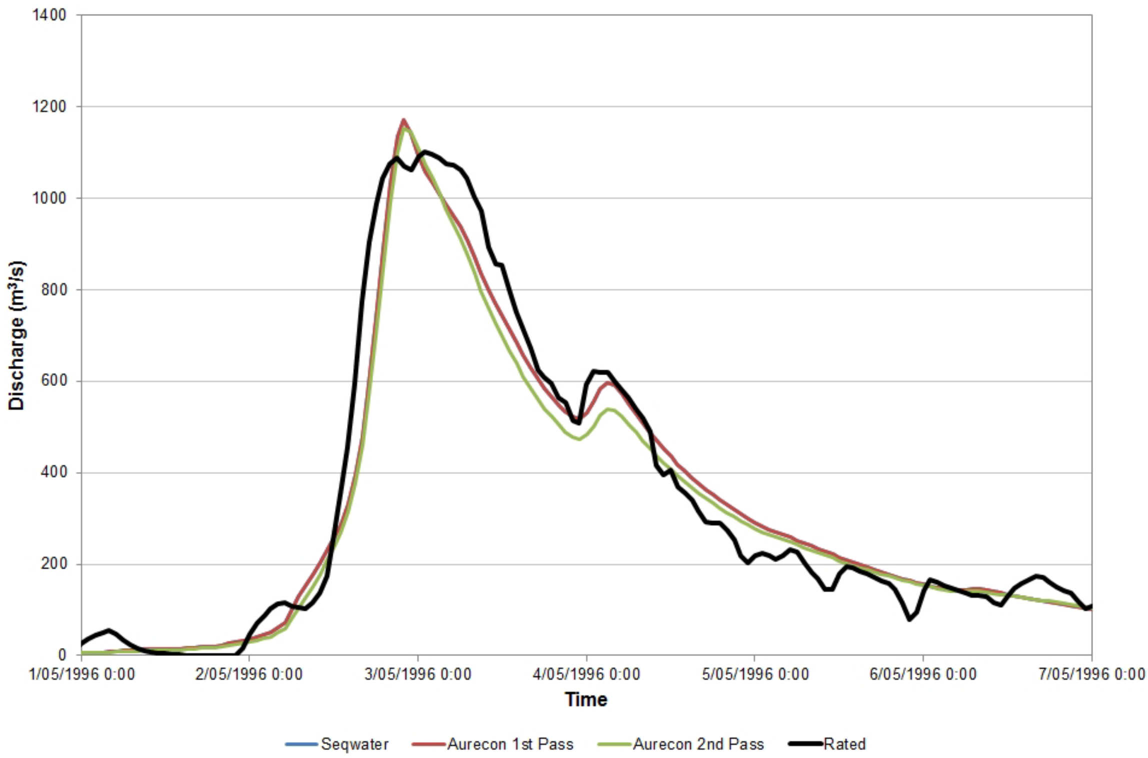


Figure A4 Somerset inflow 1996 event

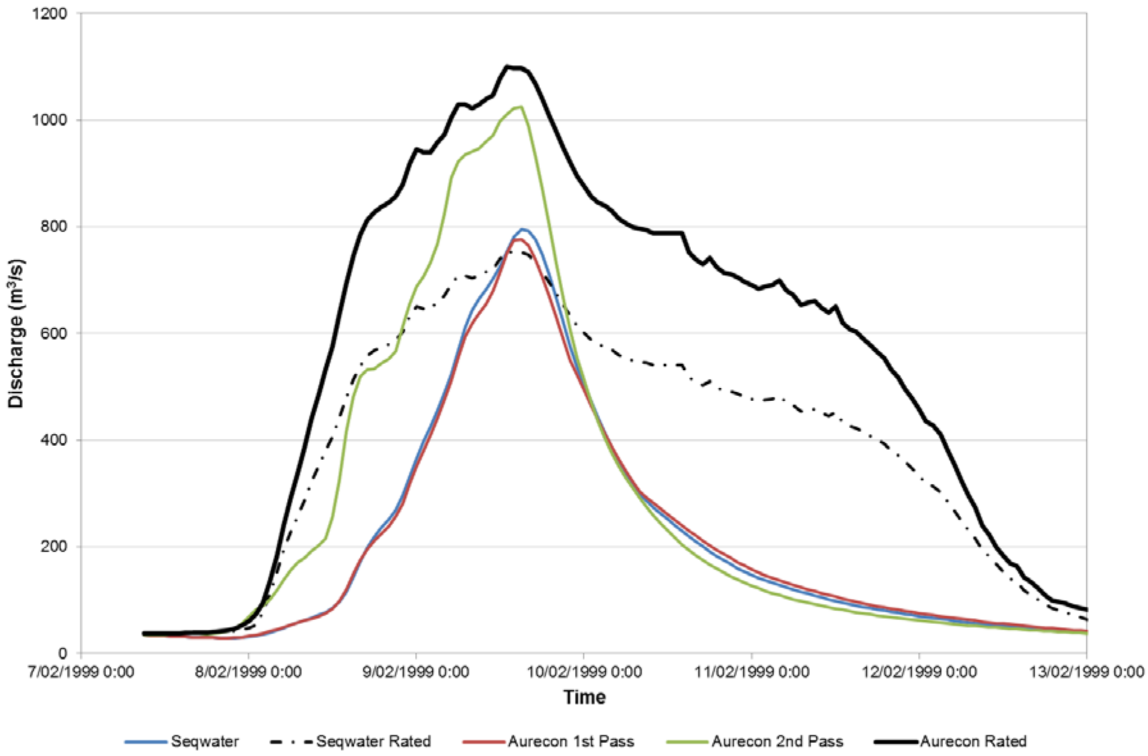


Figure A5 Woodford 1999 event

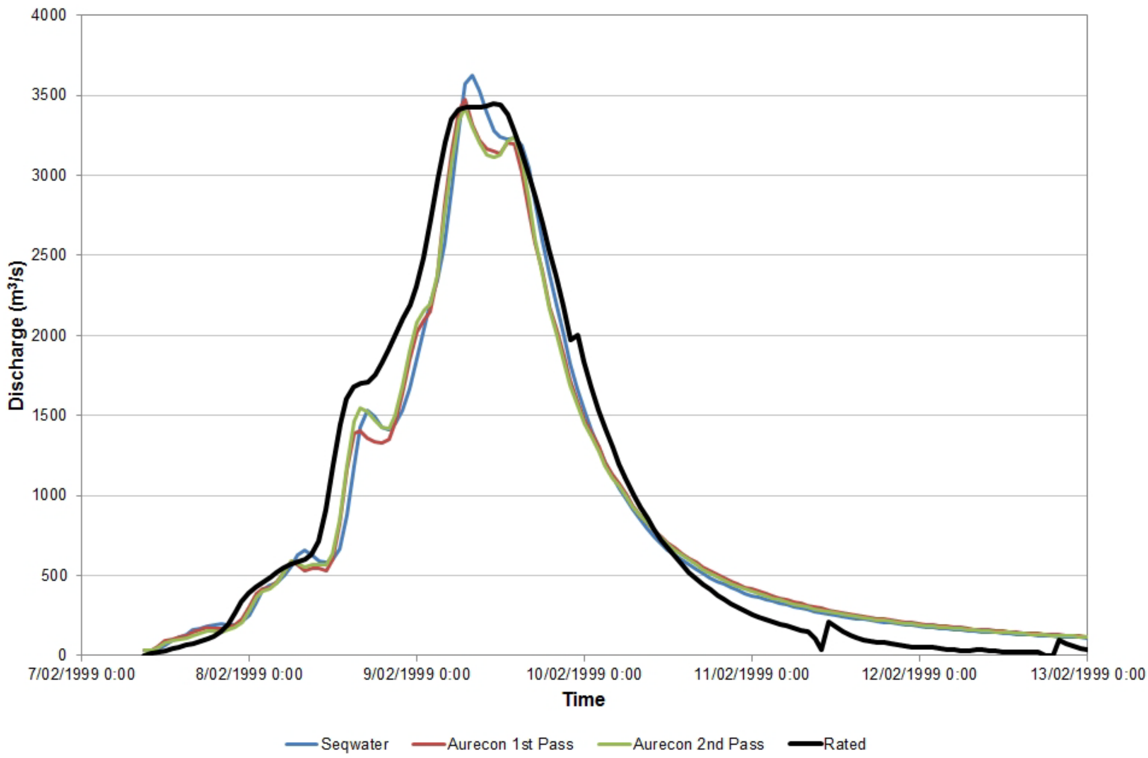


Figure A6 Somerset inflow 1999 event

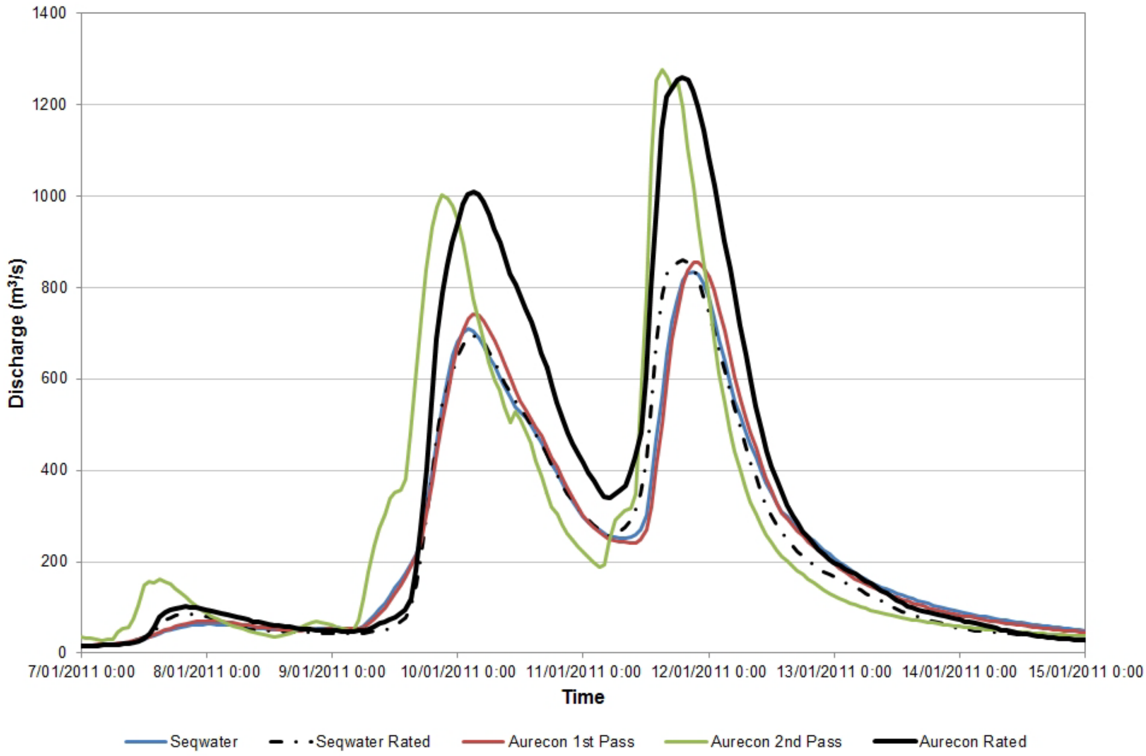


Figure A7 Woodford 2011 event

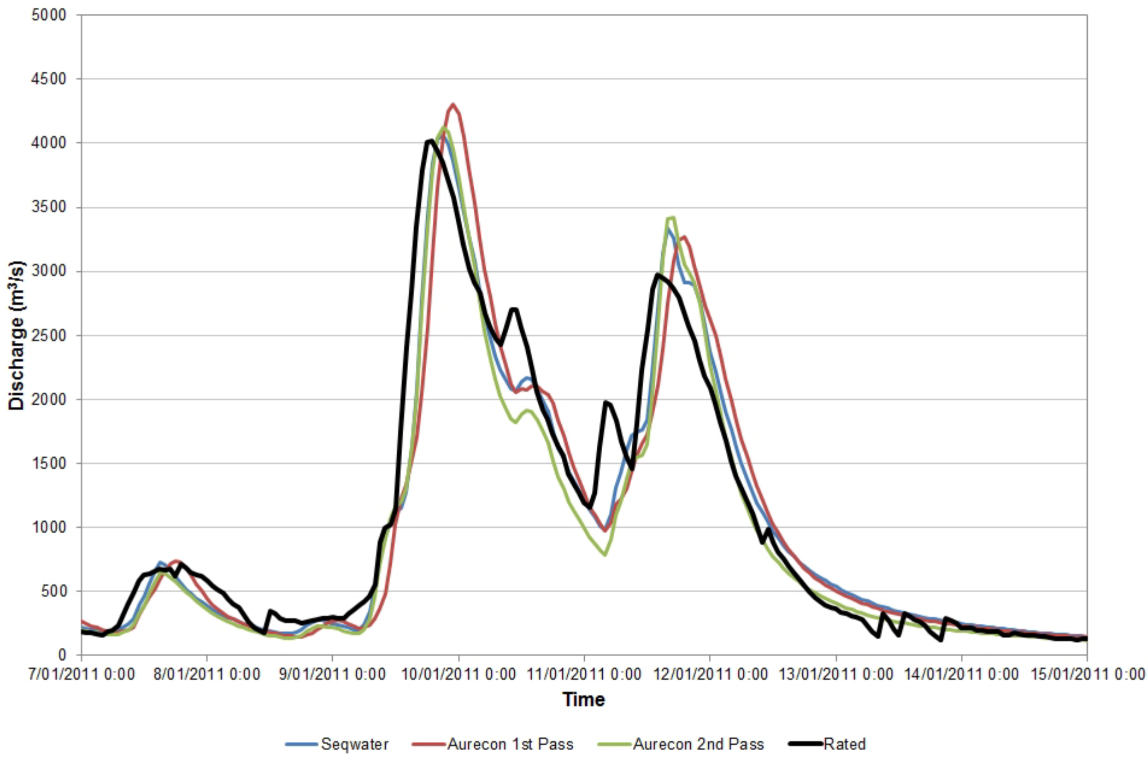


Figure A8 Somerset inflow 2011 event

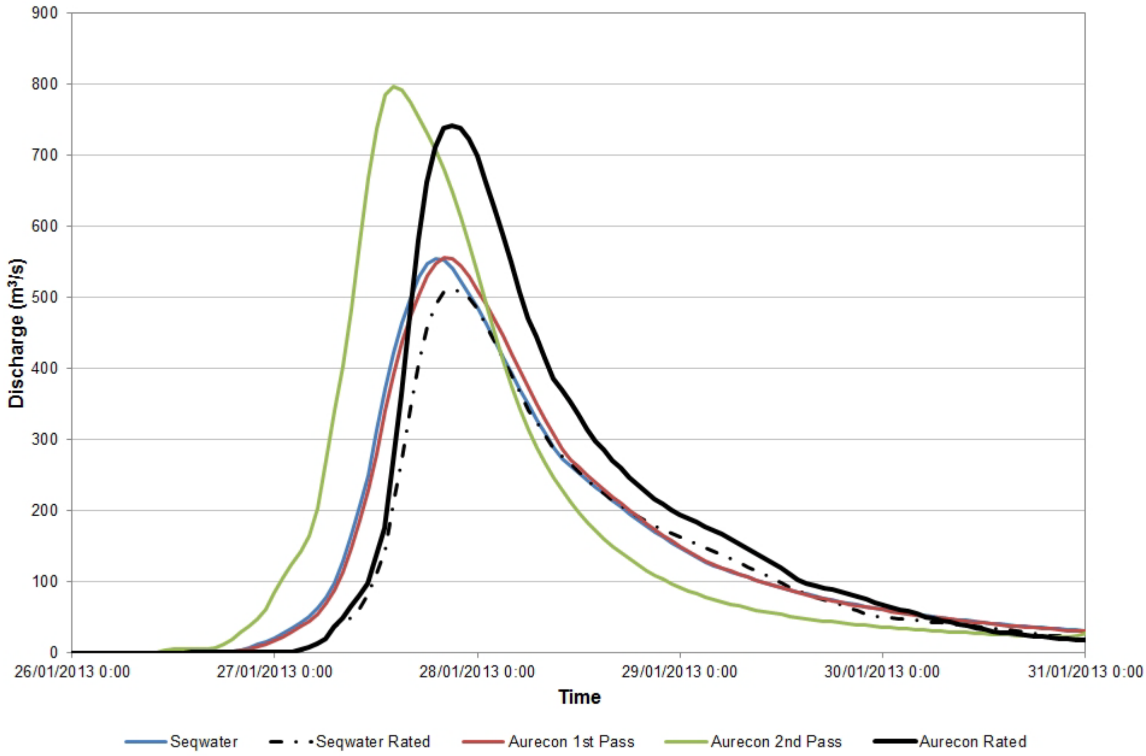


Figure A9 Woodford 2013 event

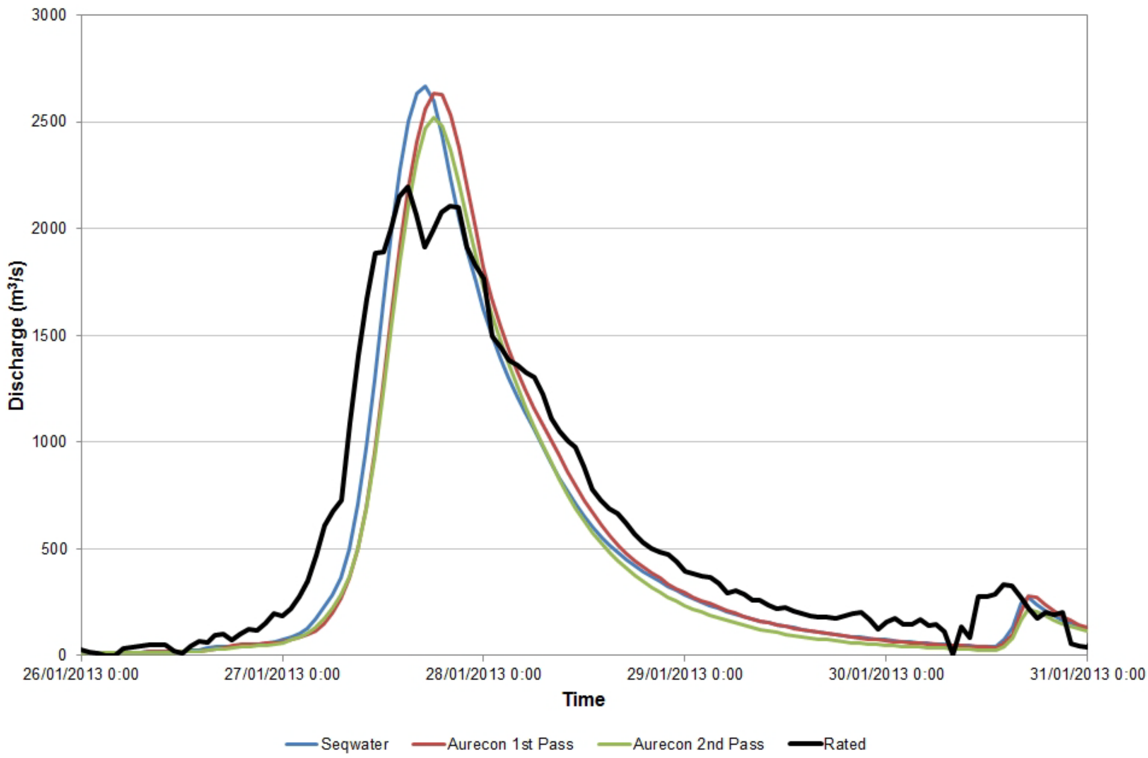


Figure A10 Somerset inflow 2013 event

Upper Brisbane River calibration plots

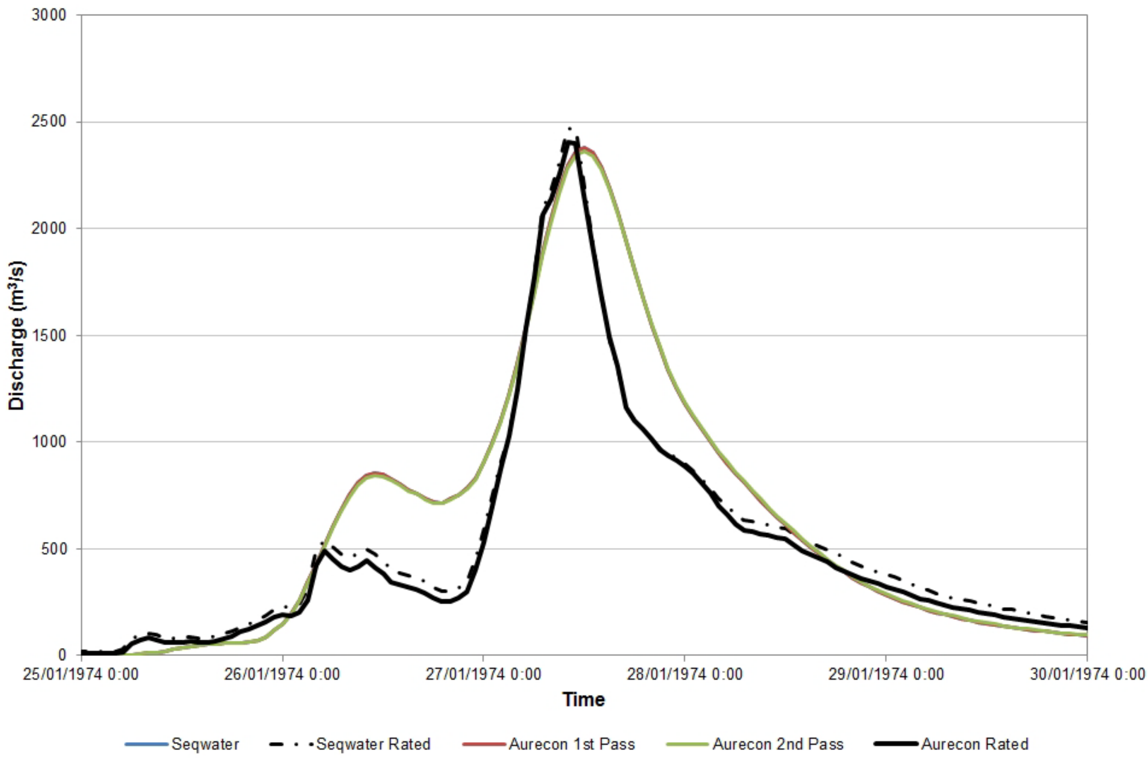


Figure A11 Linville 1974 event

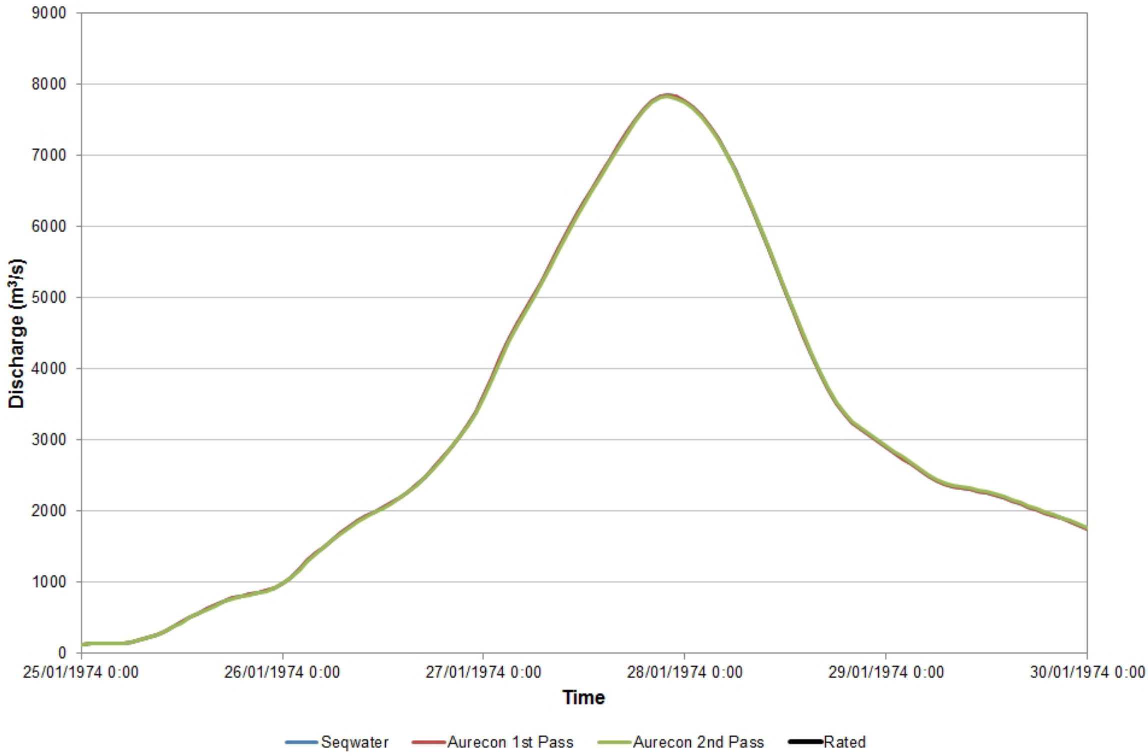


Figure A12 Wivenhoe damsite 1974 event

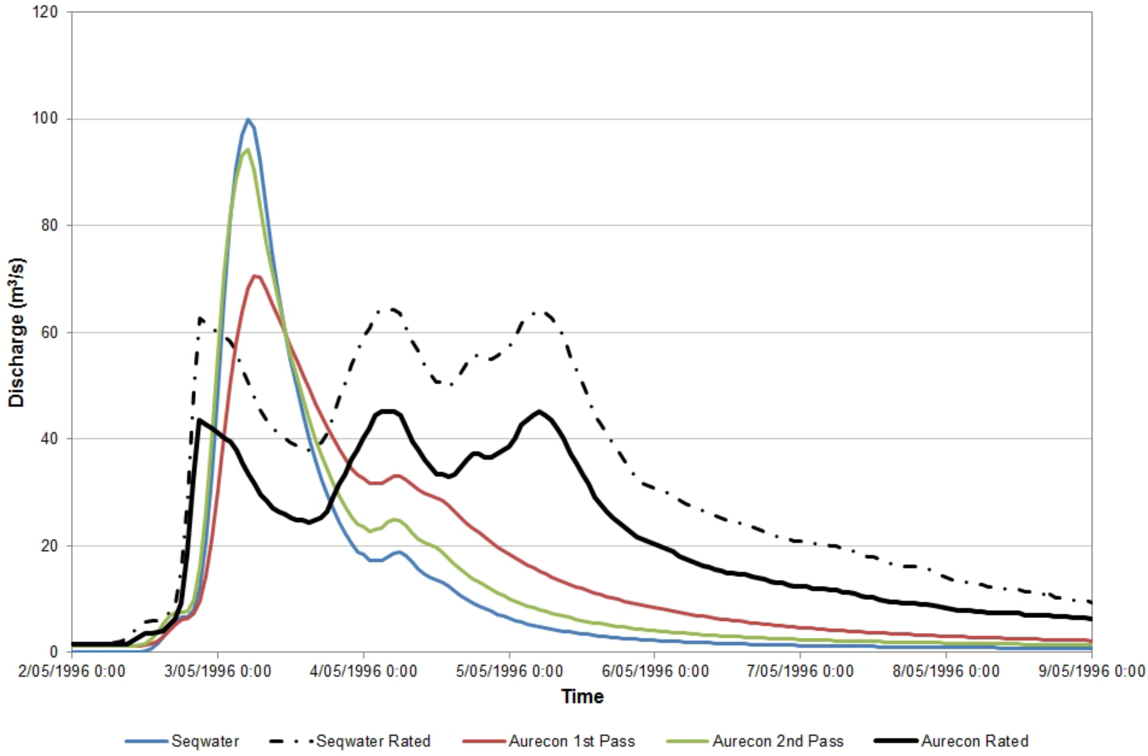


Figure A13 Linville 1996 event

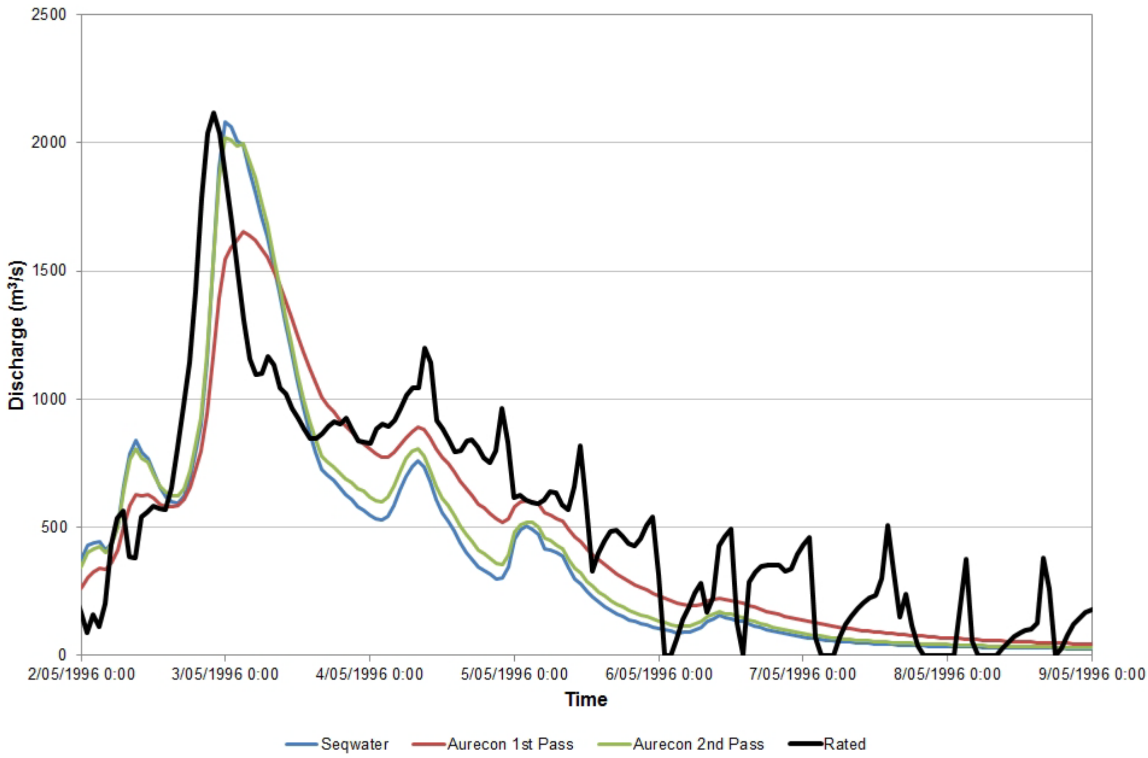


Figure A14 Wivenhoe inflow 1996 event

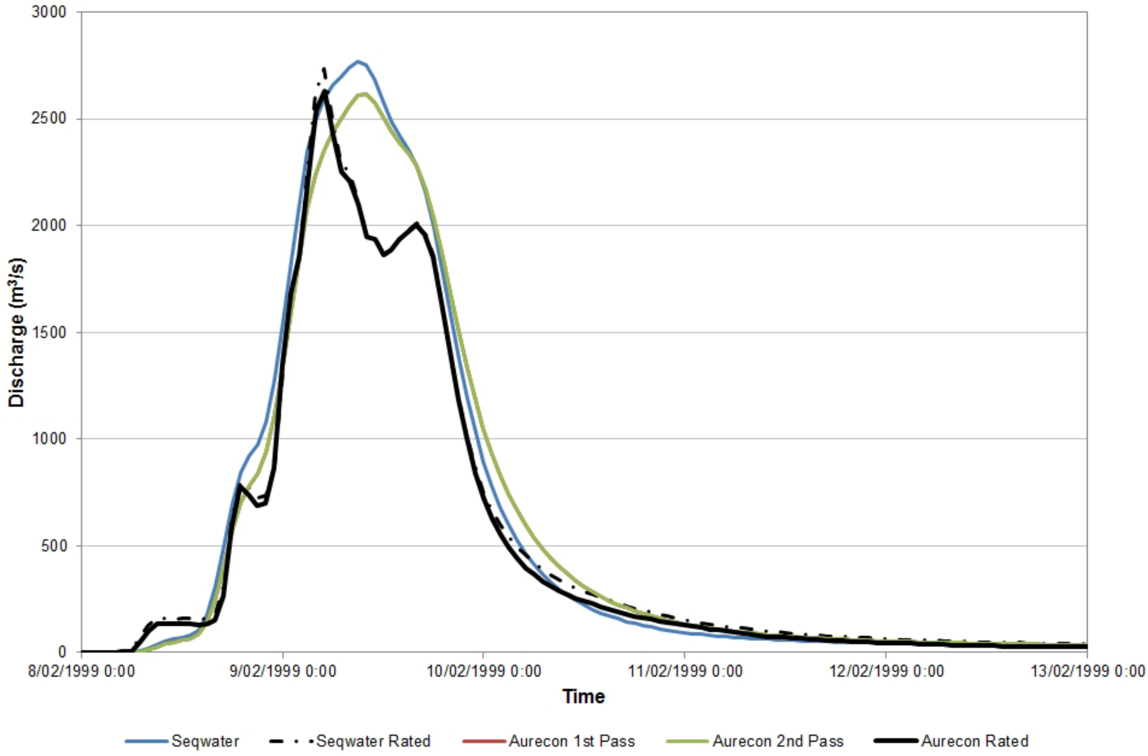


Figure A15 Linville 1999 event

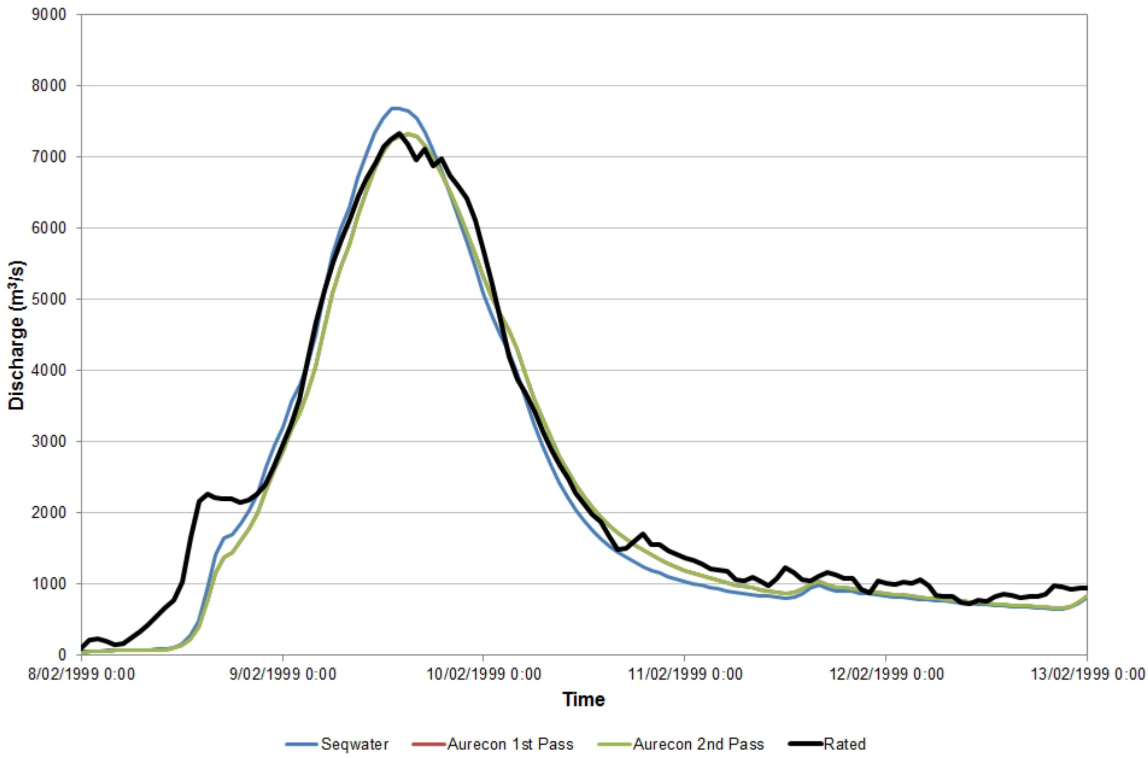


Figure A16 Wivenhoe inflow 1999 event

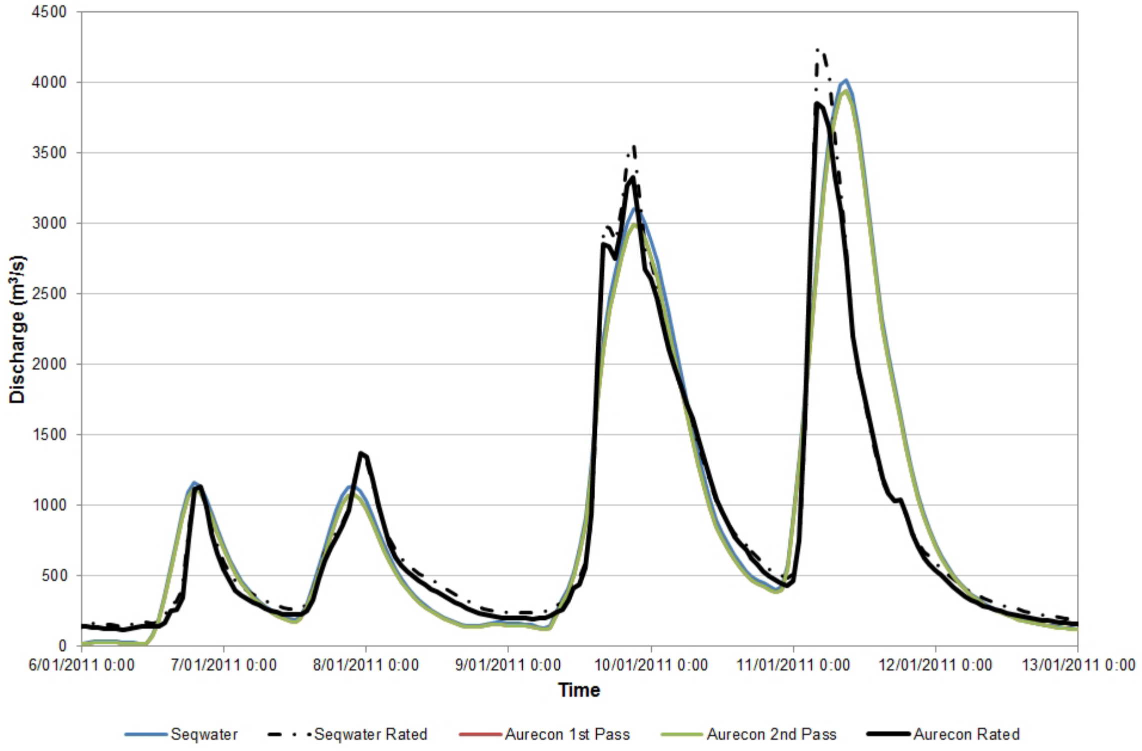


Figure A17 Linville 2011 event

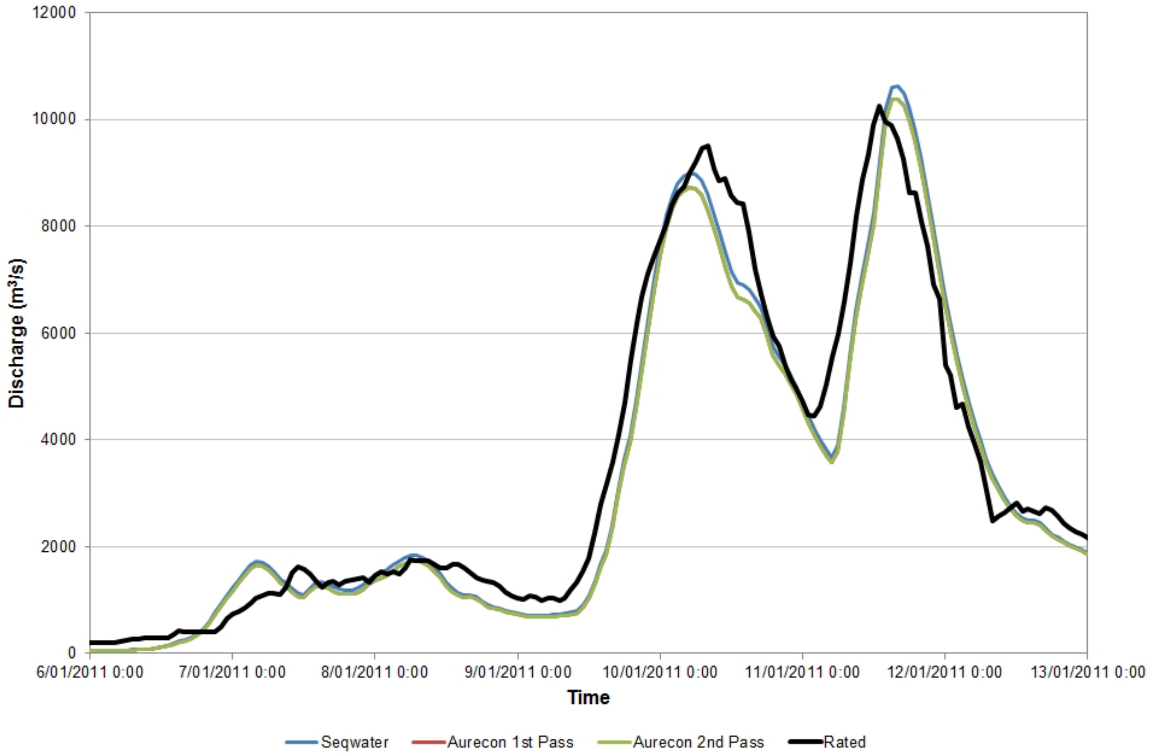


Figure A18 Wivenhoe inflow 2011 event

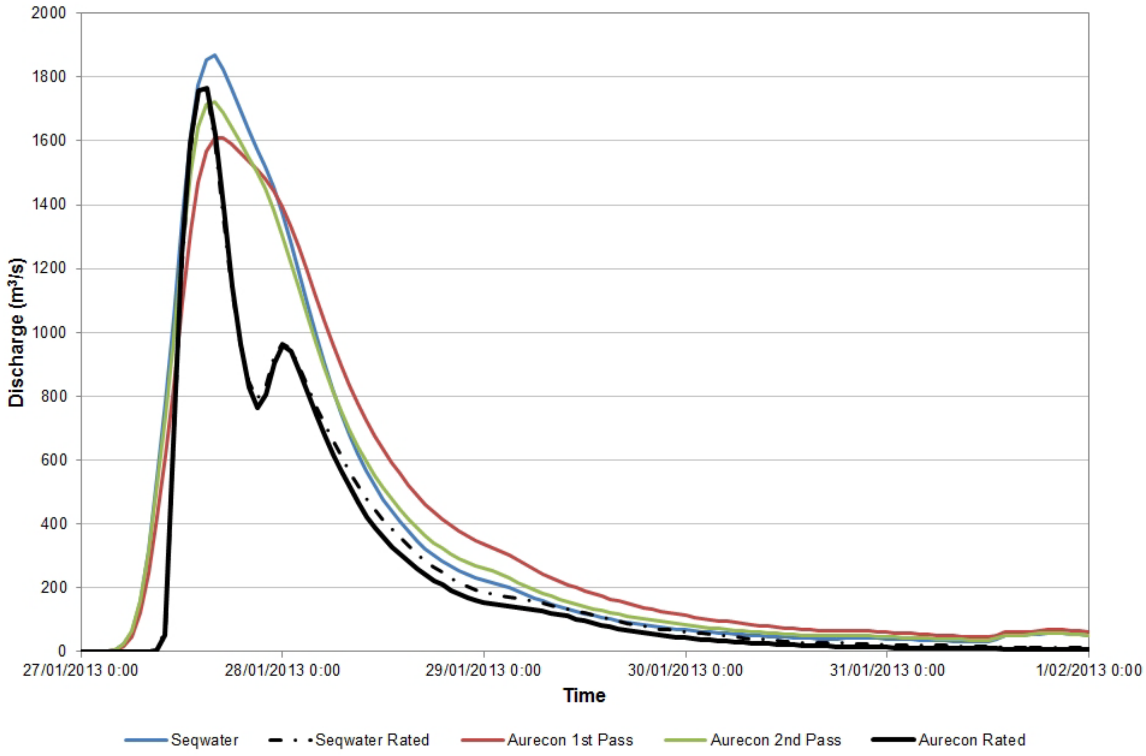


Figure A19 Linville 2013 event

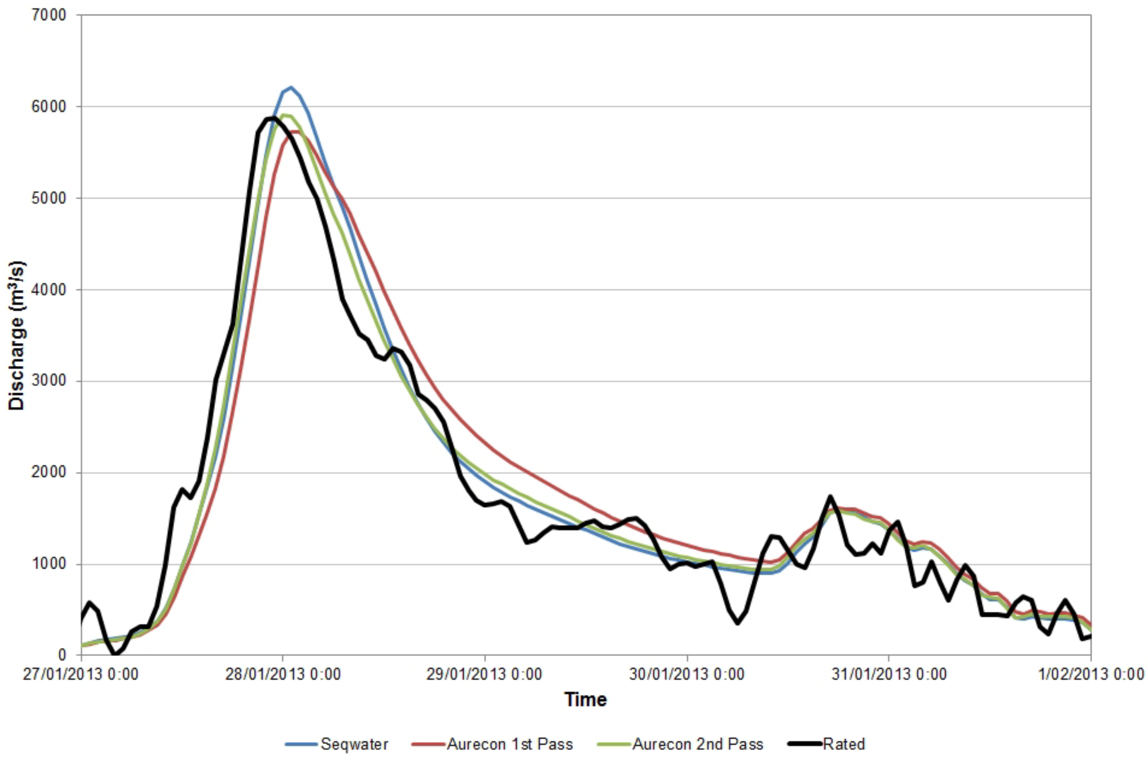


Figure A20 Wivenhoe inflow 2013 event

Lockyer Creek calibration plots

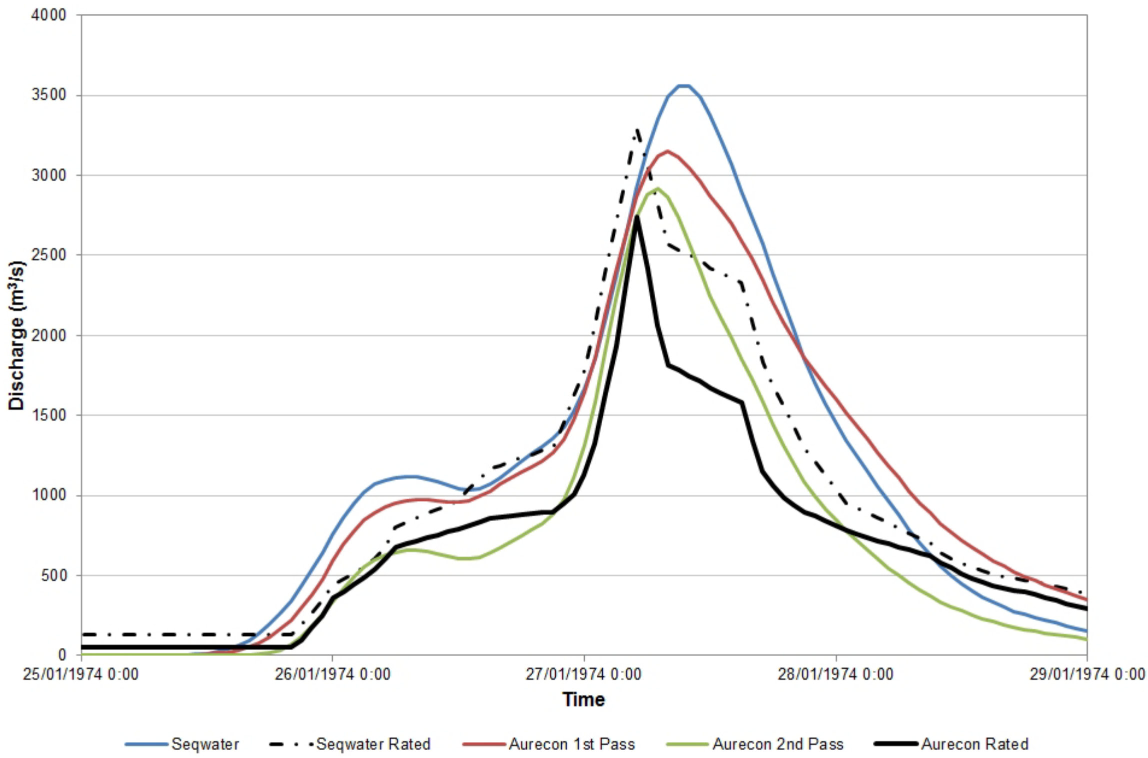


Figure A21 Glenore Grove 1974 event

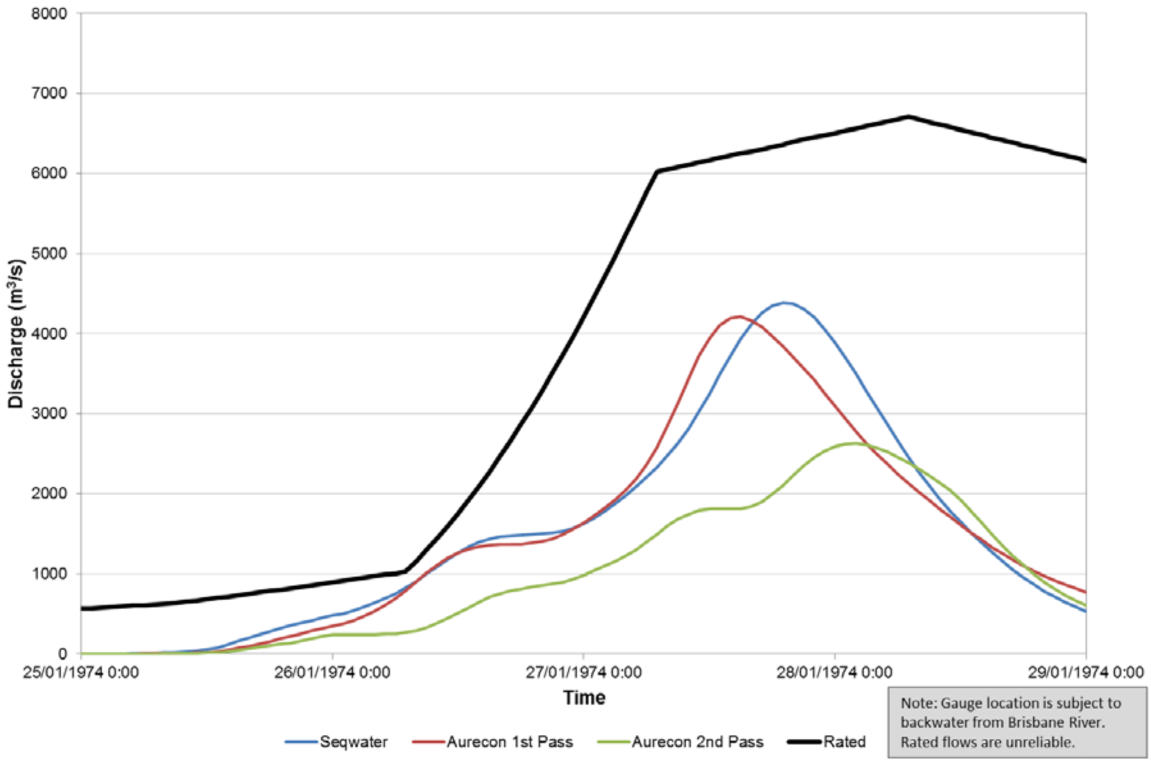


Figure A22 O'Reillys Weir 1974 event

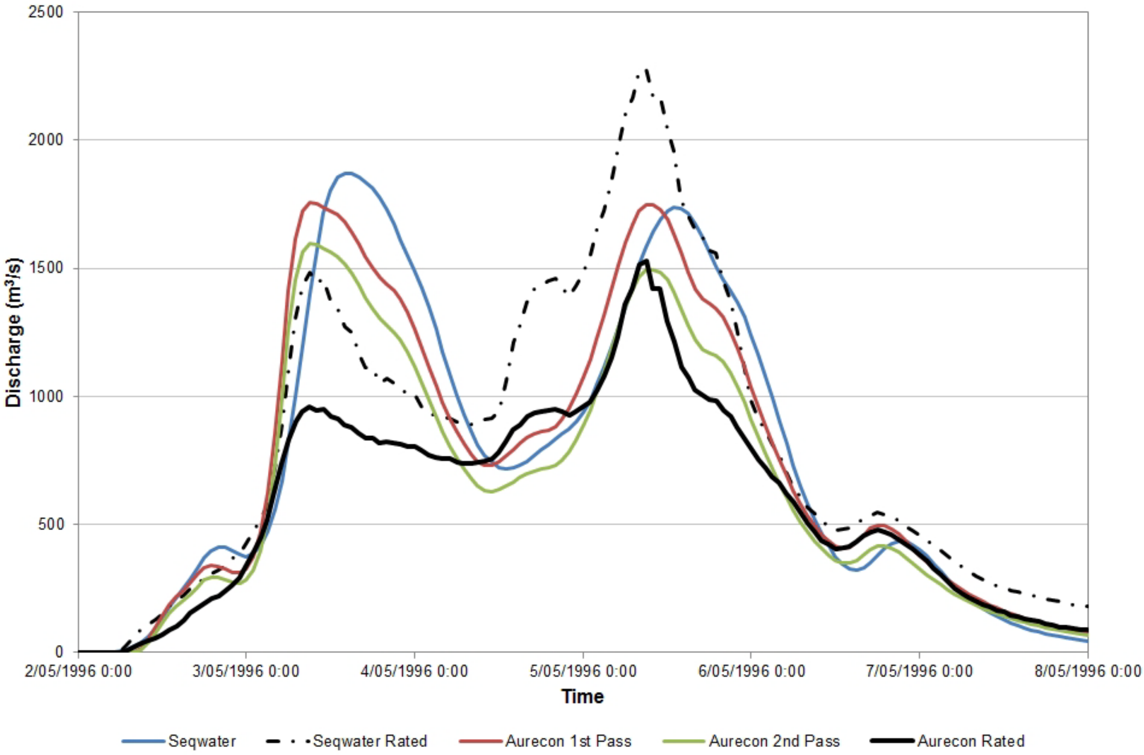


Figure A23 Glenore Grove 1996 event

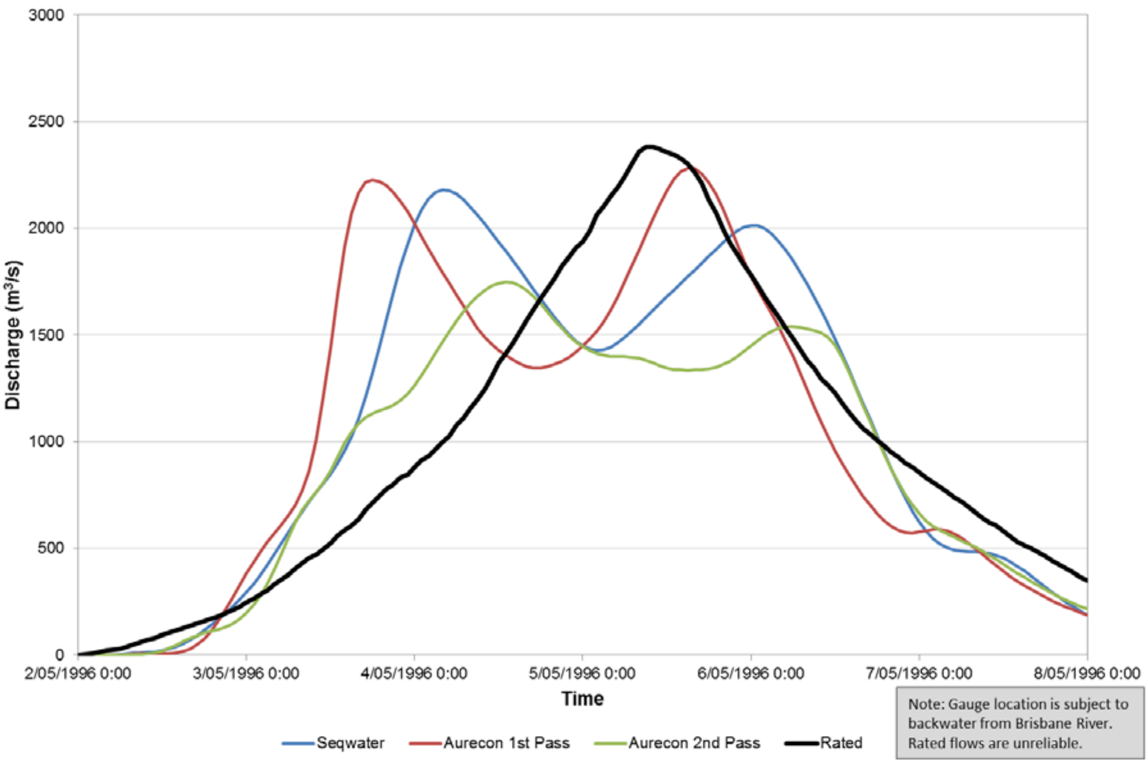


Figure A24 O'Reillys Weir 1996 event

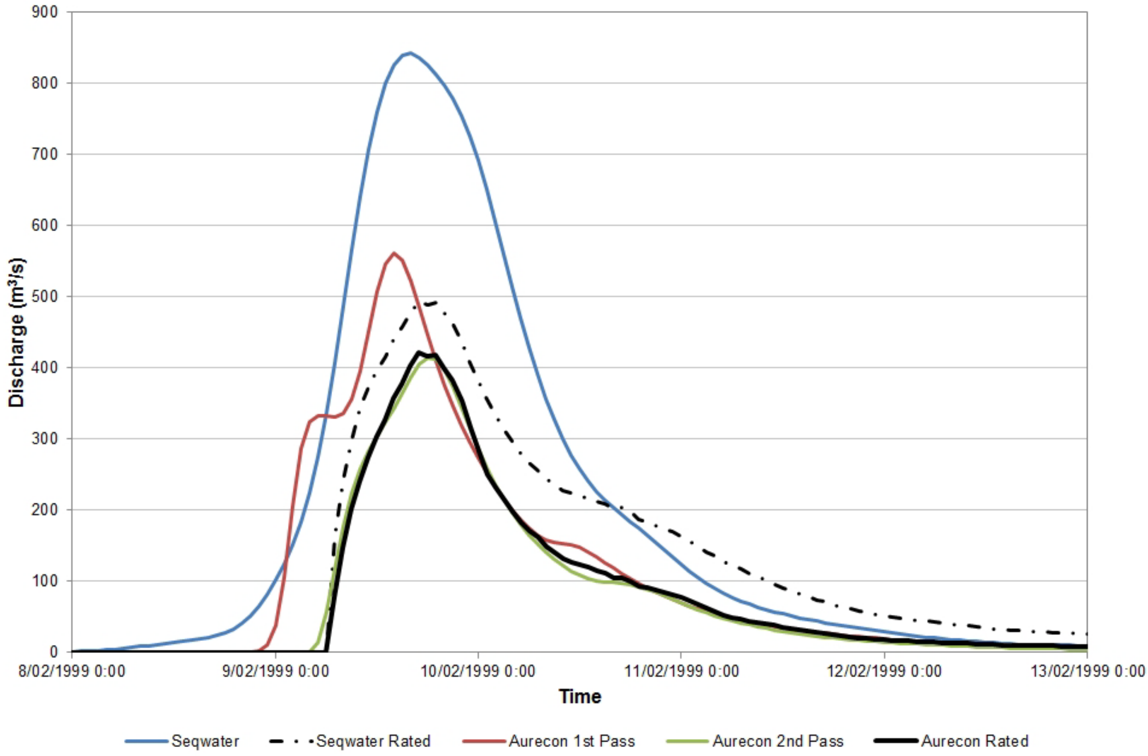


Figure A25 Glenore Grove 1999 event

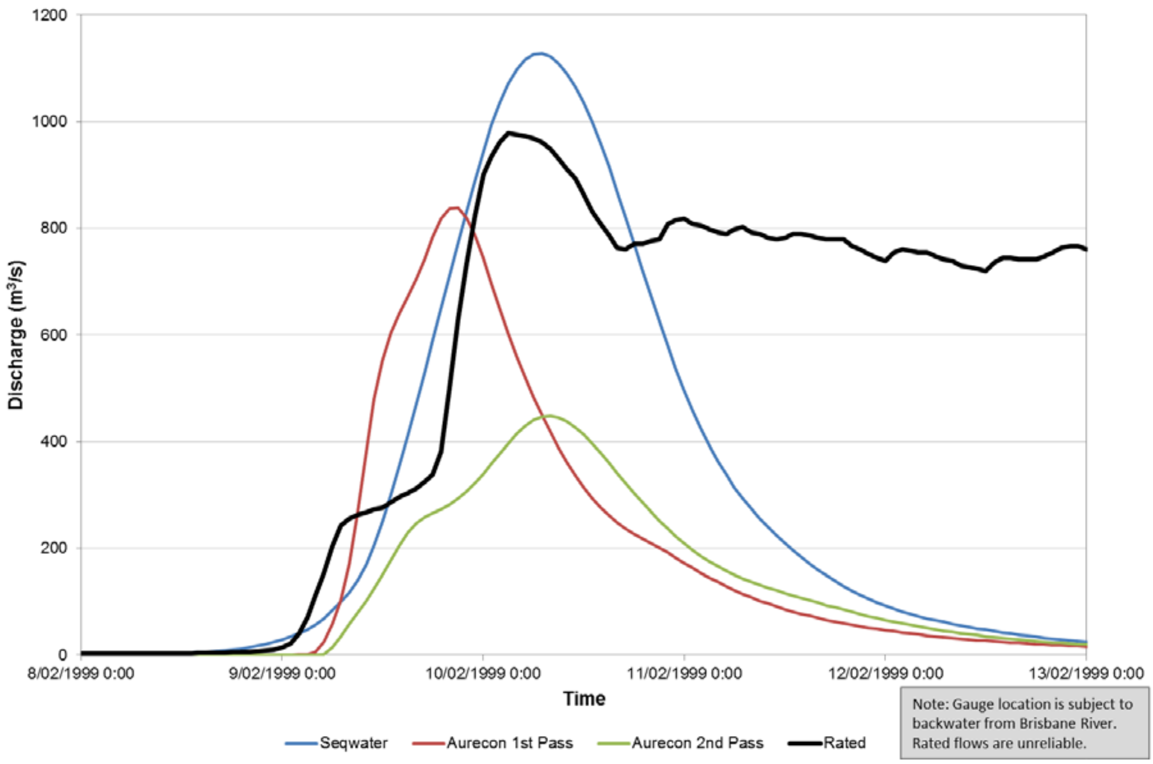


Figure A26 O'Reillys Weir 1999 event

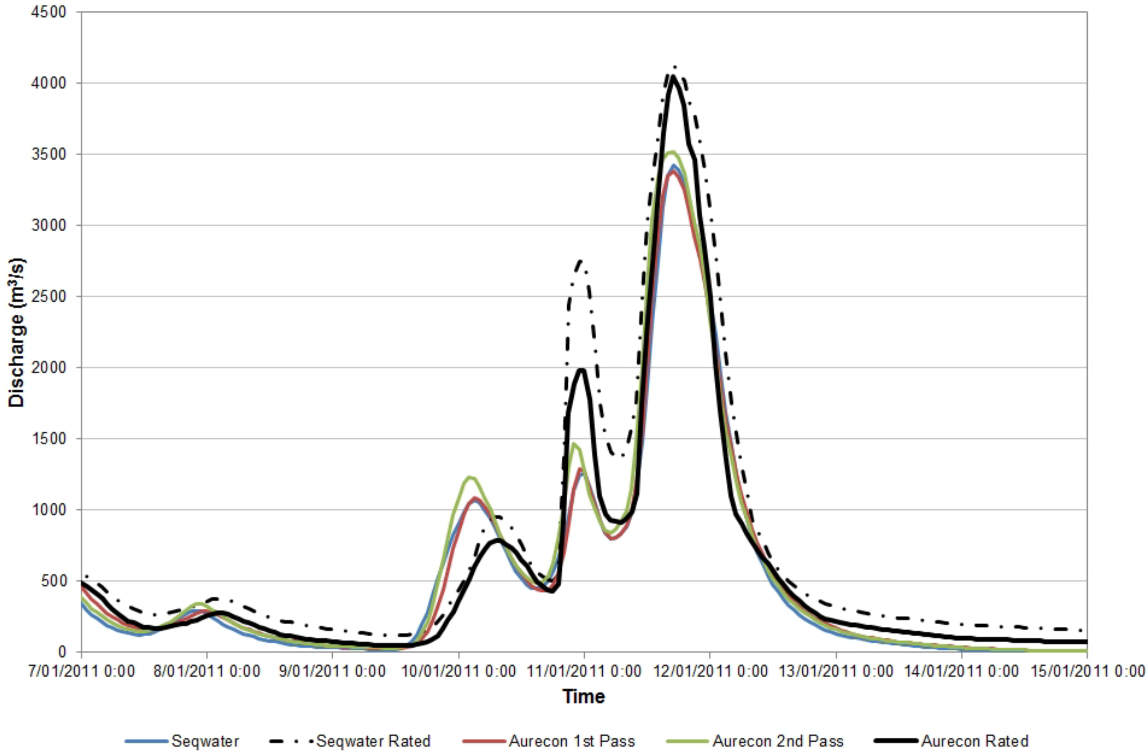


Figure A27 Glenore Grove 2011 event

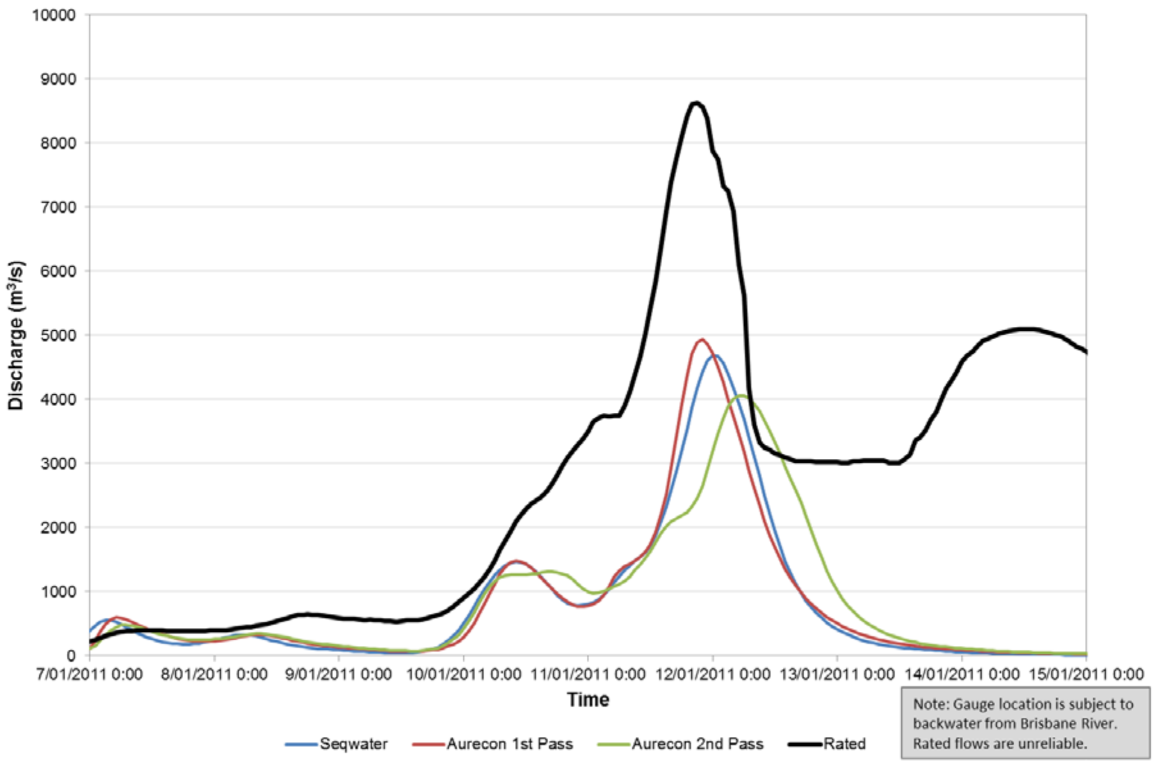


Figure A28 O'Reillys Weir 2011 event

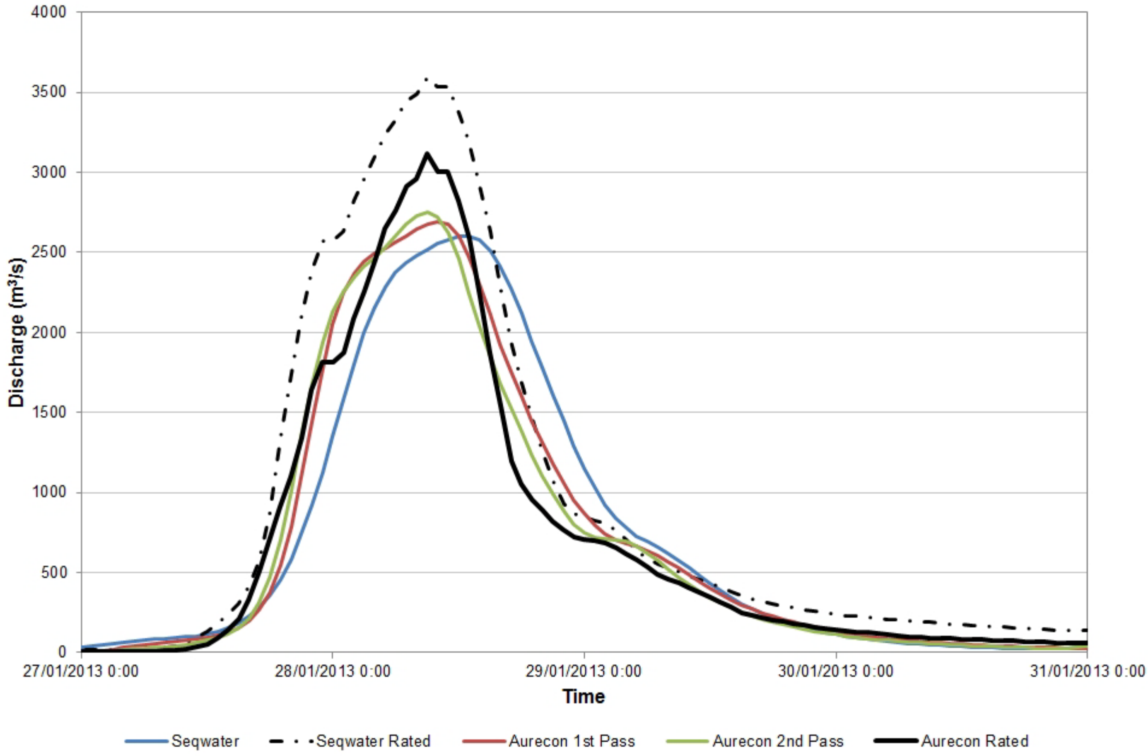


Figure A29 Glenore Grove 2013 event

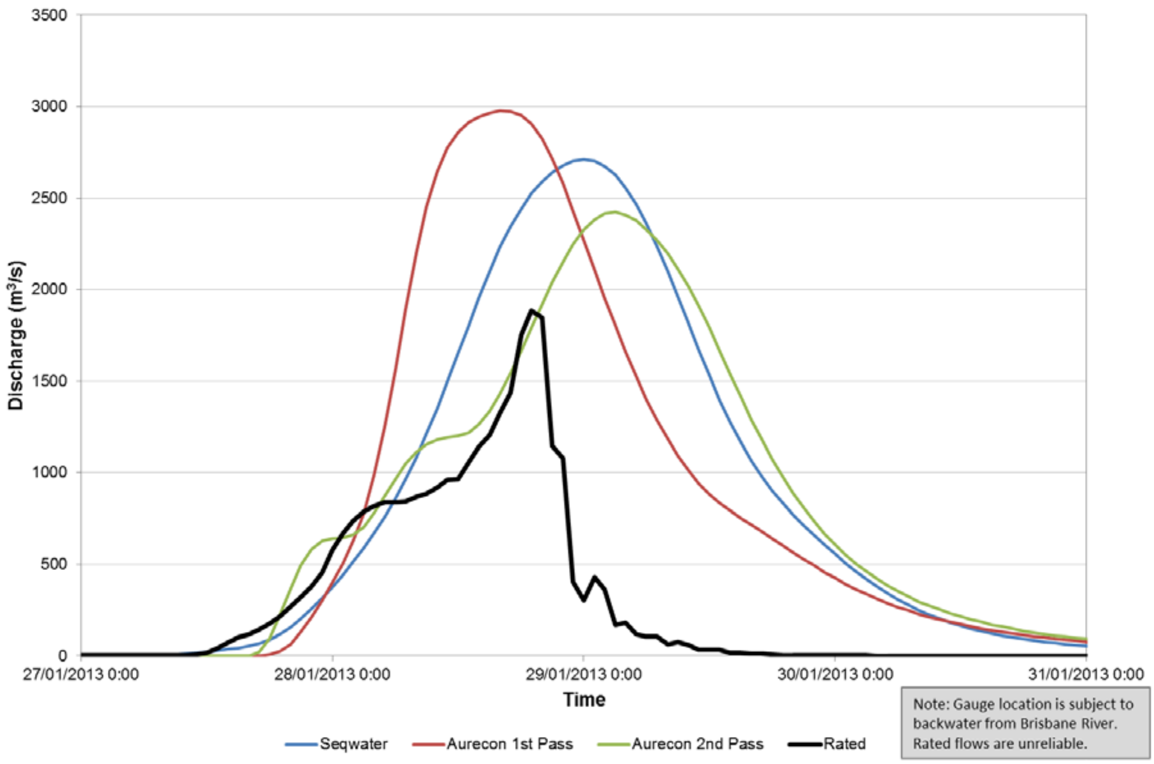


Figure A30 O'Reillys Weir 2013 event

Bremer River calibration plots

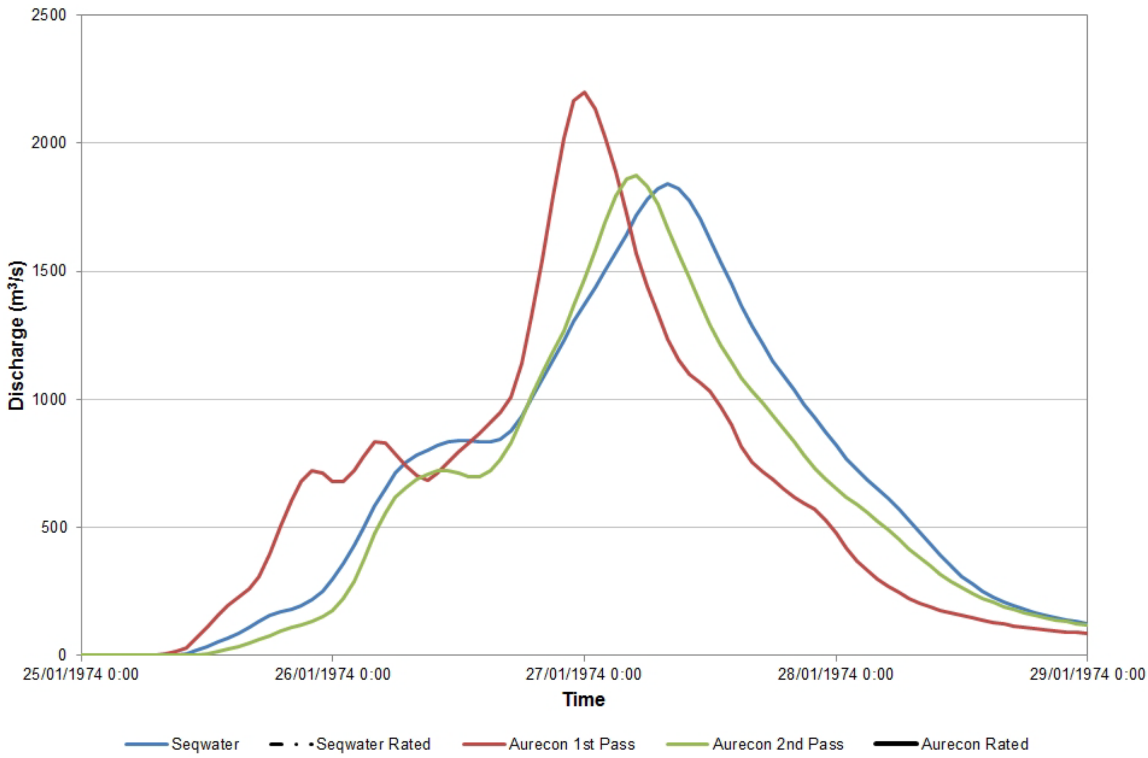


Figure A31 Walloon 1974 event

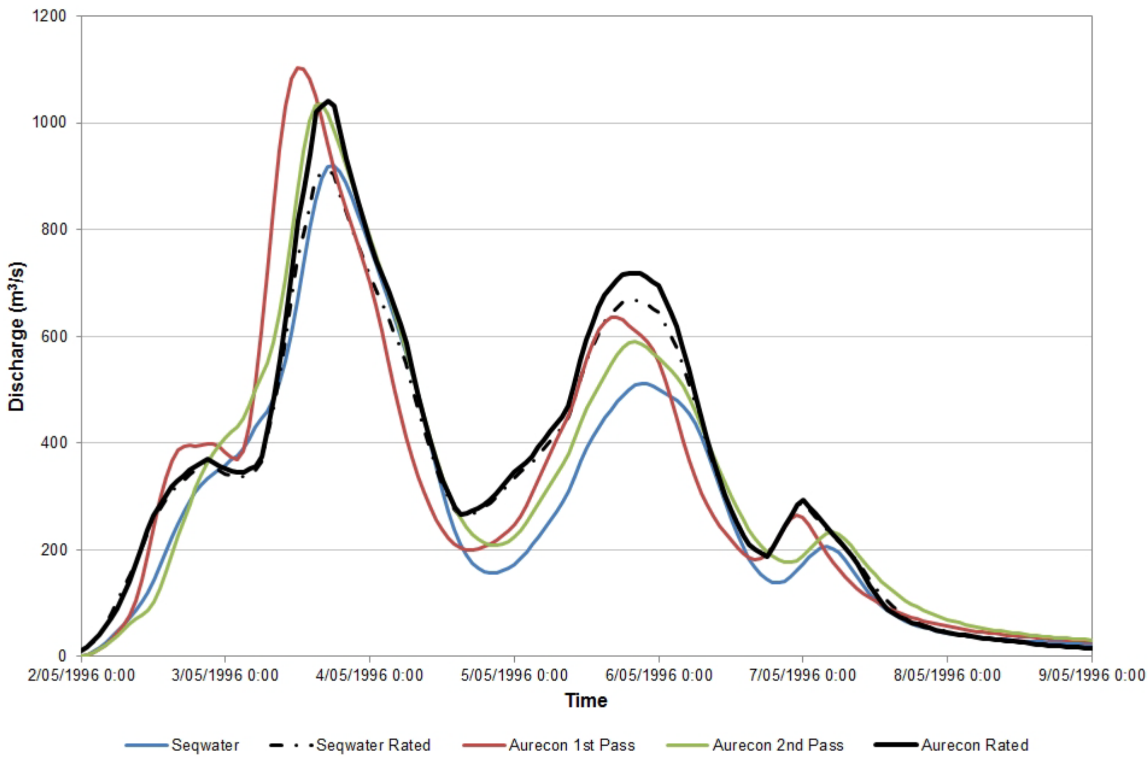


Figure A32 Walloon 1996 event

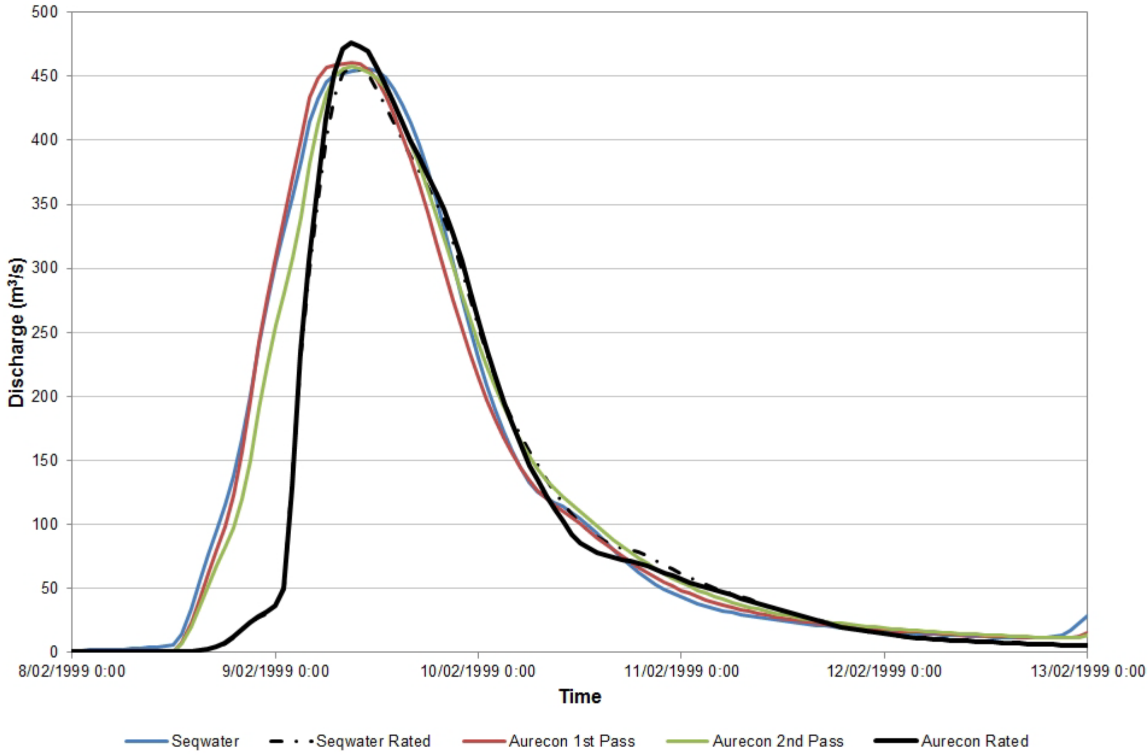


Figure A33 Walloon 1999 event

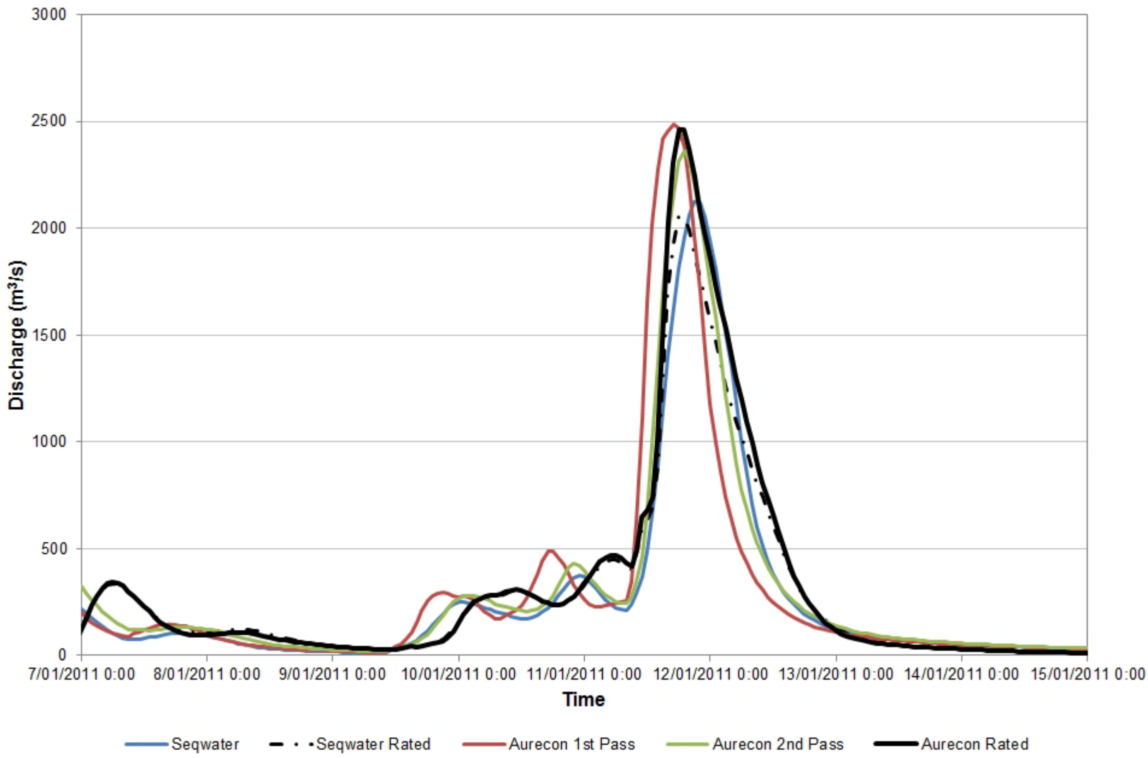


Figure A34 Walloon 2011 event

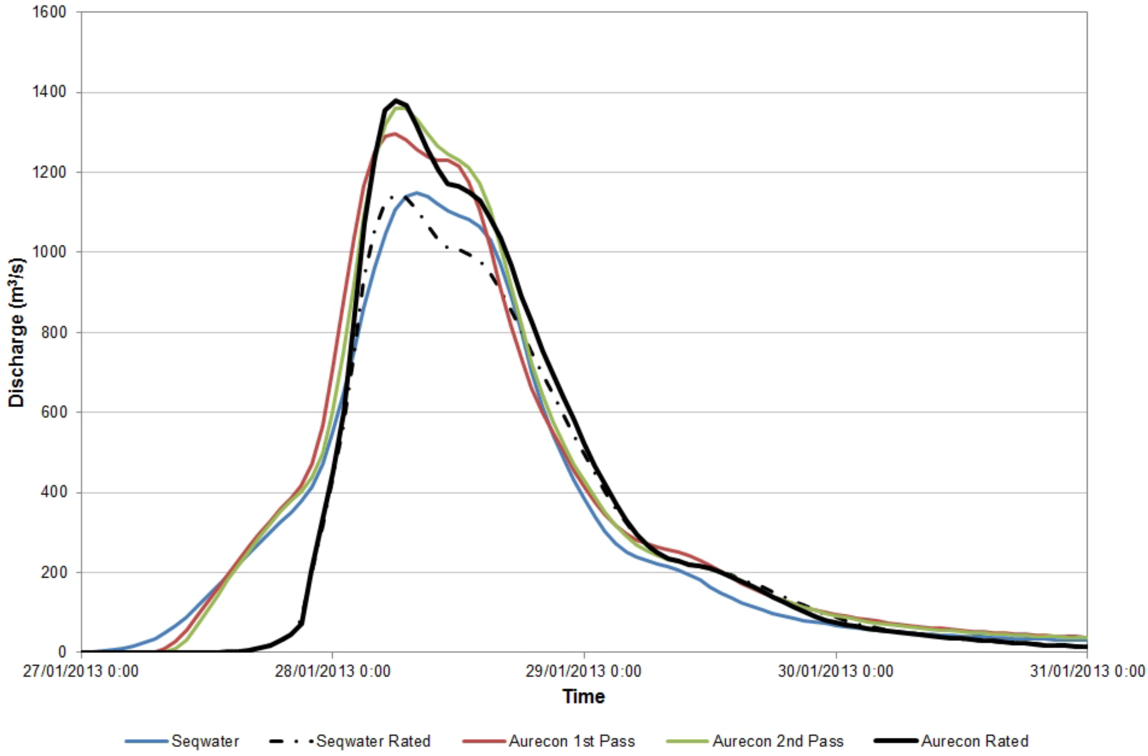


Figure A35 Walloon 2013 event

Warrill Creek calibration plots

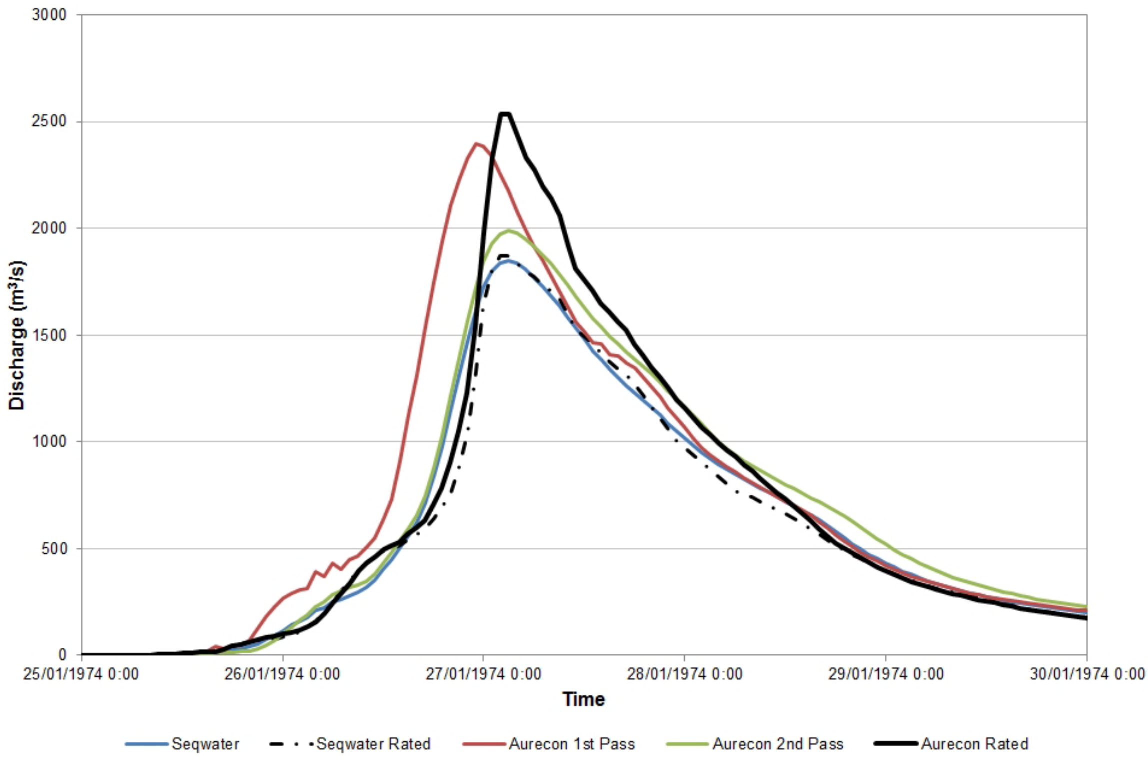


Figure A36 Amberley 1974 event

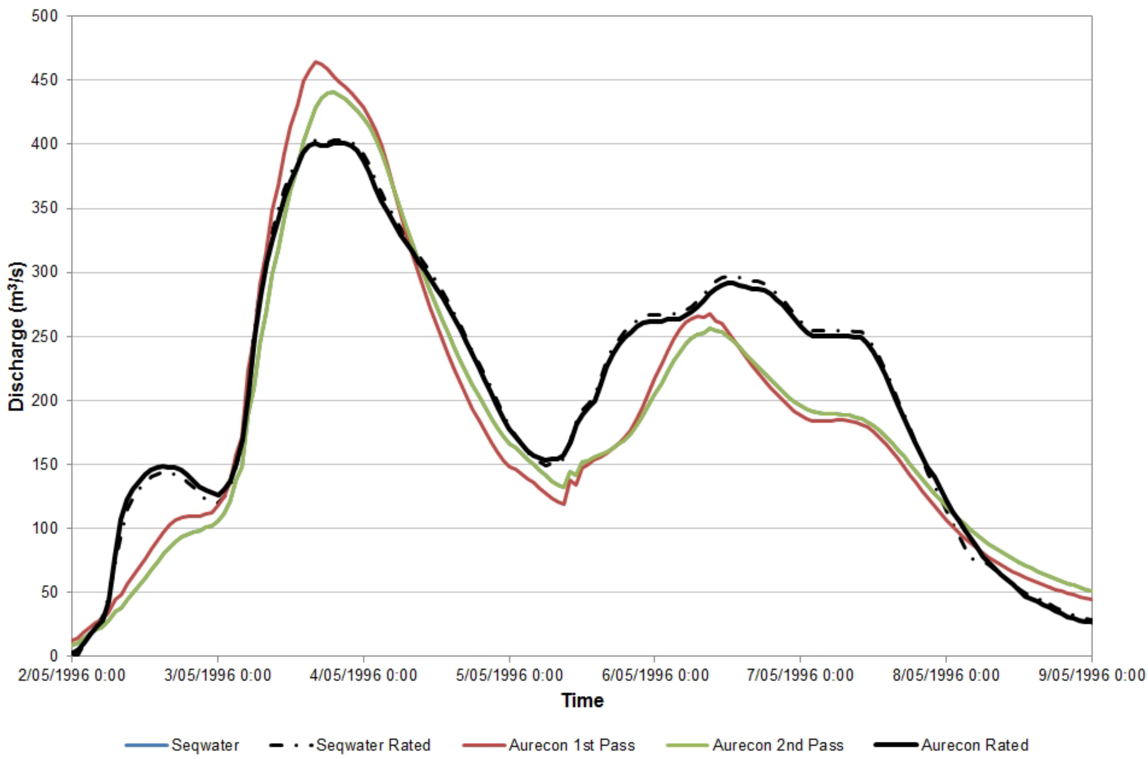


Figure A37 Amberley 1996 event

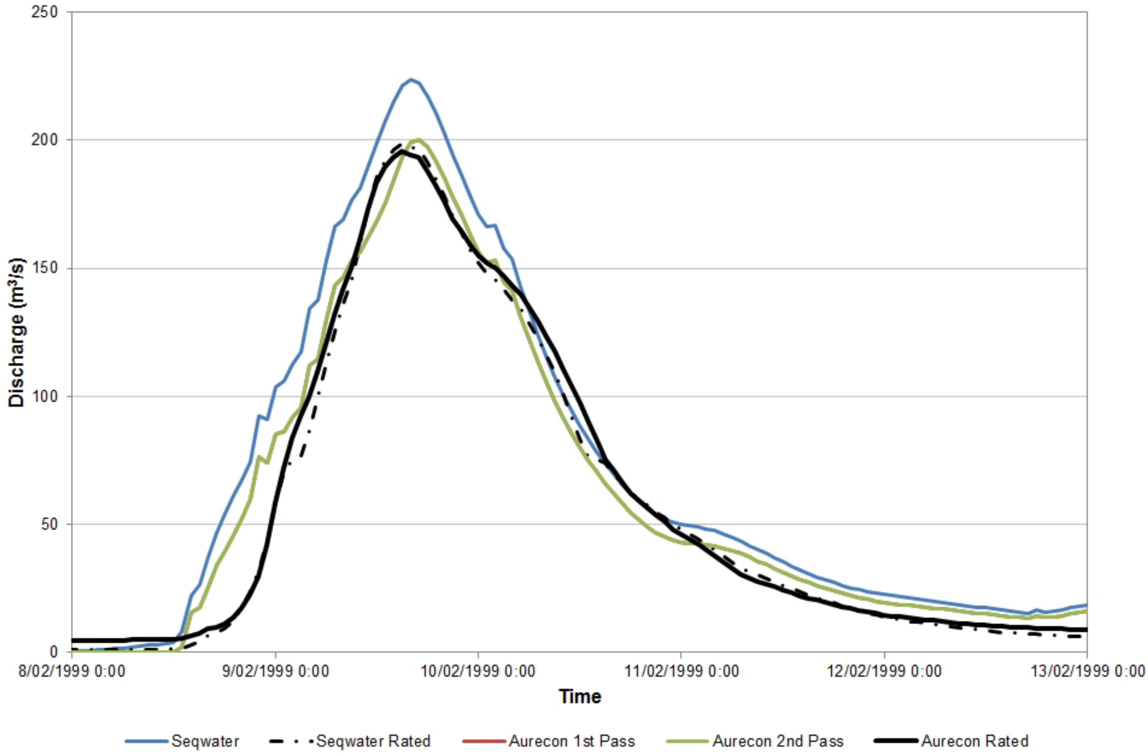


Figure A38 Amberley 1999 event

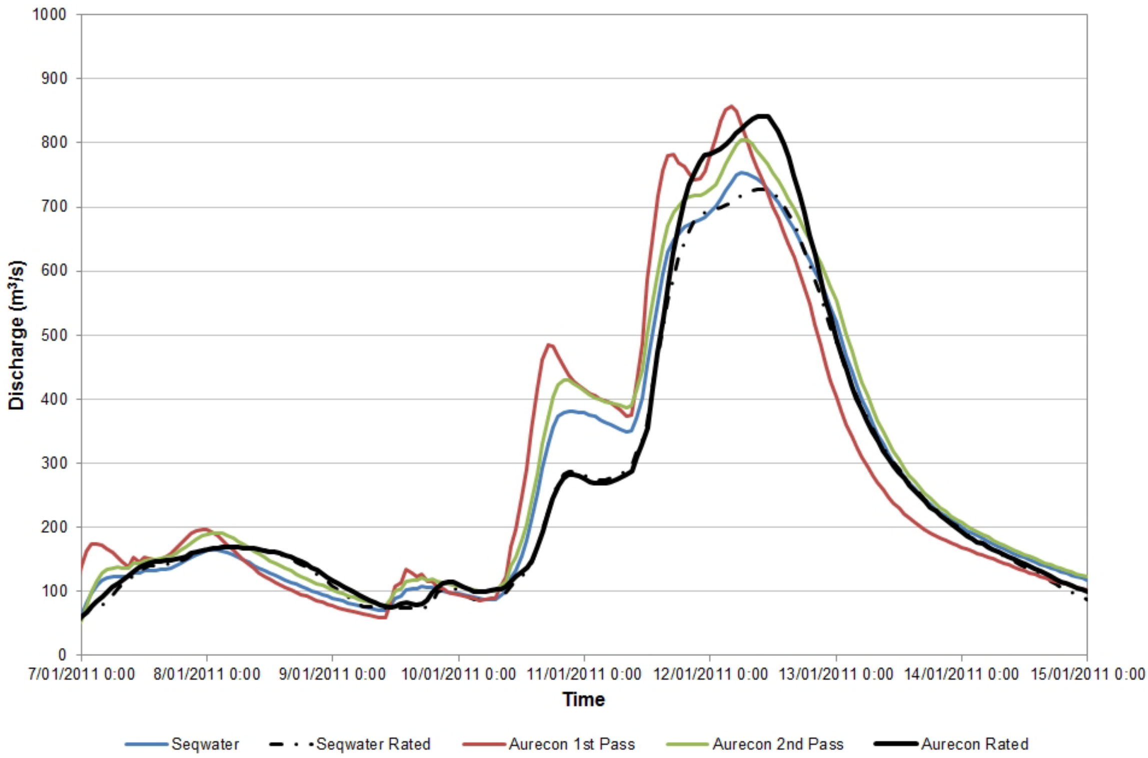


Figure A39 Amberley 2011 event

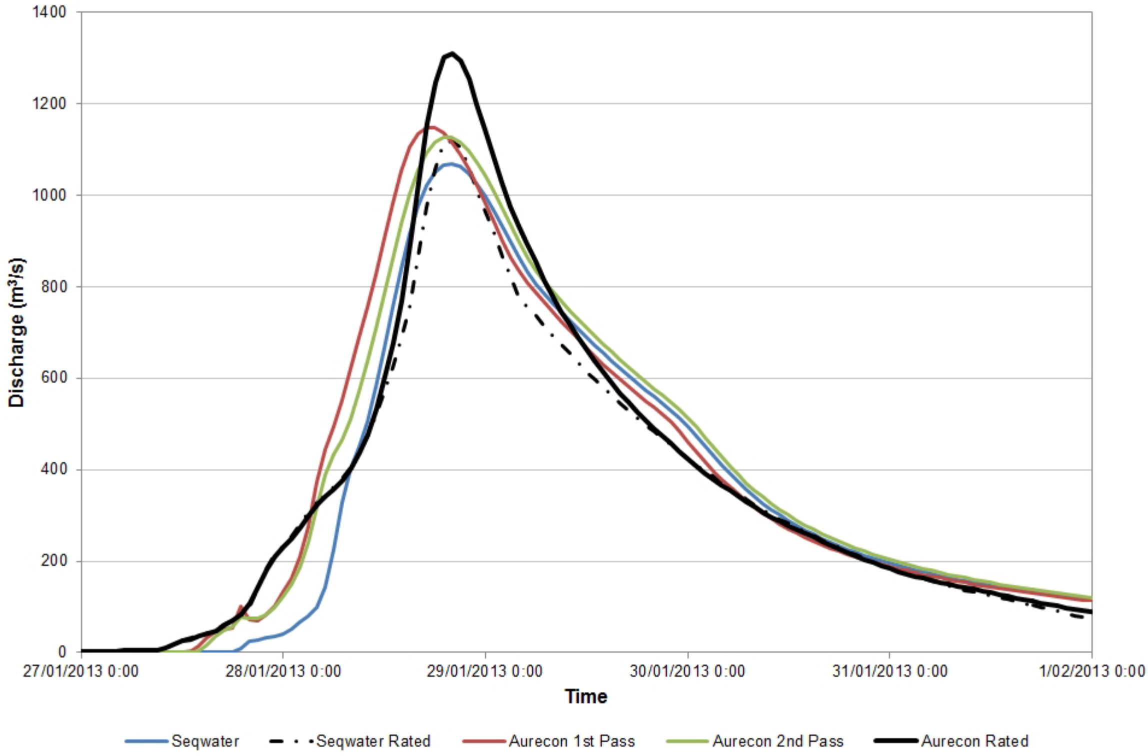


Figure A40 Amberley 2013 event

Purga Creek calibration plots

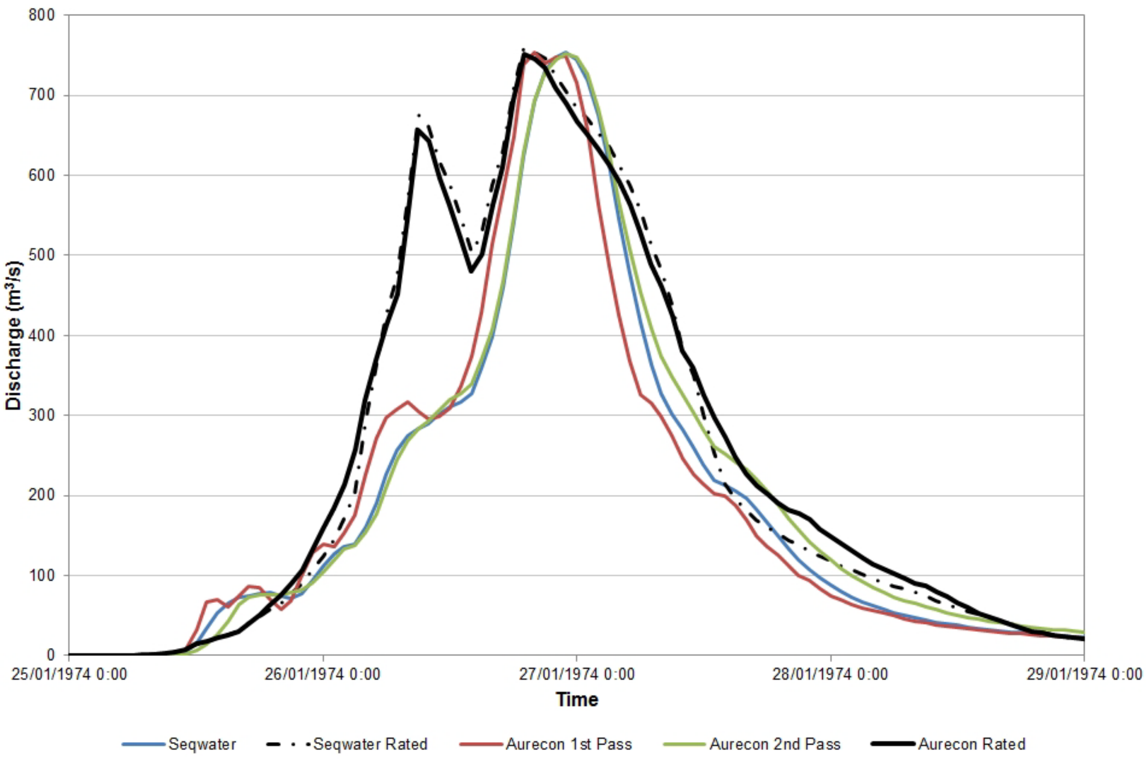


Figure A41 Loamside 1974 event

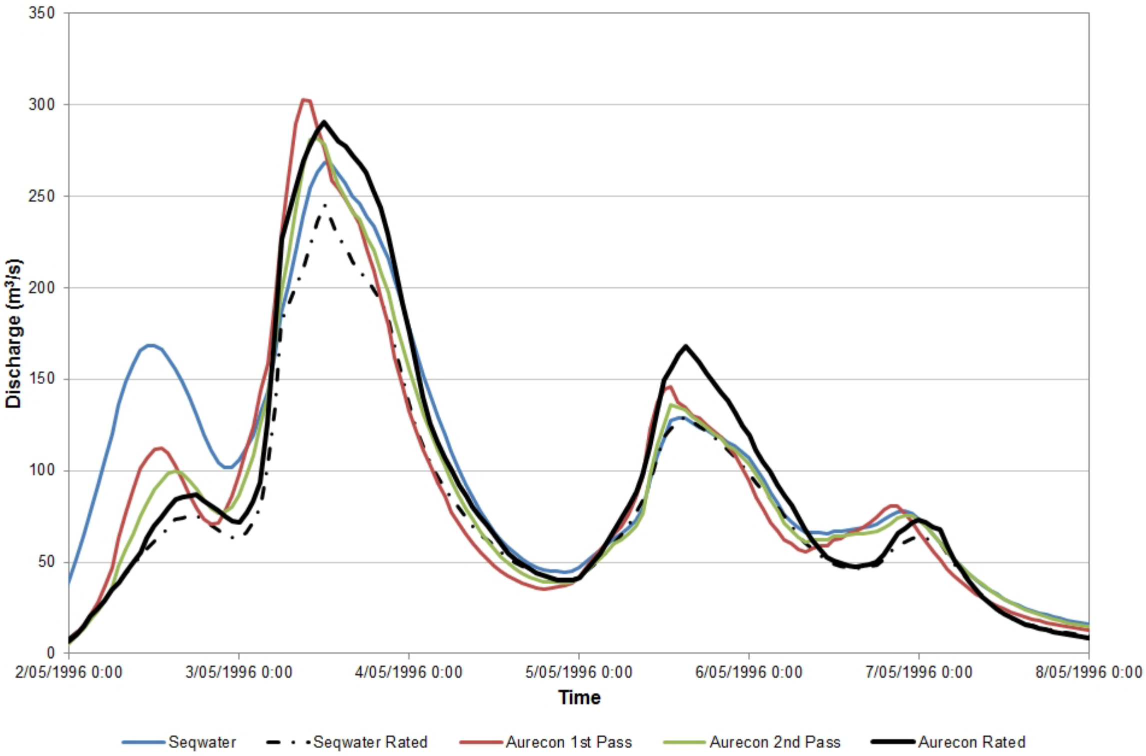


Figure A42 Loamside 1996 event

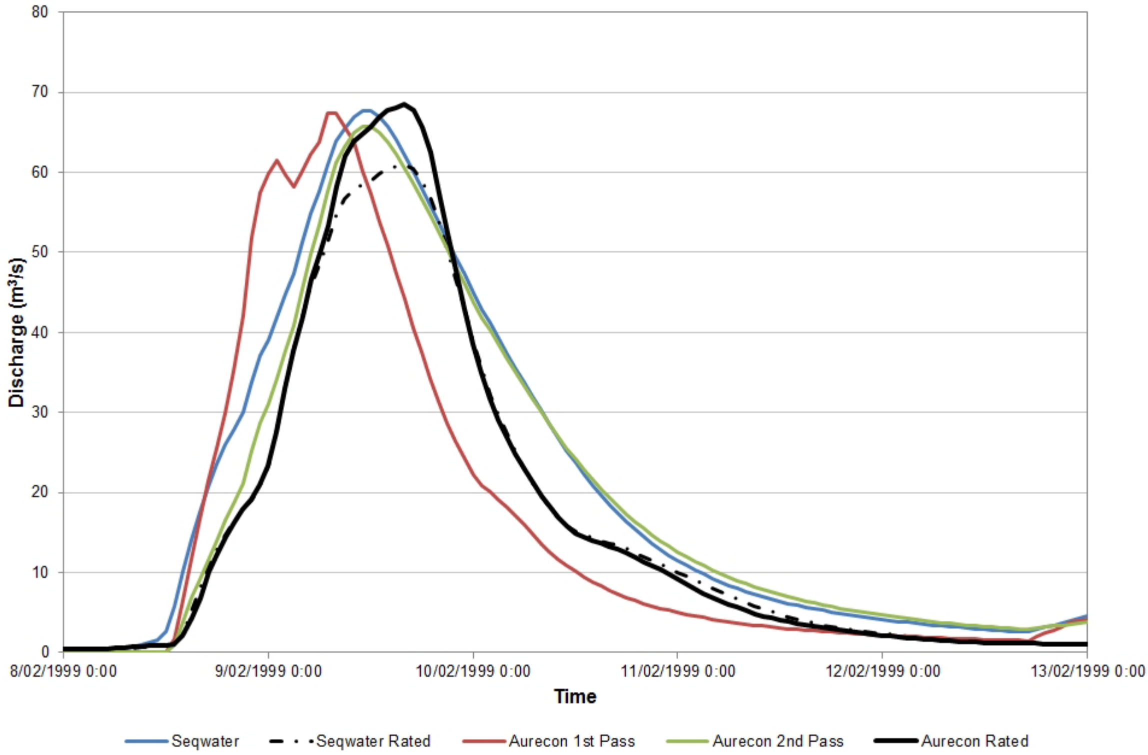


Figure A43 Loamside 1999 event

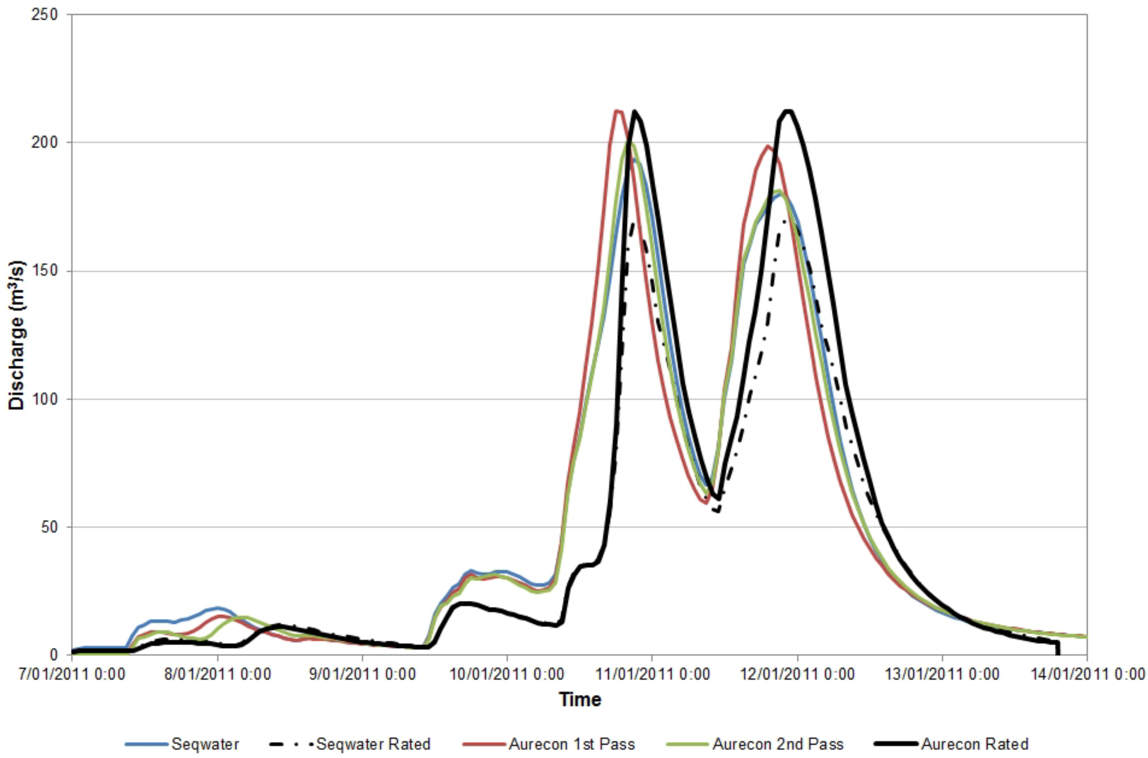


Figure A44 Loamside 2011 event

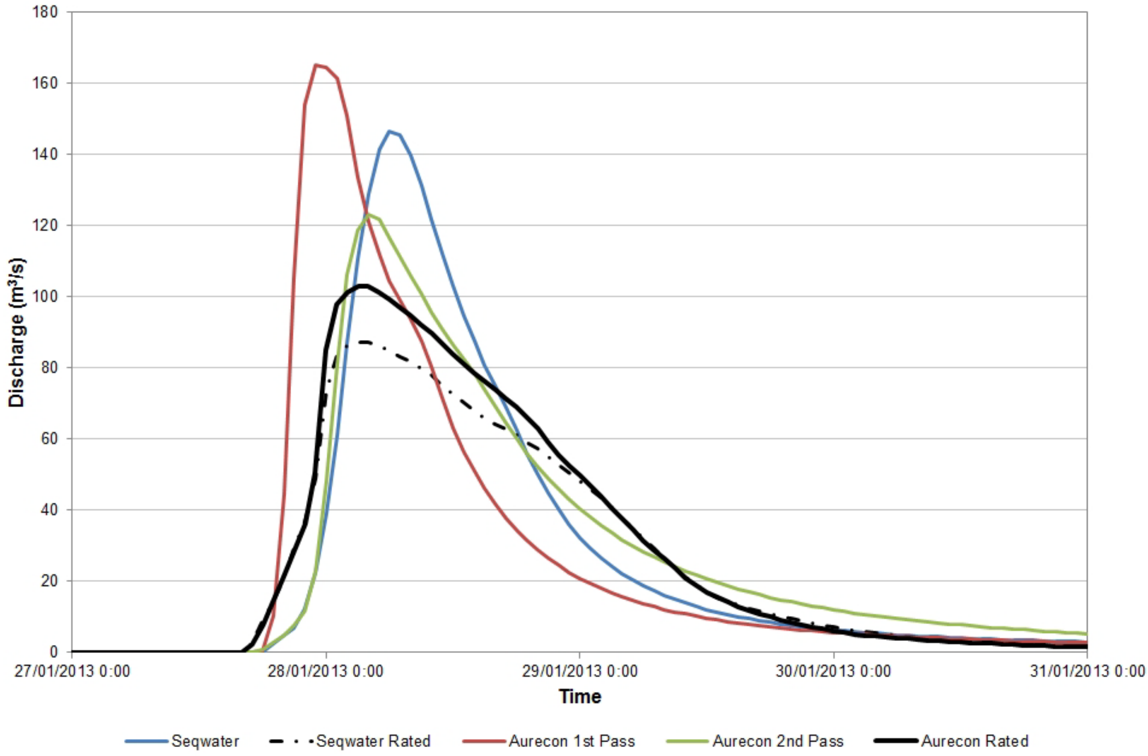


Figure A45 Loamside 2013 event

Lower Brisbane River calibration plots

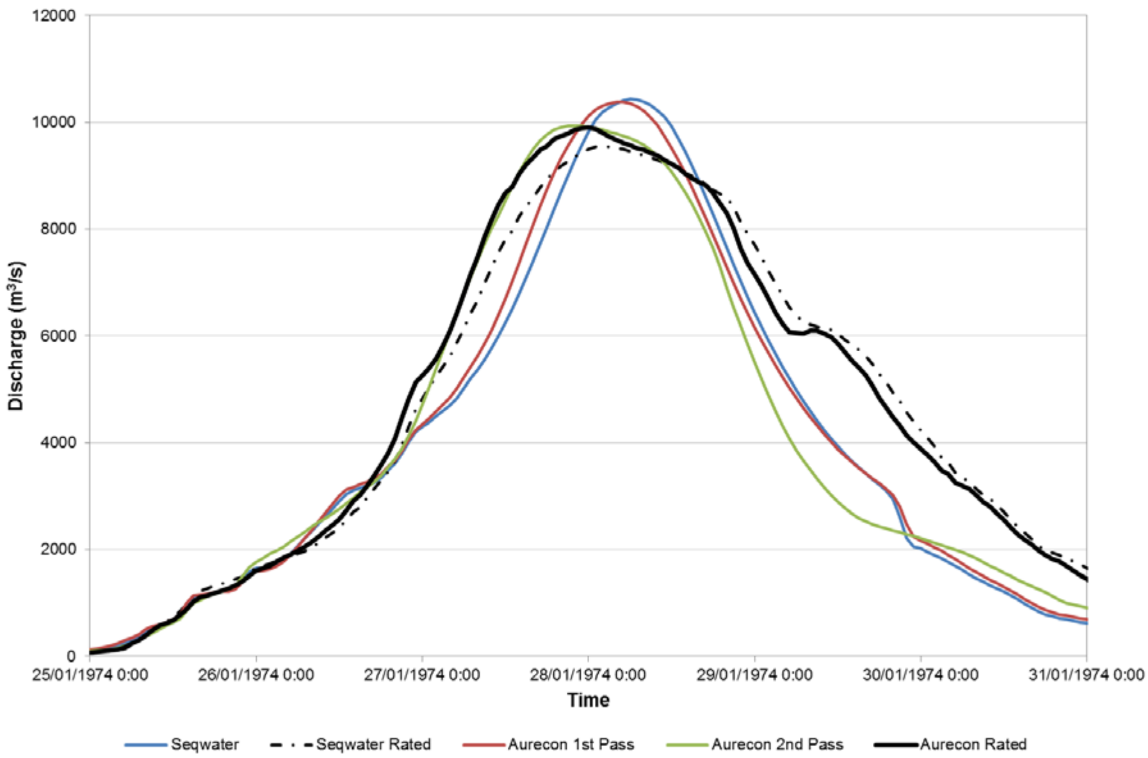


Figure A46 Savages Crossing 1974 event

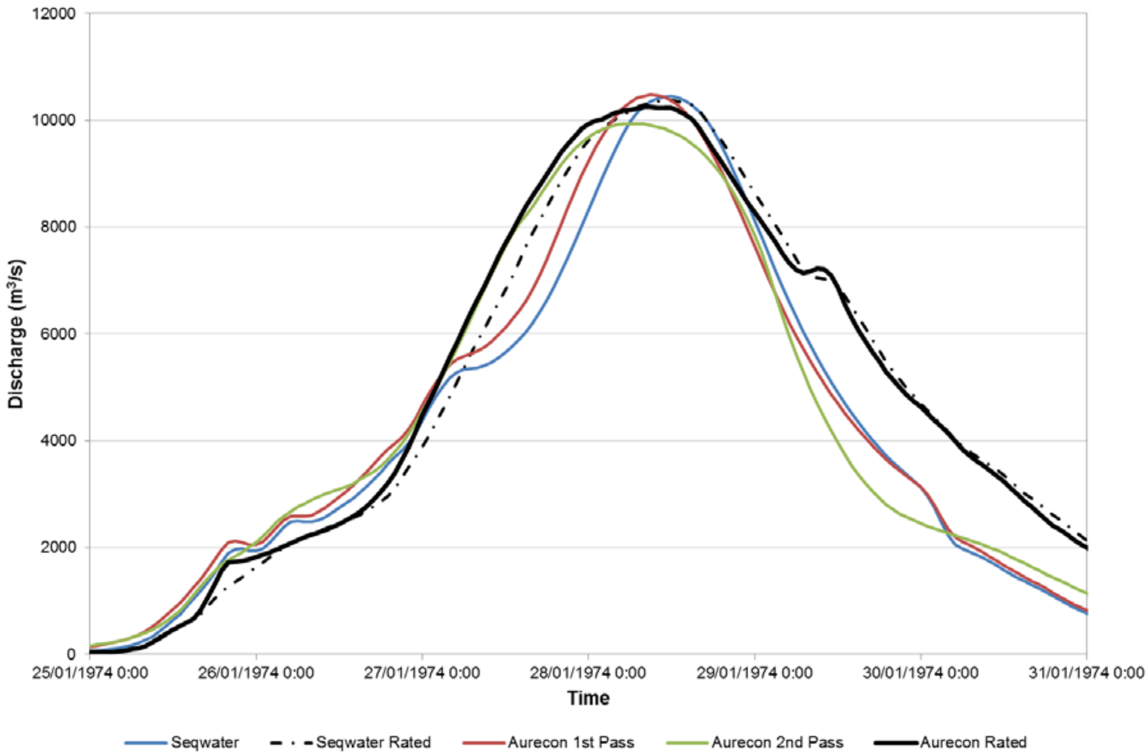


Figure A47 Mt Crosby Weir 1974 event

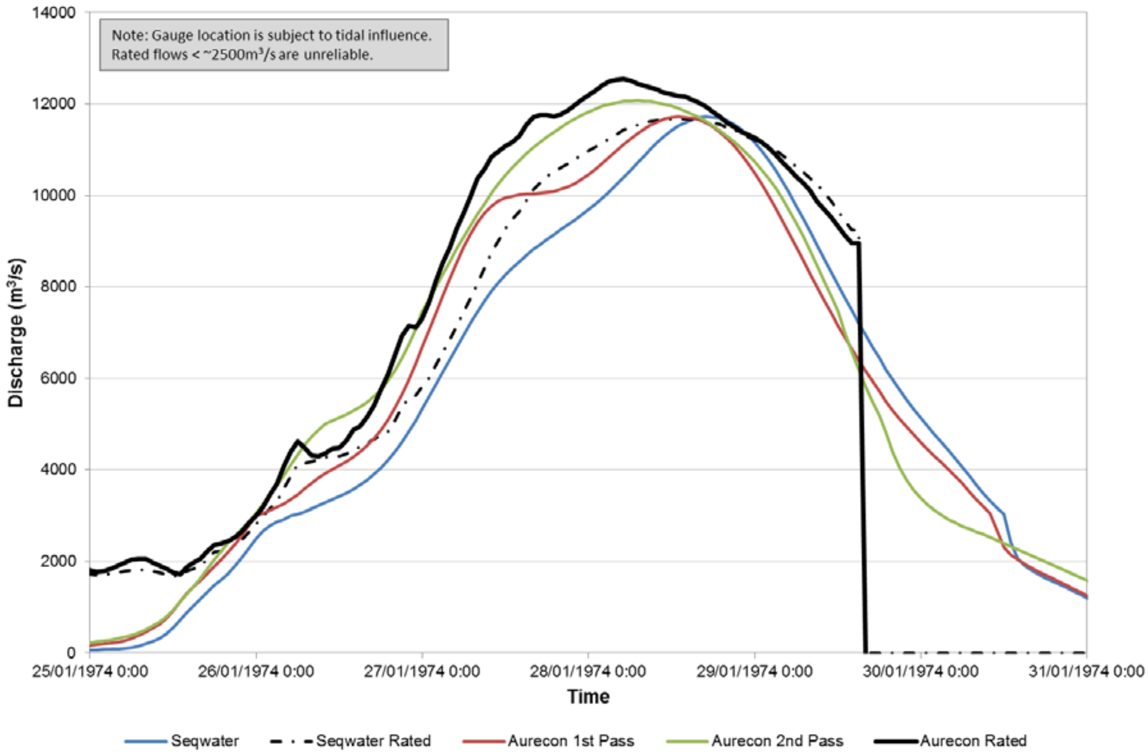


Figure A48 Moggill 1974 event

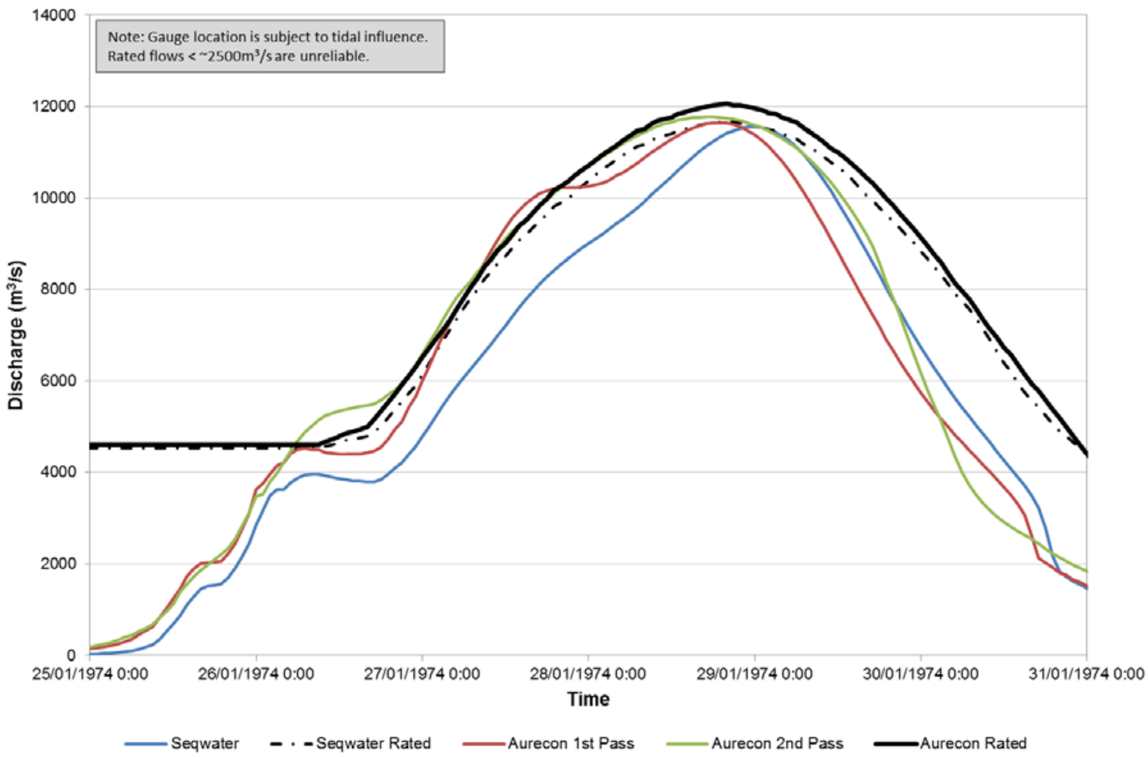


Figure A49 Centenary Bridge 1974 event

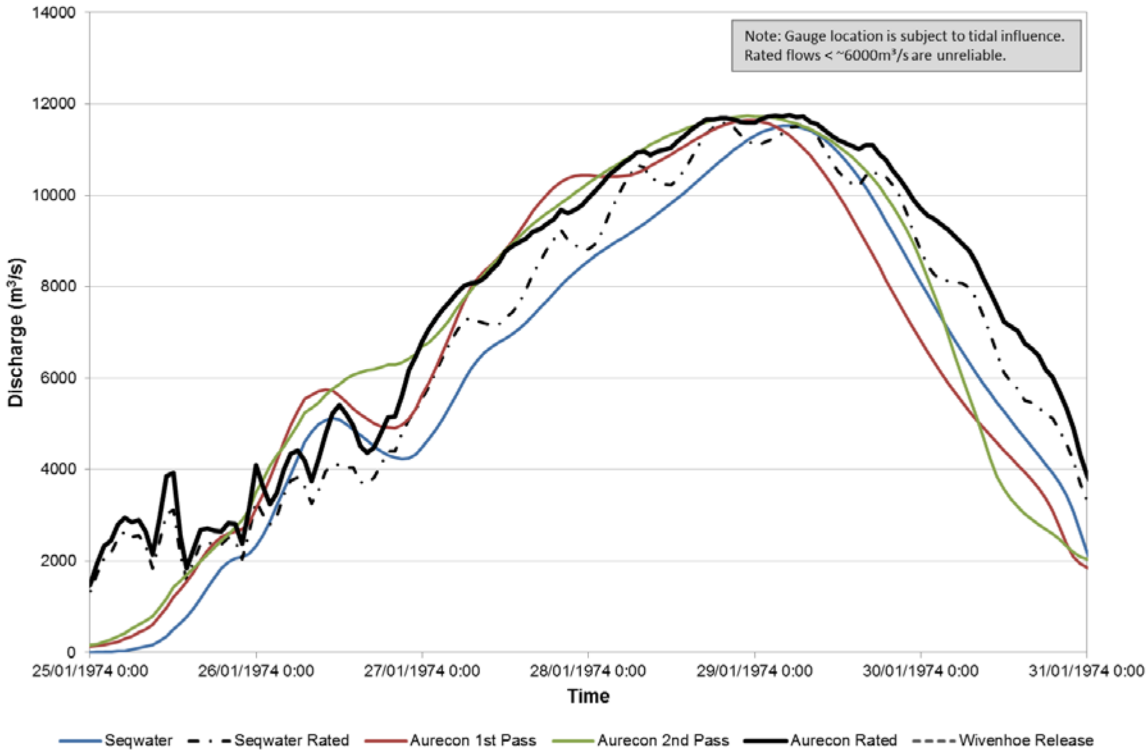


Figure A50 Brisbane City 1974 event

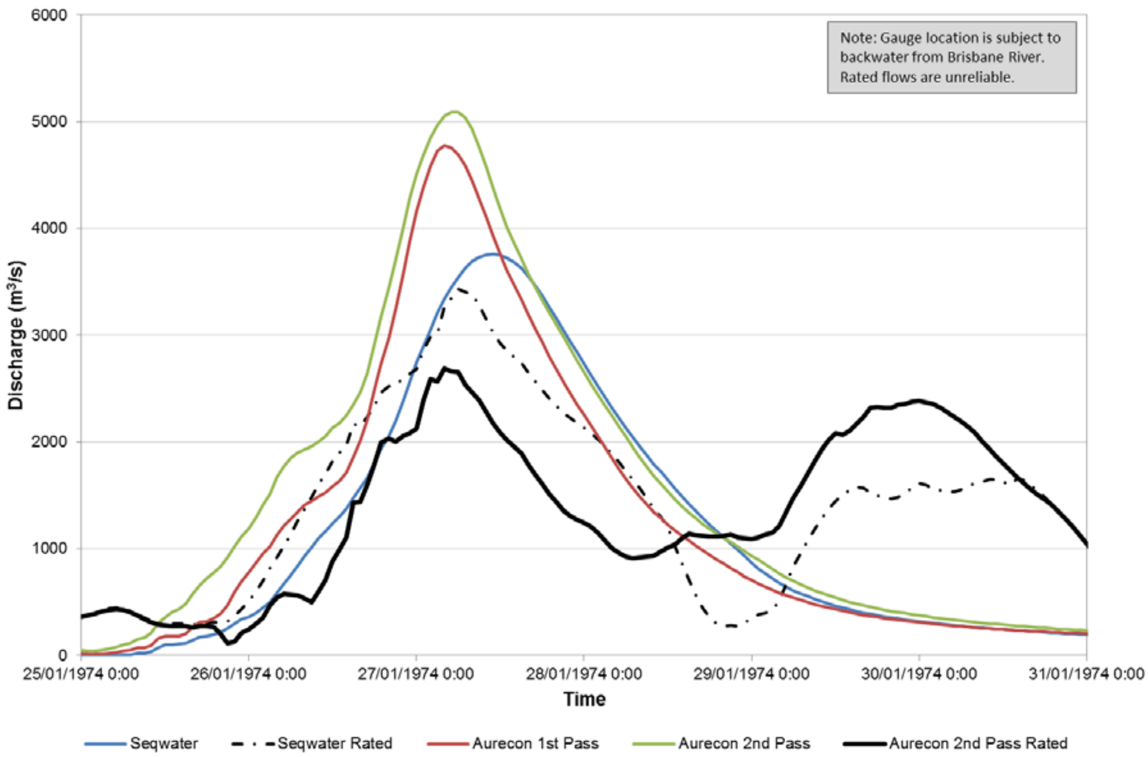


Figure A51 Ipswich 1974 event

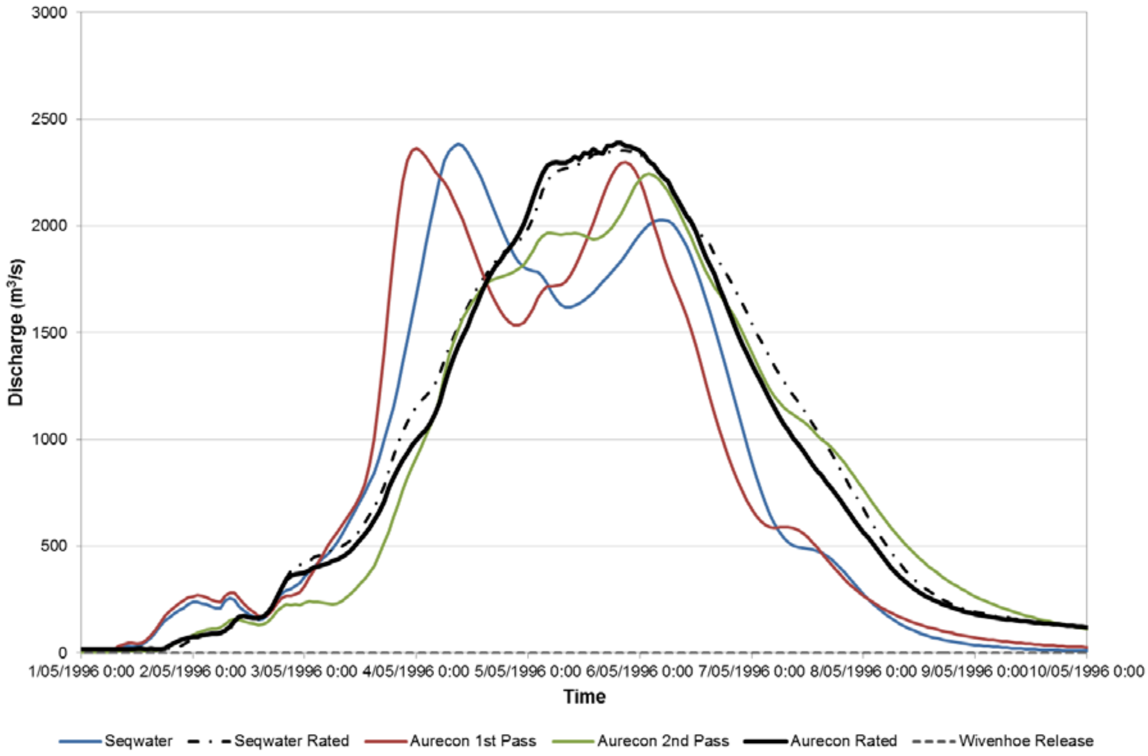


Figure A52 Savages Crossing 1996 event

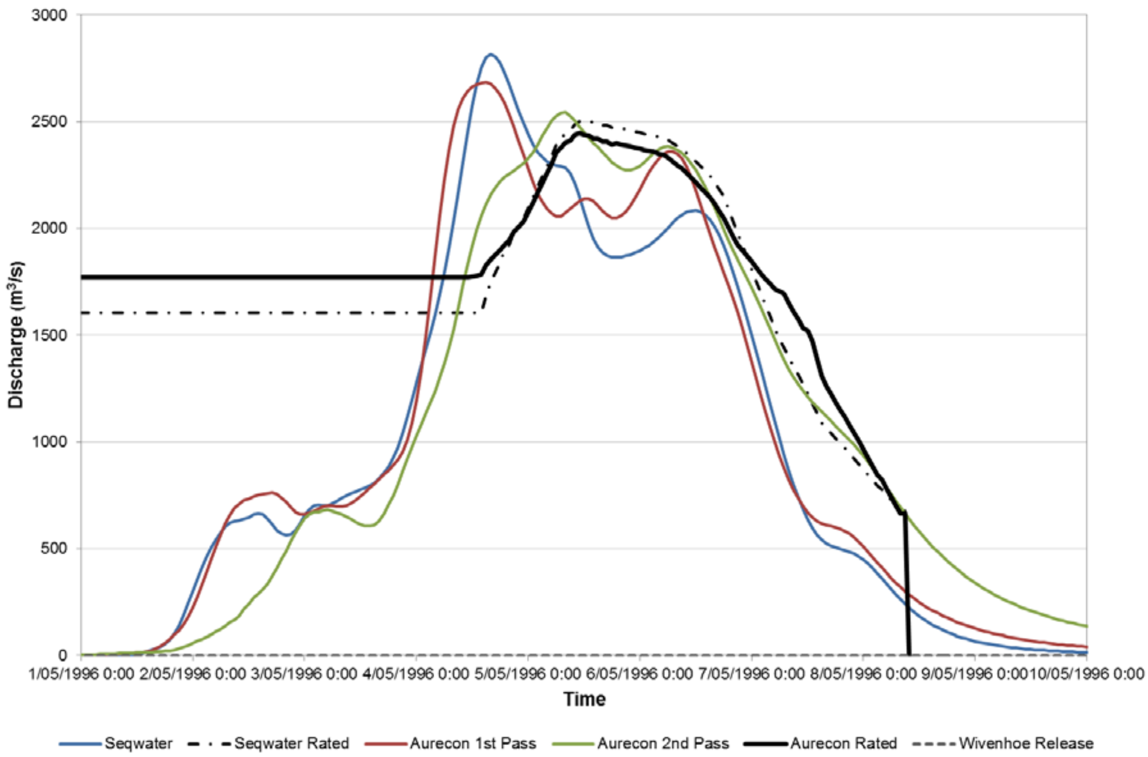


Figure A53 Mt Crosby Weir 1996 event

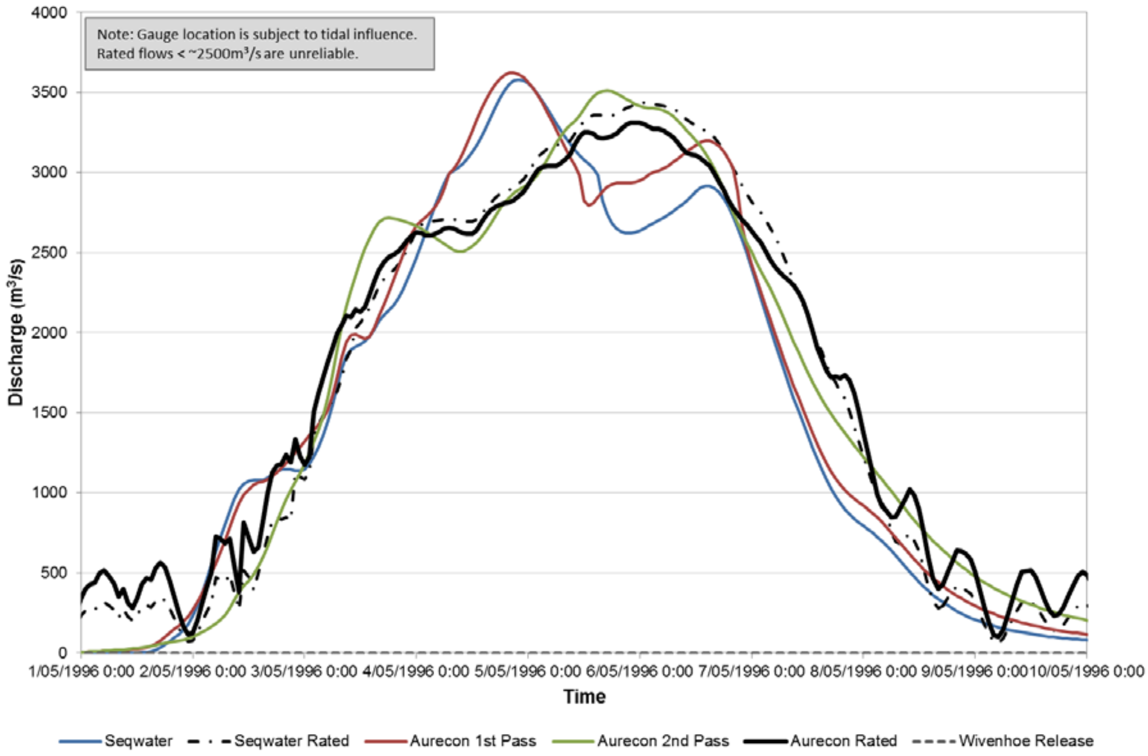


Figure A54 Moggill 1996 event

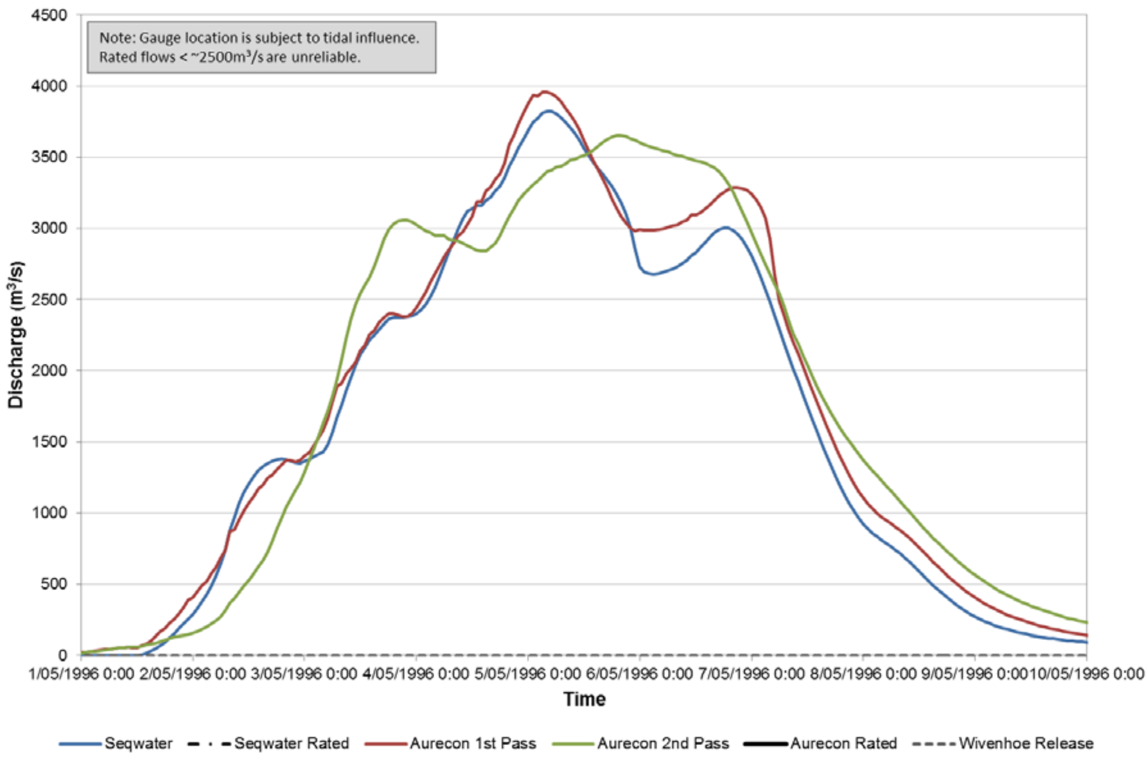


Figure A55 Centenary Bridge 1996 event

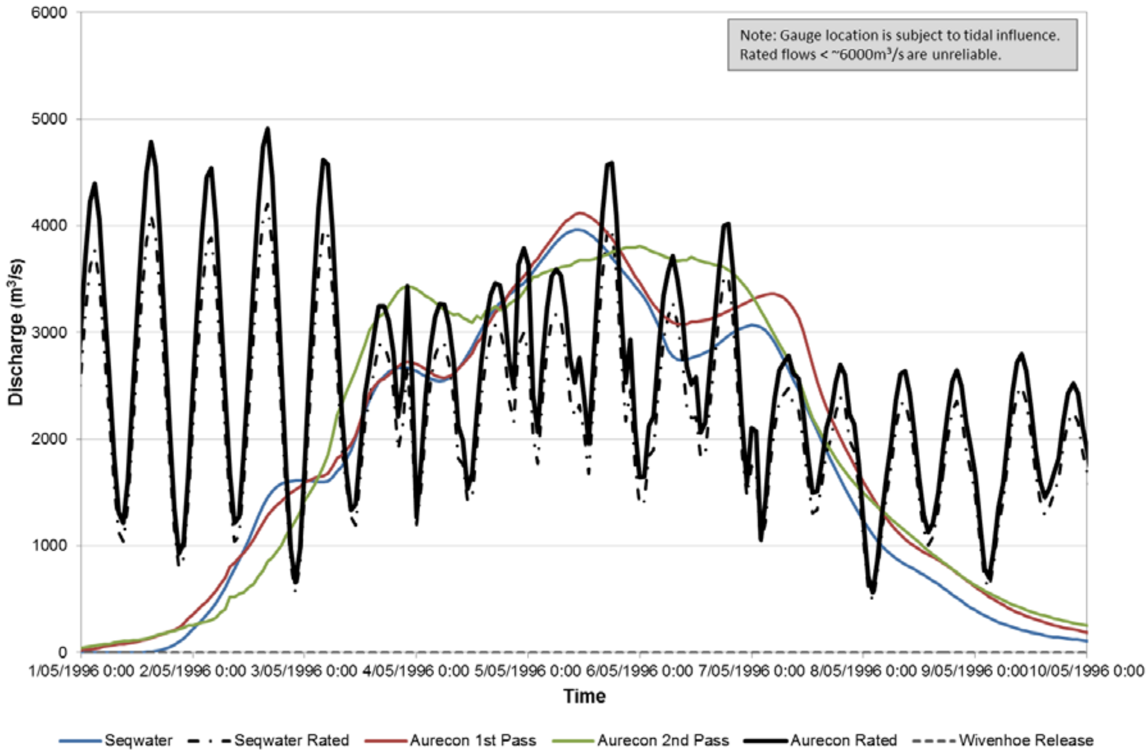


Figure A56 Brisbane City 1996 event

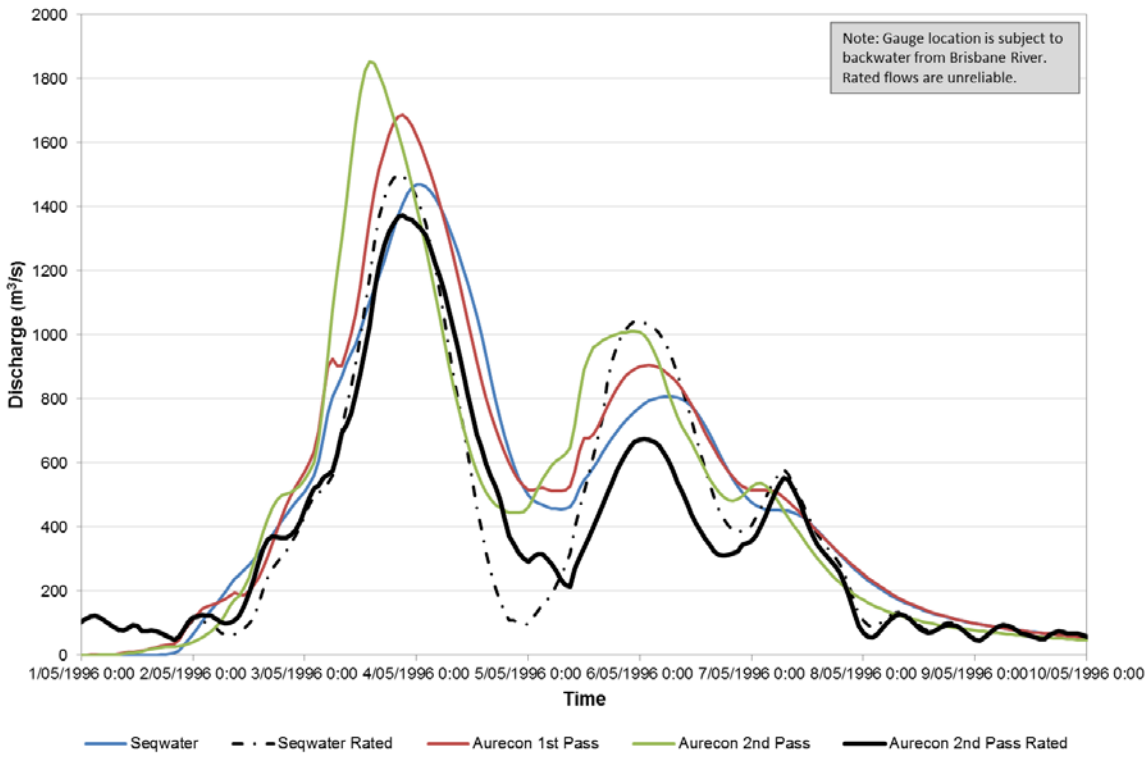


Figure A57 Ipswich 1996 event

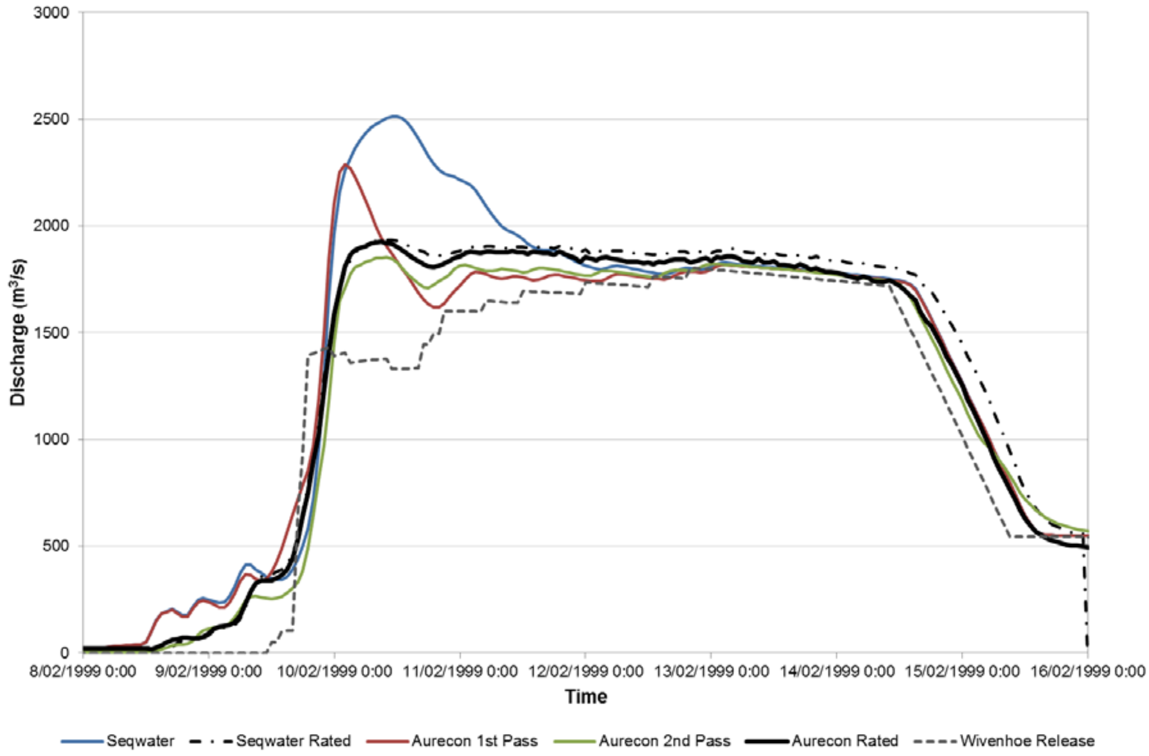


Figure A58 Savages Crossing 1999 event

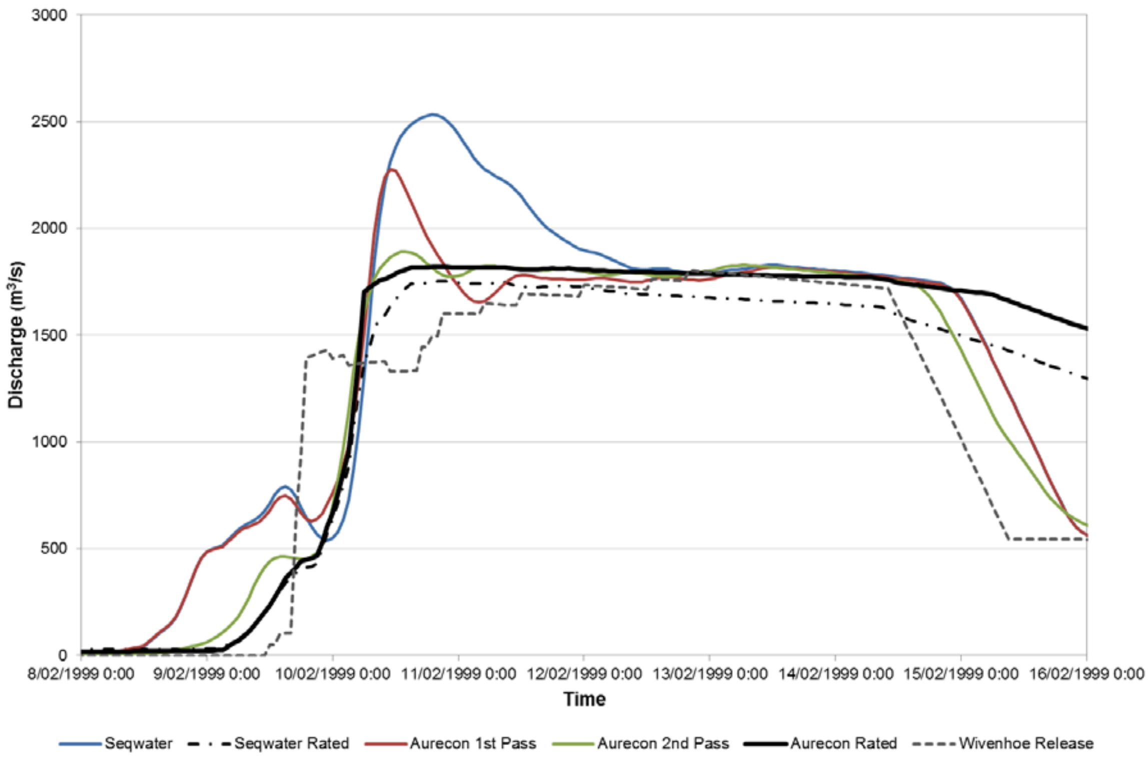


Figure A59 Mt Crosby Weir 1999 event

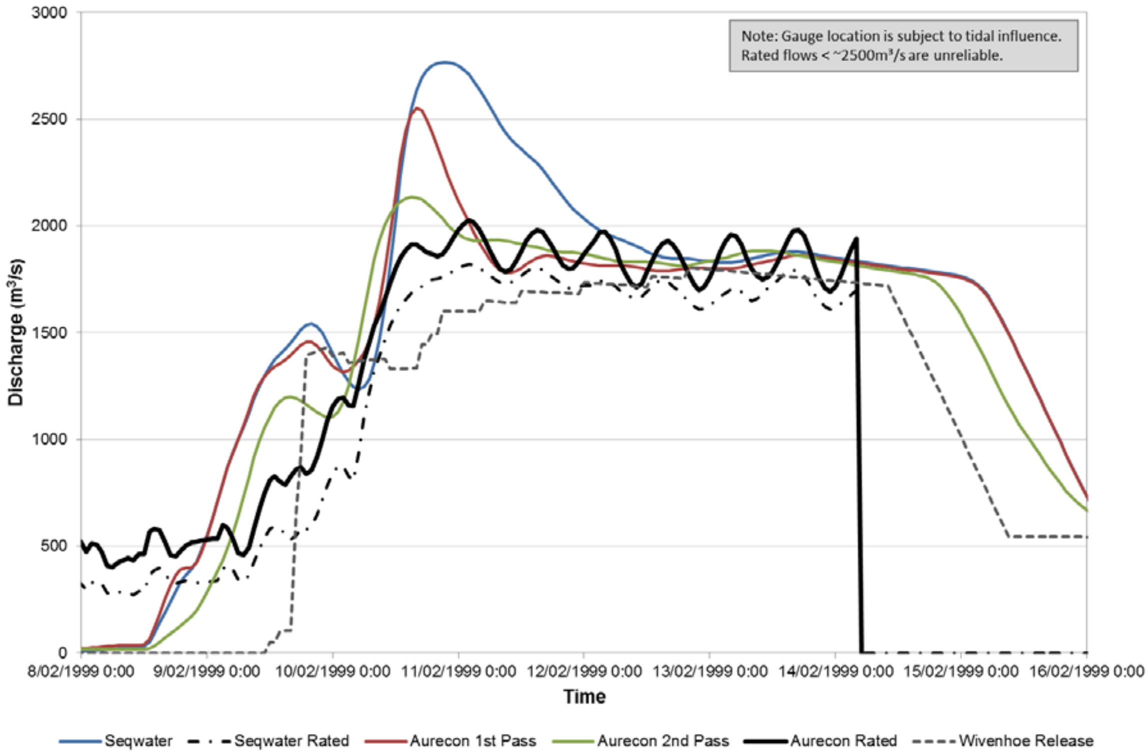


Figure A60 Moggill 1999 event

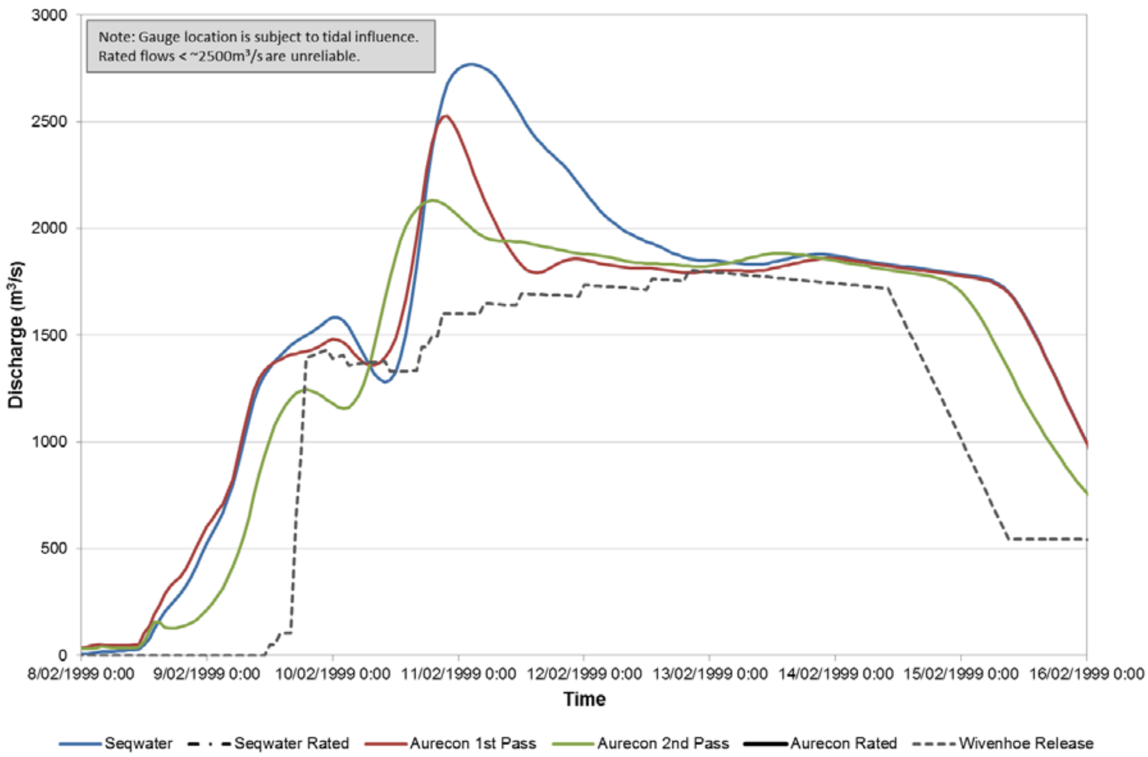


Figure A61 Centenary Bridge 1999 event

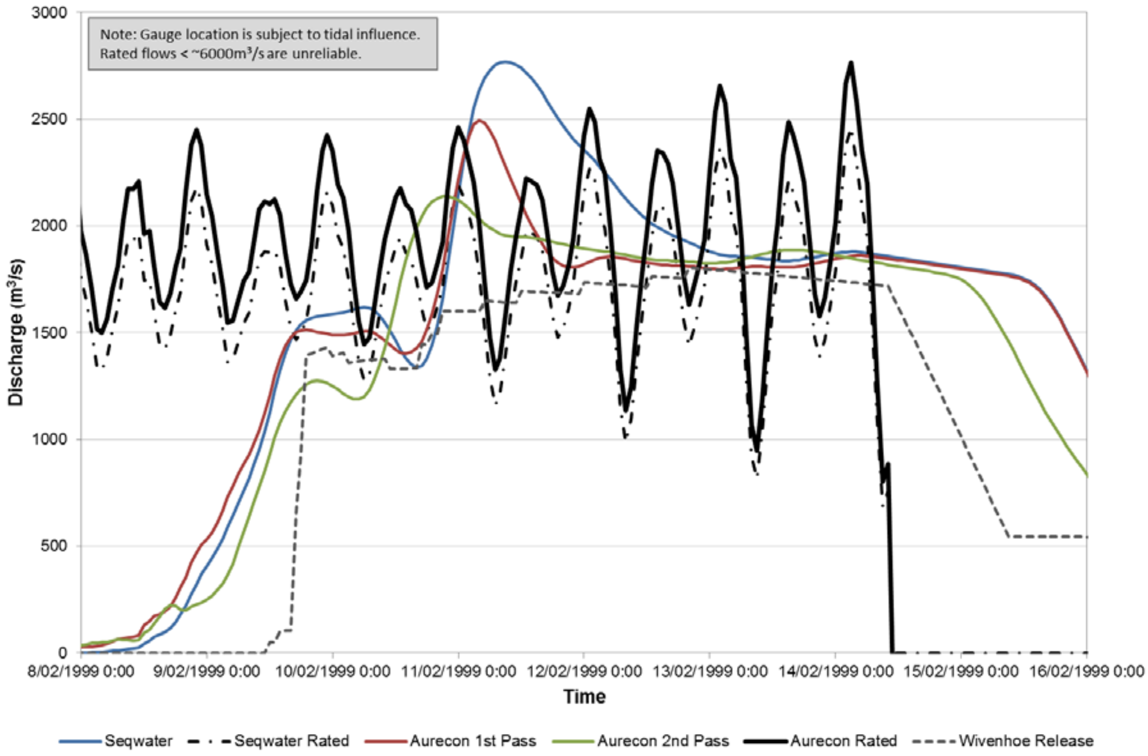


Figure A62 Brisbane City1999 event

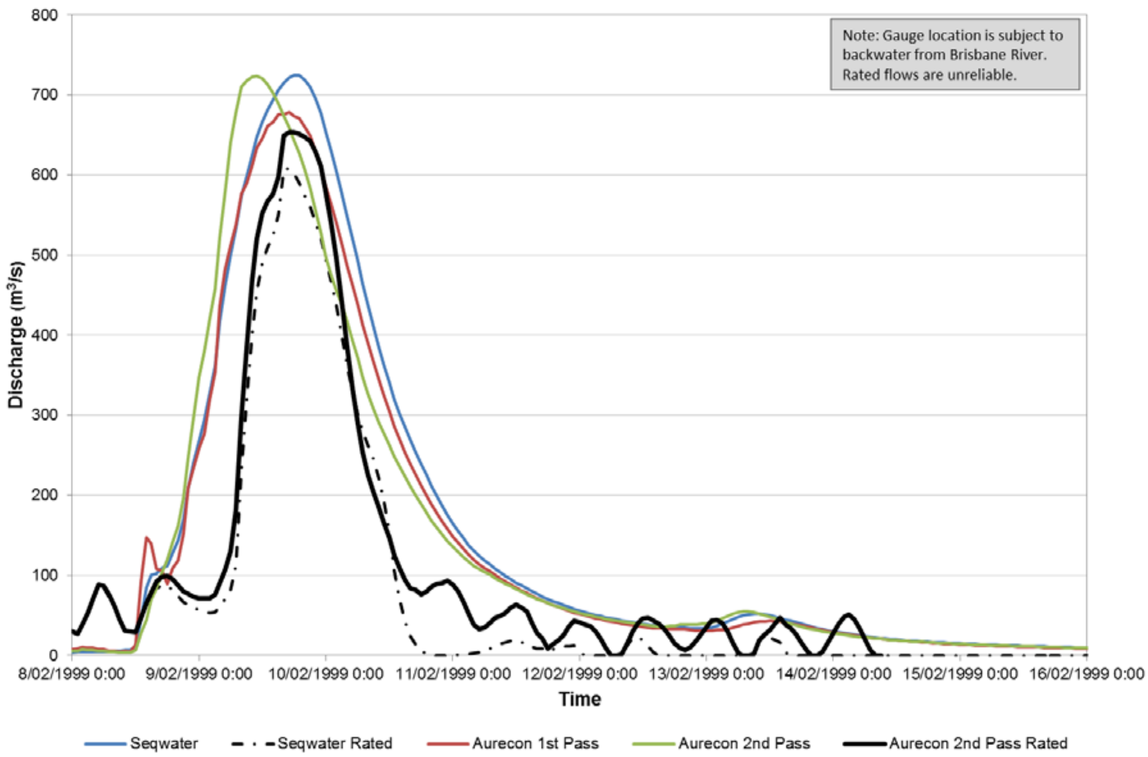


Figure A63 Ipswich 1999 event

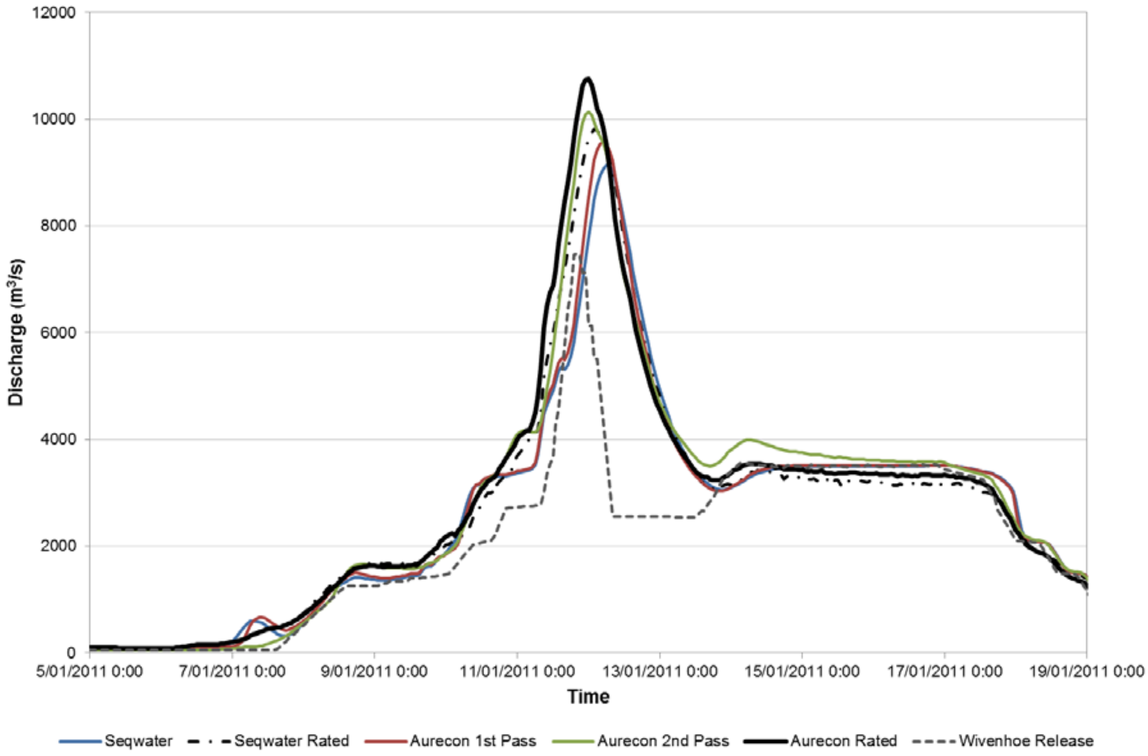


Figure A64 Savages Crossing 2011 event

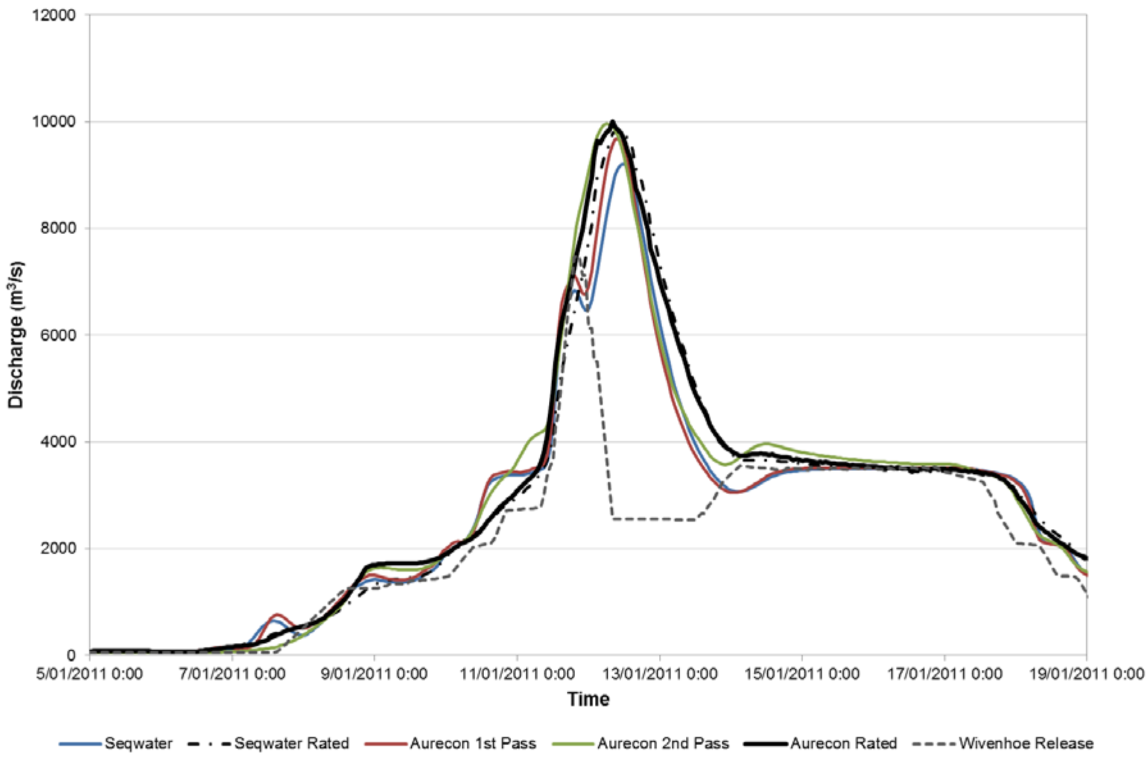


Figure A65 Mt Crosby Weir 2011 event

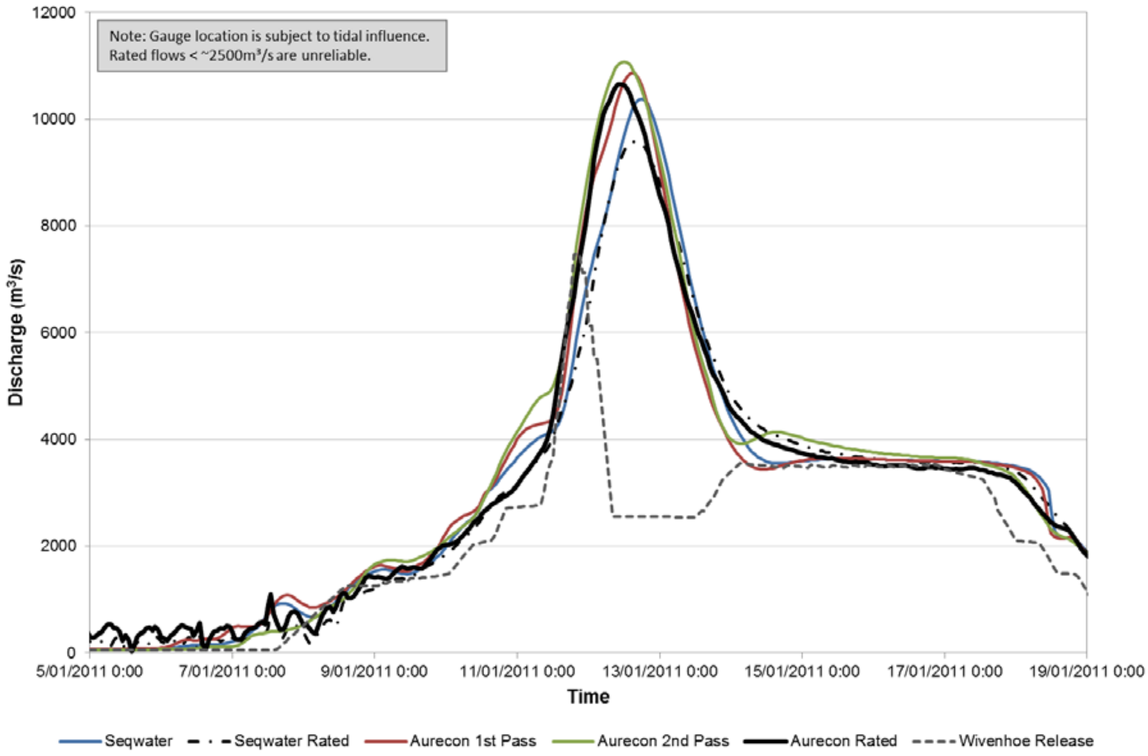


Figure A66 Moggill 2011 event

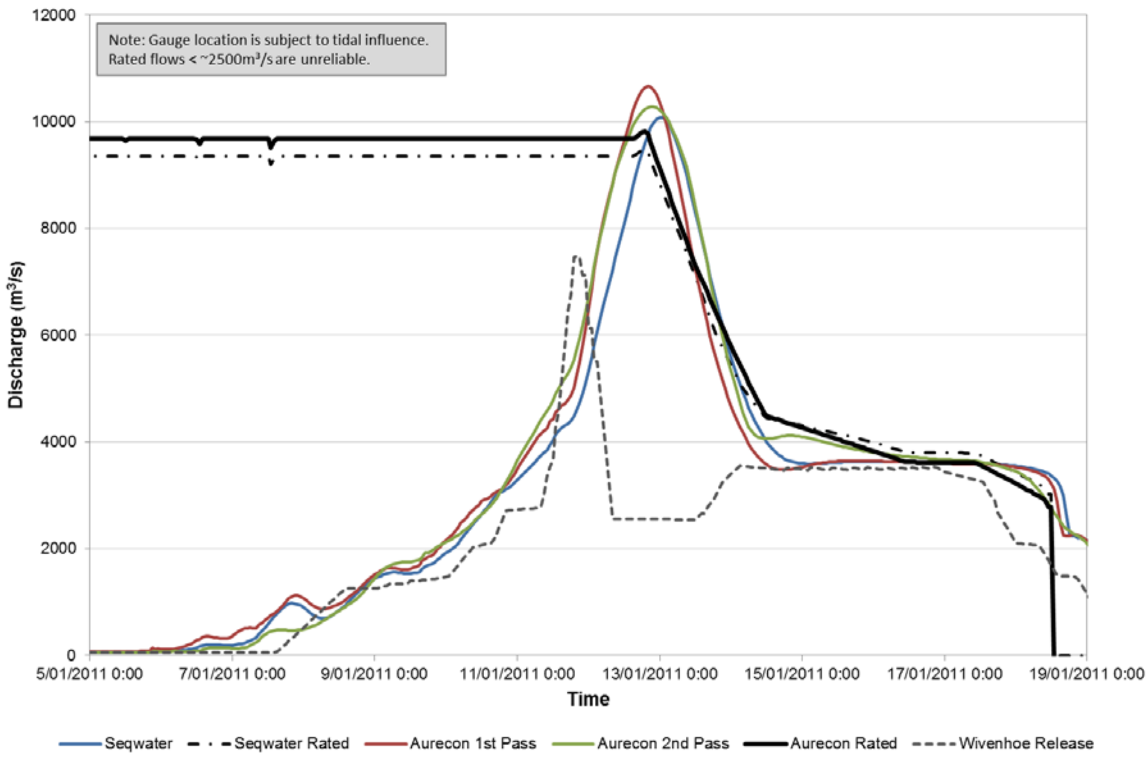


Figure A67 Centenary Bridge 2011 event

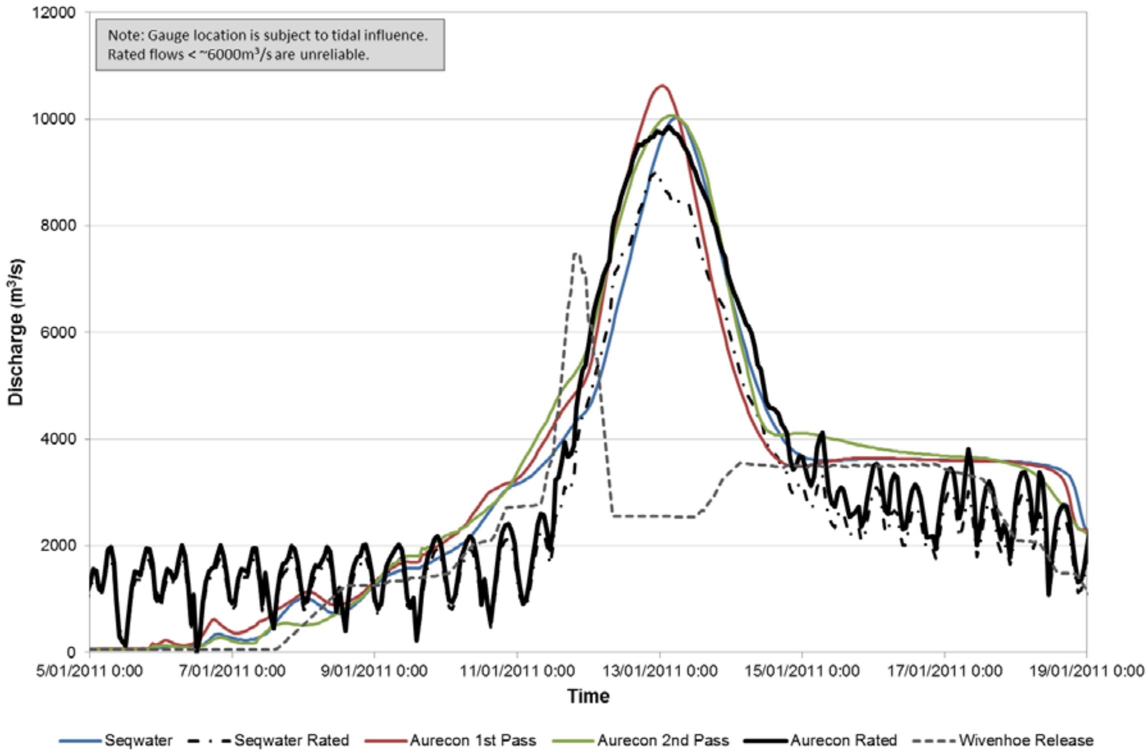


Figure A68 Brisbane City 2011 event

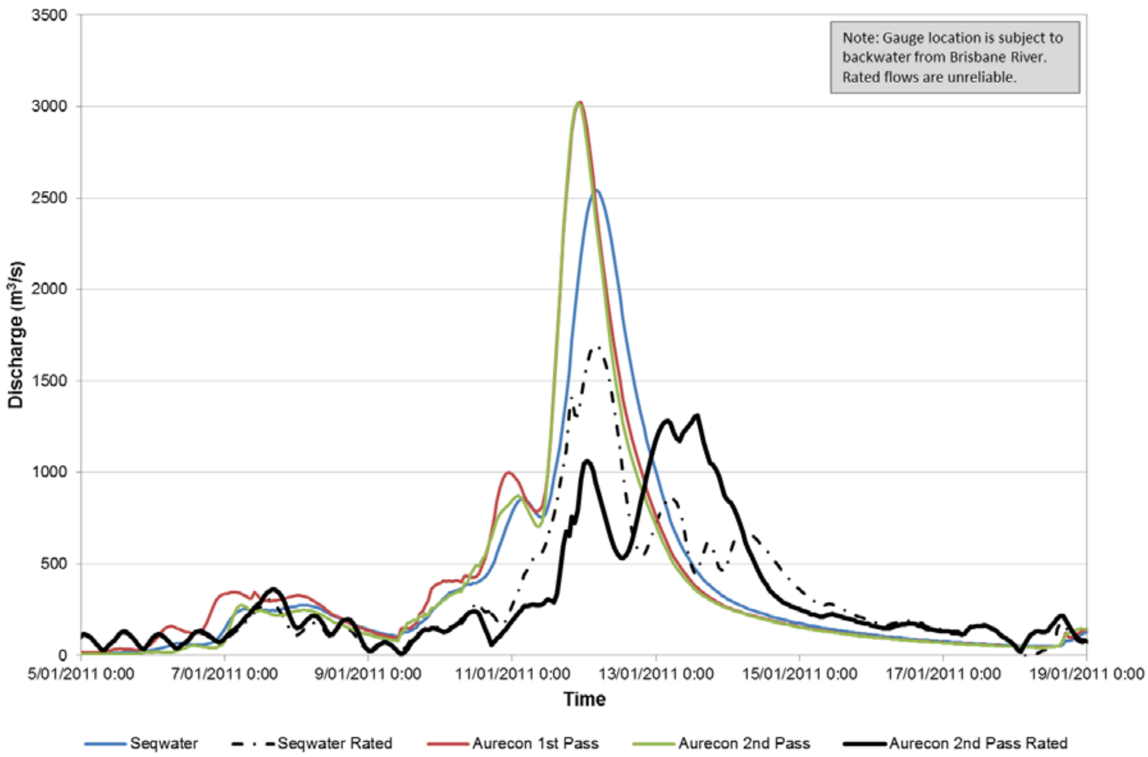


Figure A69 Ipswich 2011 event

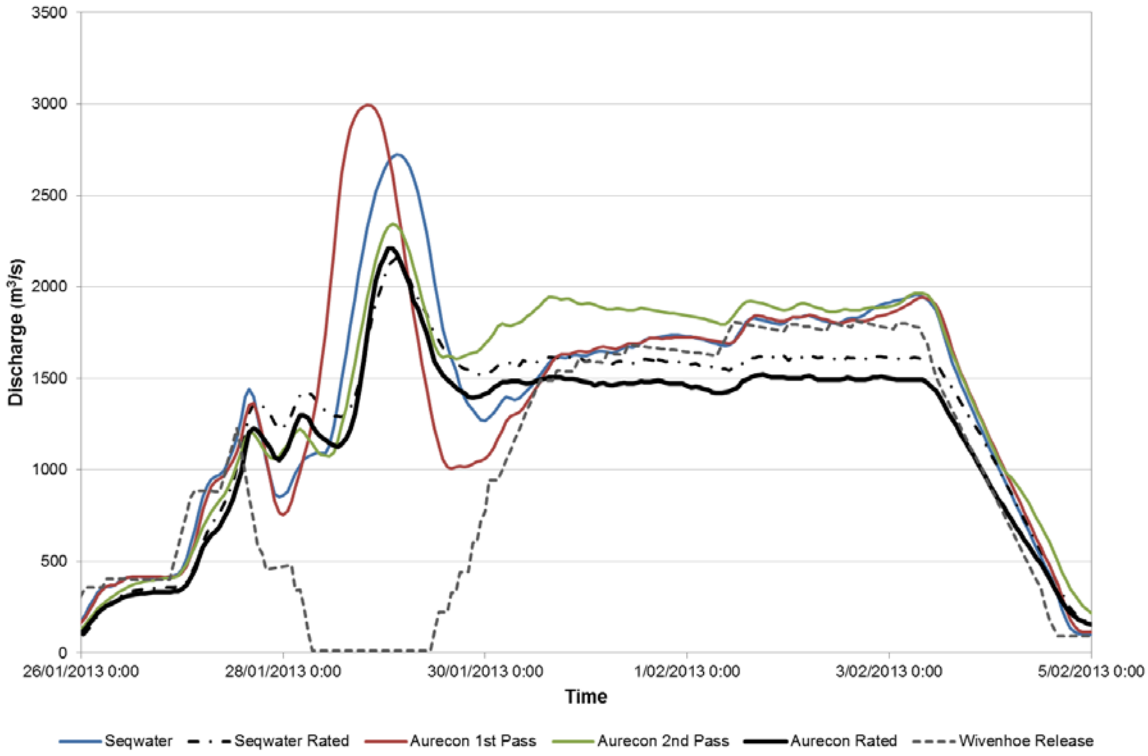


Figure A70 Savages Crossing 2013 event

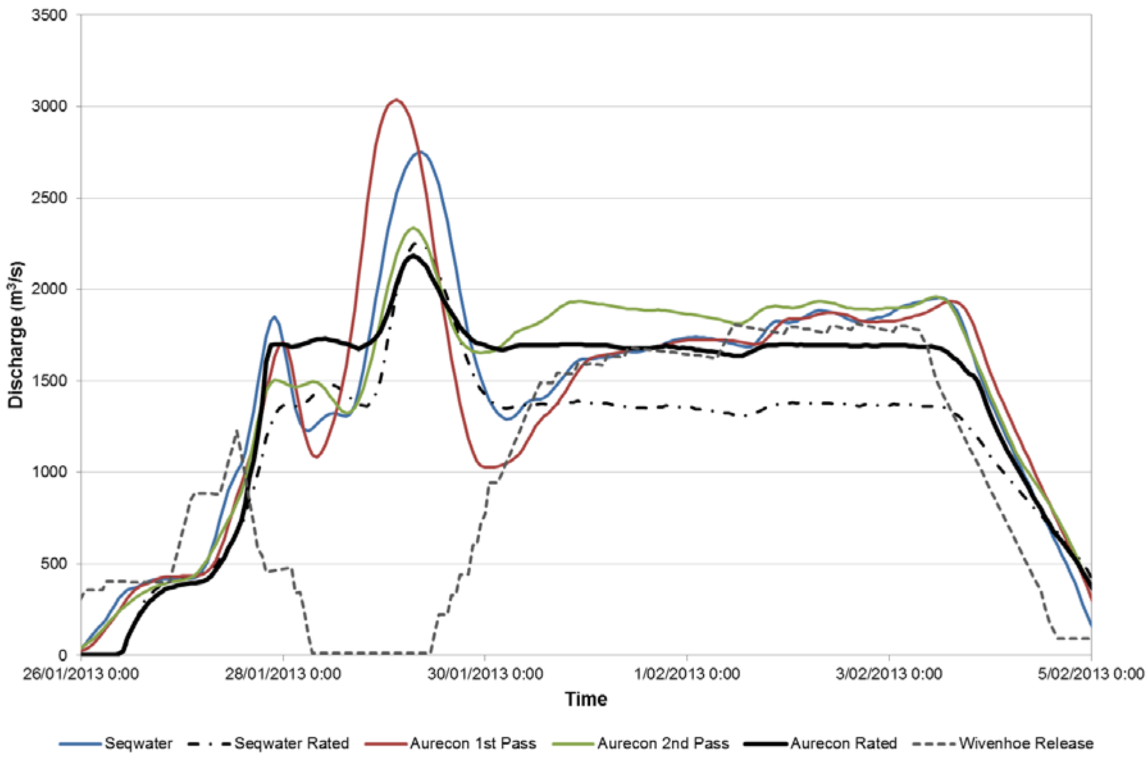


Figure A71 Mt Crosby Weir 2013 event

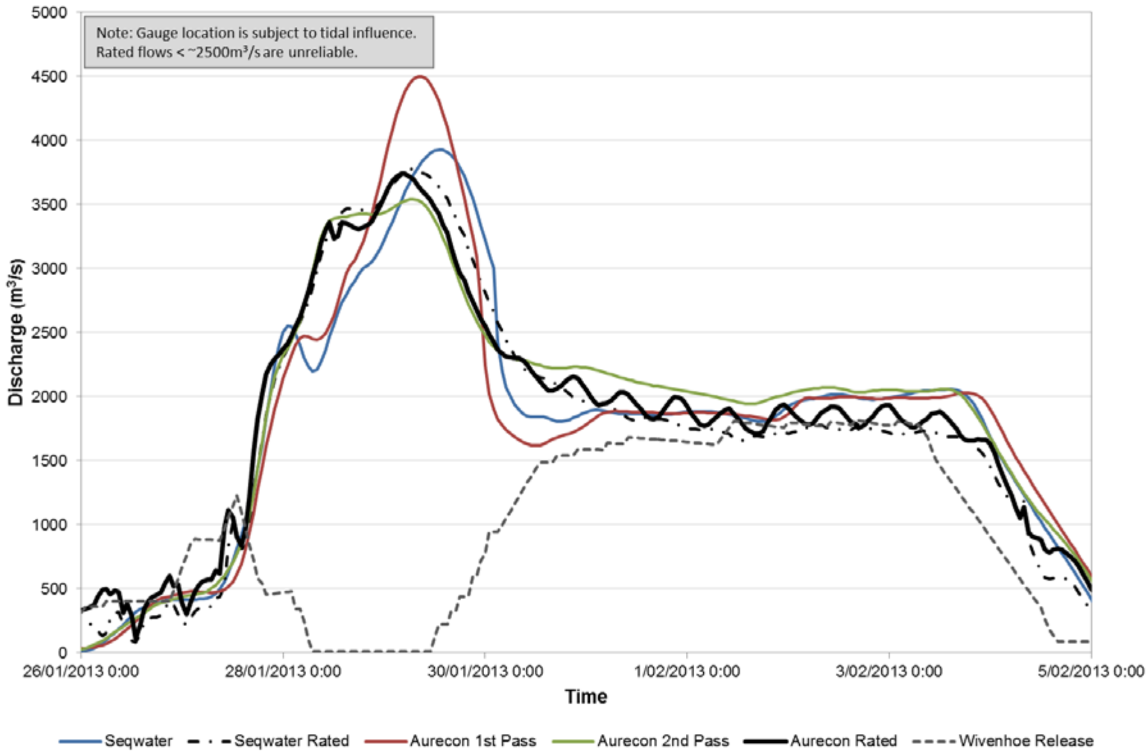


Figure A72 Moggill 2013 event

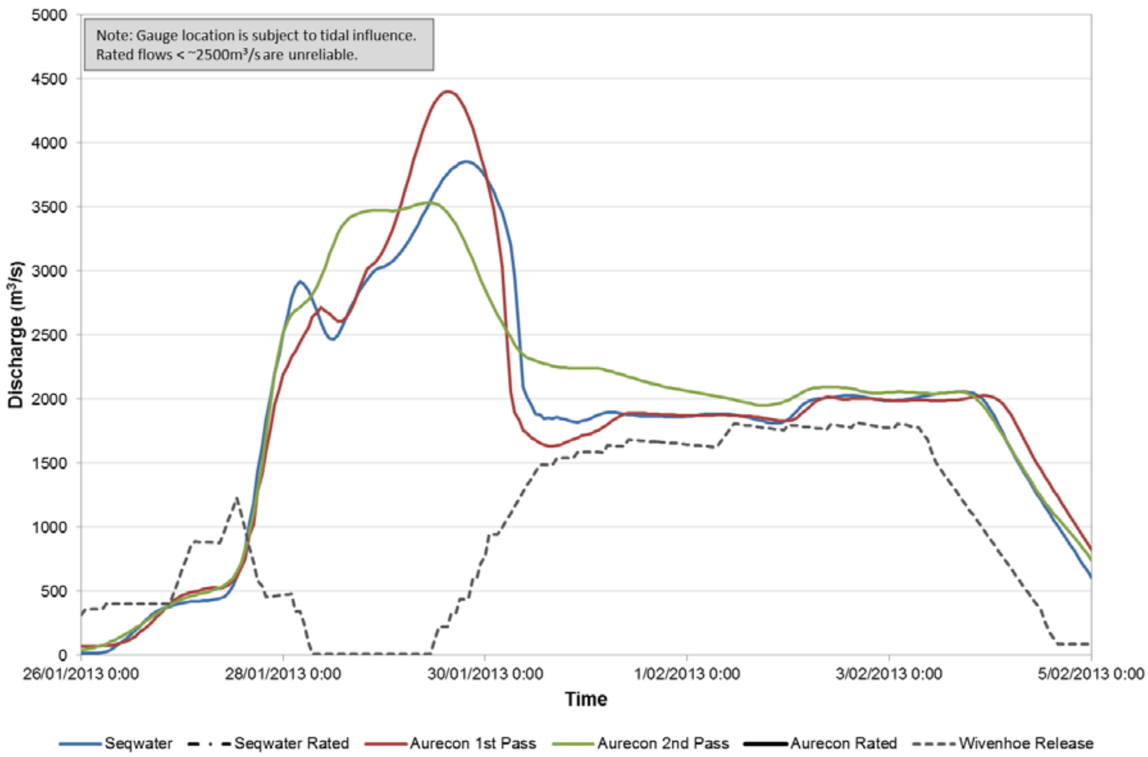


Figure A73 Centenary Bridge 2013 event

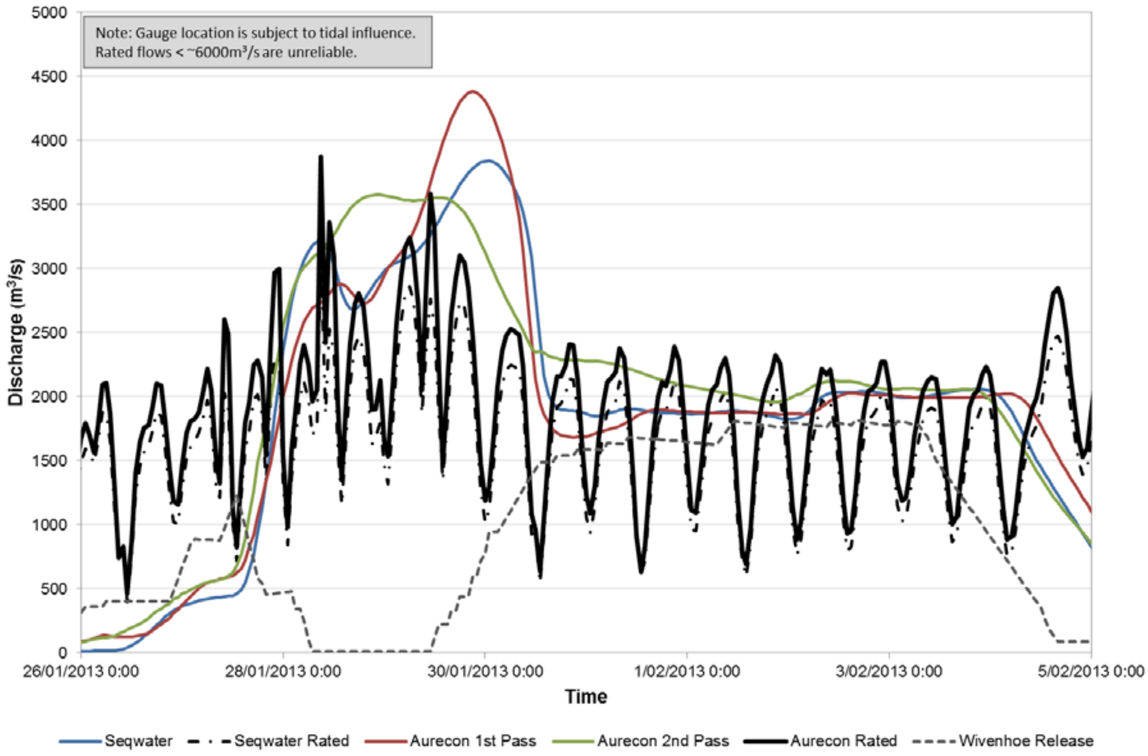


Figure A74 Brisbane City 2013 event

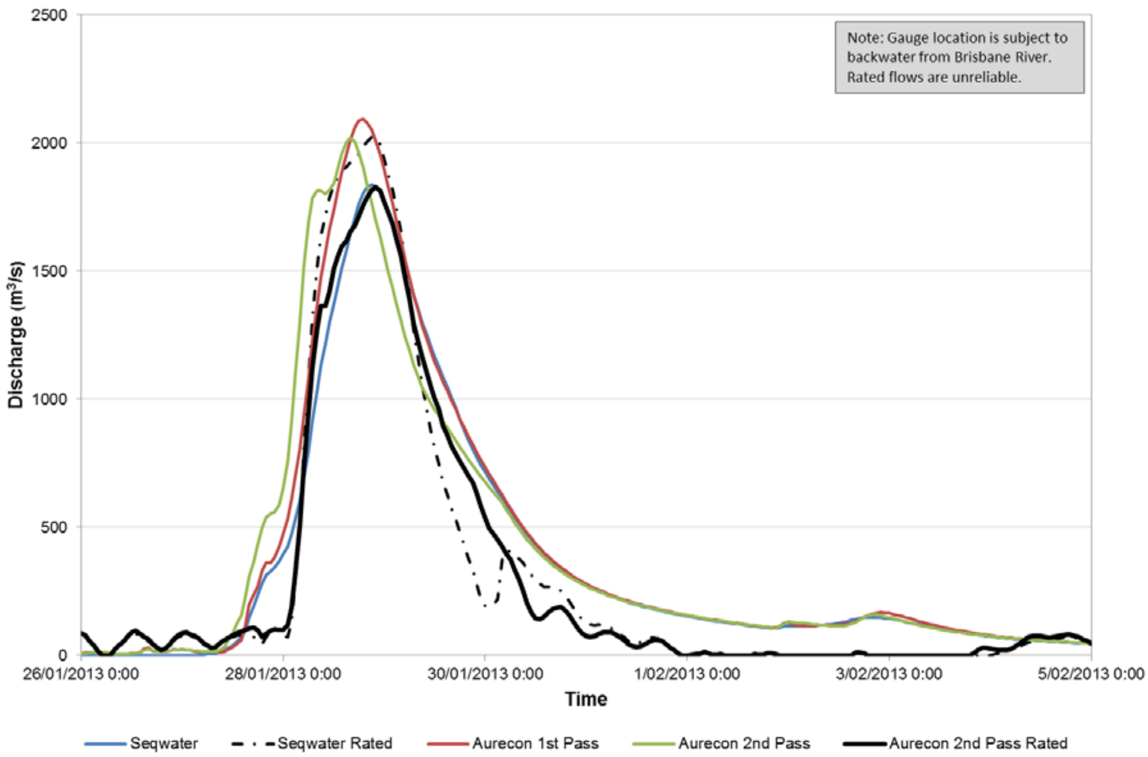


Figure A75 Ipswich 2013 event

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