Report

Model Calibration and Verification Report

10 MARCH 2011

Prepared for

Northland Regional council

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Events Selected for Model Calibration and Verification

As part of the Priority Rivers Modelling Report, this report is intended to state the model calibration and verification results, as well as some observations recorded during the modelling process.

It should be noted that model calibration and verification process was a joint effort between the project team and NRC staff. Extensive support and discussion with NRC were carried out all the way through the calibration and verification. These include:

- Selection of events
- Source and verification raw observed data
- Identifying likely errors in the modelling data and investigation for further model improvements

Due to the limitation of observed data and the priority level of each catchment, not every catchment was calibrated and/or verified. However, the approach was to use the calibrated parameters as reference for other catchments which do not have adequate observed data

The table below lists the events selected to calibrate and verify particular catchments. The selection was based on the availability and the quality of raw data.

Table 1-1 Events for Calibration and Verification

Events for Calibration and Verification- Confirmed by NRC

Mar-10

Catchment Name	Calibration event	Verification Event(s)
01_WAIAROHIA_RAUMAUNGA_RIVERS	Apr-99	Mar-07
02_RUAKAKA_RIVER	Mar-07	Jul-07
03_OTAIKA_RIVER	No Calibration	Mar-07
04_WAITANGI_RIVER	Mar-07	Jun-97
05_HATEA_RIVER	Jul-08	Mar-95 Mar-88
06_KAWAKAWA_RIVER	May-93	Mar-07
07_WAIHOU RIVER		
17_NGUNGURU_RIVER	Mar-07	Apr-08
21_WAIAMA & PUNAKITERE RIVERS		

In addition to the above events, model predicted flood level and flood extents maps with 100 year AEP design event were checked against historical flood information by the NRC team. The feedback was used as input to the model calibration.

2

Methodology

Calibration was processed in the following stages:

- Check of the data errors built in the model
- Check of the model schematics in presenting the critical areas
- Check of the boundary conditions
- Verified observed data
- Verified observed rainfall distribution
- Flow balance analysis
- Calibrate rainfall loss parameters and volume at the flow gauges. This estimated rainfall loss parameter (SCS CN number) for each individual land cover with a particular soil type.
- Compare the loss parameters with other catchments in Priority 1 and derived a common set of parameters (if possible). The common set of loss parameters may not be the best ones for one particular catchment, but is good in general.
- The common set parameter will be used for other catchments. Soil antecedent conditions may be considered.
- Hydraulic calibration against observed flow, level and flood extent, where available.

Model calibration was carried out through the rough model build, and event based calibration and verification. Other then correcting or improving network schematics, critical areas considered during the calibration are:

- **Observed event rainfall distribution:** due to limited rain gauges, gaining appropriate rainfall distribution and rainfall temporal pattern is a challenge. Extra rain gauges from neighbouring catchments and through rain data and flow volume analysis essential to provide a good estimate on these critical parameters. Good understanding on hydrology is also critical.
- **River cross-section Roughness (Manning coefficient):** Roughness is an important variable which impacts river flow velocity. This was initially estimated based on the river bed composition and shape information shown on aerial photo, globally adjusted through water level and flow calibration.
- **Missing LiDAR at river mouth:** Most catchments are missing LiDAR information at the river mouth. Some catchments (such as Otaika), ground level information at the river mouth was quite sensitive.
- **Using of Flood point Survey:** using previous flood point survey information for model calibration and verification should be cautious, as there might be some expression discrepancies or coordinates errors involved. The level comparison should only be used as a kind of verification to help model improvements and gain general feeling on the model reliability.
- **Observed level and flow:** Observed level and flow data validation is essential during the calibration. This part of the work is important and needed in-depth experience and extensive inputs from local staff.

Once a model was calibrated, a verification run was then carried out with no further parameter changes to check the model performance against the observed data on that verification event.

3

Criteria

We consider the main purpose of model calibration and verification is to examine model build methodology and model performance with the available observed information. Criteria and accuracy of model calibration results should be considered with the project purpose, status of available data for the model build, and quality of the available observed data.

The first versions of the full catchment models for all Priority Rivers used the following approaches and therefore were developed and adopted as the modelling calibration and verification criteria:

- Using consistent model build procedures for each catchment. This allows to easily identify systematic errors which may be fixed in one go when a cause is diagnosed;
- Rather than just calibrate each catchment individually, a common set of parameters and knowledge should be applied and used as cross reference checks;
- Where raw data has embedded and a certain degree of uncertainties lies, calibration should be done carefully with appropriate consideration of the likely errors in the raw data.
- Best efforts should be made to improve the model to achieve better calibration accuracy only with understood reasons.
- Applying Fixed Calibration accuracy may not be appropriate for this project. We value model calibration results errors against the observed data. Rather than just trying to achieve numerical agreement between model and observed data with "guesses". We believe it is more valuable to stop when models match observation and knowledge fairly well and keep the model results discrepancies. This approach is helpful in identifying directions for future model improvements, when needed.

With the above approach, The NRC staff team were extensively involved in detailed discussion and provision of local knowledge. Until calibration and verification results had reached a mutually accepted level.

3.1 Common Parameters, Sub-catchment CN Values

CN values were estimated based on the land cover available in GIS. A group C drainage class was assumed for all catchments. CN values vary dependent on soil conditions and especially upon antecedent moisture conditions. These initial values were changed if calibration suggested it.

Table 3-1 CN Values

ID	Description	Average % Impervious	Curve Number by Hydrologic Soil Group				Typical Land Uses
			A	B	C	D	
1	Residential (High Density)	65.00	77	85	**90**	92	Multi-family, Apartments, Condos, Trailer Parks
2	Residential (Med. Density)	30.00	57	72	**81**	86	Single-Family, Lot Size ¼ to 1 acre
3	Residential (Low Density)	15.00	48	66	**78**	83	Single-Family, Lot Size 1 acre and Greater
4	Commercial	85.00	89	92	**94**	95	Strip Commercial, Shopping Ctrs, Convenience Stores

3 Criteria

ID	Description	Average % Impervious	Curve Number by Hydrologic Soil Group				Typical Land Uses
			A	B	C	D	
5	Industrial	72.00	81	88	**91**	93	Light Industrial, Schools, Prisons, Treatment Plants
6	Disturbed/ Transitional	5.00	76	85	**89**	91	Gravel Parking, Quarries, Land Under Development
7	Agricultural	5.00	67	77	**83**	87	Cultivated Land, Row crops, Broadcast Legumes
8	Open Land – Good	5.00	39	61	**74**	80	Parks, Golf Courses, Greenways, Grazed Pasture
9	Meadow	5.00	30	58	**71**	78	Hay Fields, Tall Grass, Ungrazed Pasture
10	Woods (Thick Cover)	5.00	30	55	**70**	77	Forest Litter and Brush adequately cover soil
11	Woods (Thin Cover)	5.00	43	65	**76**	82	Light Woods, Woods-Grass combination, Tree Farms
12	Impervious	95.00	98	98	**98**	98	Paved Parking, Shopping Malls, Major Roadways
13	Water	100.00	100	100	**100**	100	Water Bodies, Lakes, Ponds, Wetlands

3.2 Observed Rainfall Data Processing

There were not sufficient rain gauges for every catchments calibration events. Processing the limited observed rain data was an important step. Rain gauges in neighbouring catchments, and elevations were considered in the analysis to derive spatial rainfall distribution using Thiessen polygons.

Rain profile was derived from the available auto gauges and applied to the closest daily rain gauges. It is important to carry out thorough rainfall spatial analysis with all available rain data from surrounding catchments to gain confidence on spatial distribution. This analysis may also need to be done in conjunction with flow gauge water balance analysis with consideration of antecedent conditions relating to the calibration event.

4

Results Summary

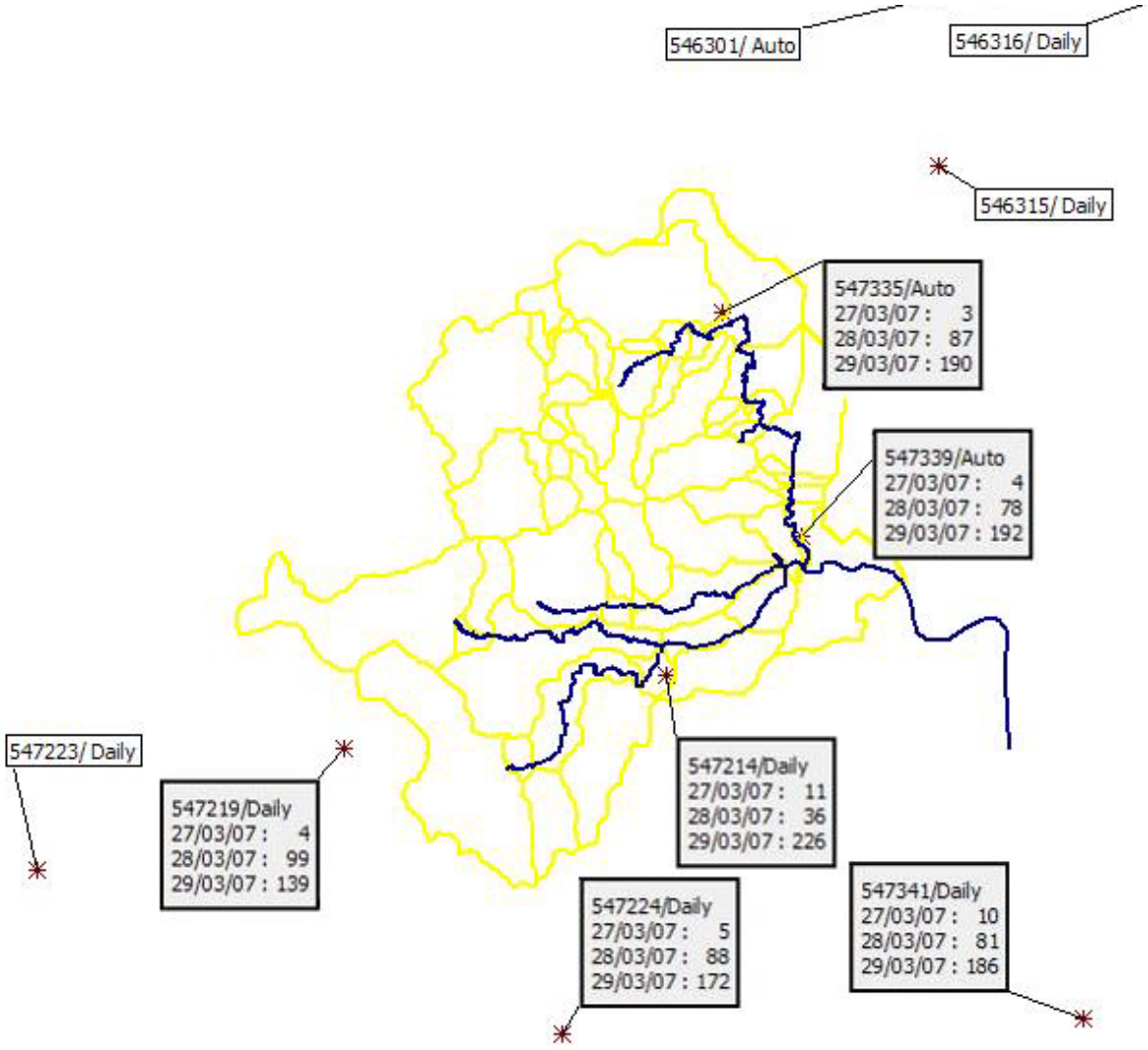
4.1 Waiarohia - Raumaunga Rivers (Catchment 01)

4.1.1 Rainfall Distribution

Waiarohia – Raumaunga River catchment is one of the most important catchments in the Northland area. However, there is not sufficient rainfall data for both calibration and verification events.

As shown in the figure below, the central part and northwest part of the catchment have no rain gauges. The auto gauges, which will be used to derive rainfall temporal patterns, are located in the eastern edge of the catchment.

Table 4-1 Rain gauge Locations Waiarohia/Raumanga River



For this reason, daily rain gauges(see the above figure) from the surrounding catchments were used to assist rainfall spatial distribution. .

4 Results Summary

4.1.2 Whau Valley Reservoir – Spillway and Emergency Weir

The Whau Valley Dam is an important component within this catchment river model. There was an issue on the correct spillway size and level. These were eventually measured and the model was updated. NRC surveyed relevant information is summarised in the following table:

Table 4-2 Whau Valley Dam Details

Description	Elevation OTP (m)
Bellmouth crest level	107.587
Dam Crest (central span)	111.502
Bellmouth crest level relative Staff Gauge	16.342 (SG)
SG Zero	91.245
Start up reservoir level March 2007 (13.93 SG)	105.175
Peak reservoir level March 2007 (16.97 SG)	108.215
Emergency Spillway invert level (from URS survey)	109.44
Max Head above bellmouth Mar 2007	0.628
Freeboard Mar 2007 to Emergency spillway invert level	1.225
Dam construction datum (107.587 – 138.2)	-30.613

Reservoir Volumes

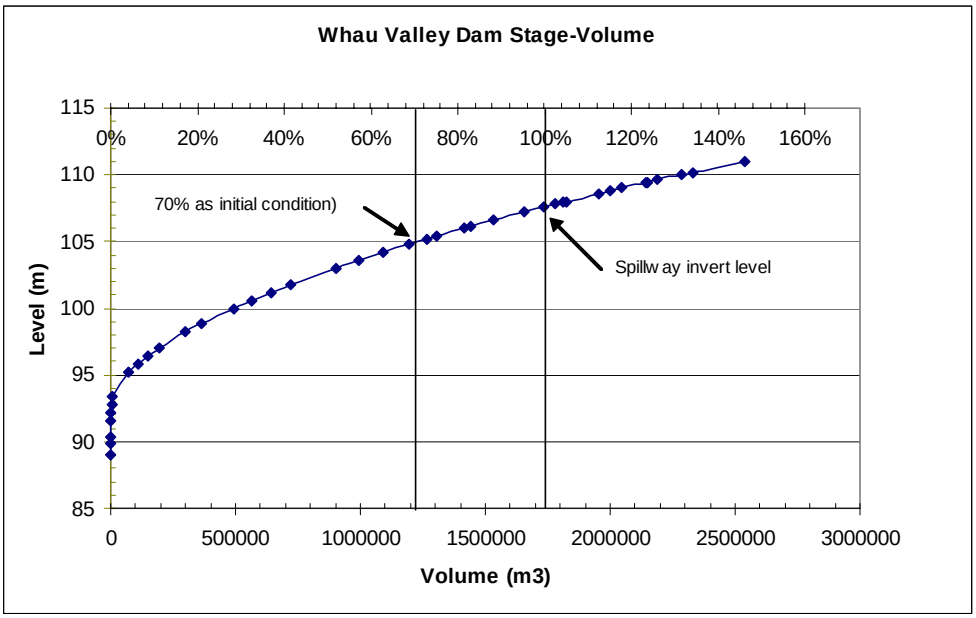
The Whau Valley Dam Reservoir volumes were configured as a storage reservoir in the model. The stage-volume curve was obtained from the available LiDAR. LiDAR does not cover levels under reservoir water. Estimation had to be made to extrapolate the stage-volume curve to lower water levels.

This extrapolated volume at low water level areas has little impact to the model, as in extreme events, the reservoir is normally relatively full.

The following graph shows the volume curve of the reservoir.

4 Results Summary

Figure 4-1 Whau Valley Reservoir Stage/Storage Curve



Bellmouth Spillway, bellmouth and tunnel

The bellmouth spillway was modelled based on the layout of the spillway (shown below) and the level survey of June of 2010. It consists of a broad crested weir of 32.1m wide (perimeter of circumference) with a discharging coefficient of C=0.90.

4 Results Summary

Figure 4-2 Layout of Spill

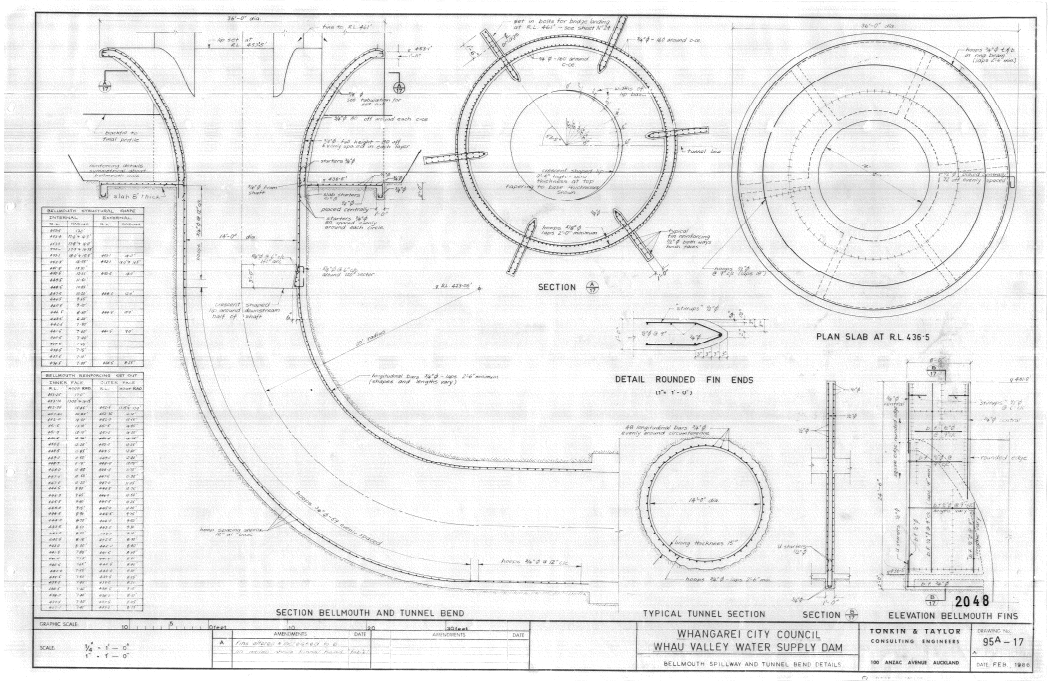


Figure 4-3 Spillway photo

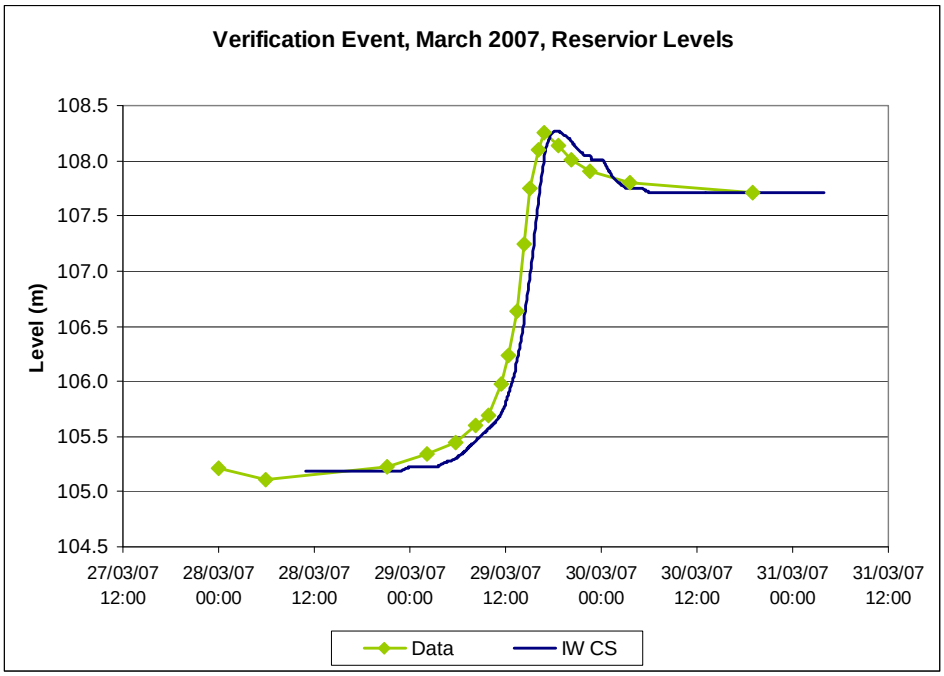
4 Results Summary

The verification event has been used as the calibration event of the reservoir and spillway. This is due to reservoir and spillway data only being available for the verification event and not the calibration event.

Under the previous approach we are confident about the accuracy of the spillway and weir performances.

The following graph shows the recorded levels in the reservoir with the modelled results.

Figure 4-4 Reservoir Levels

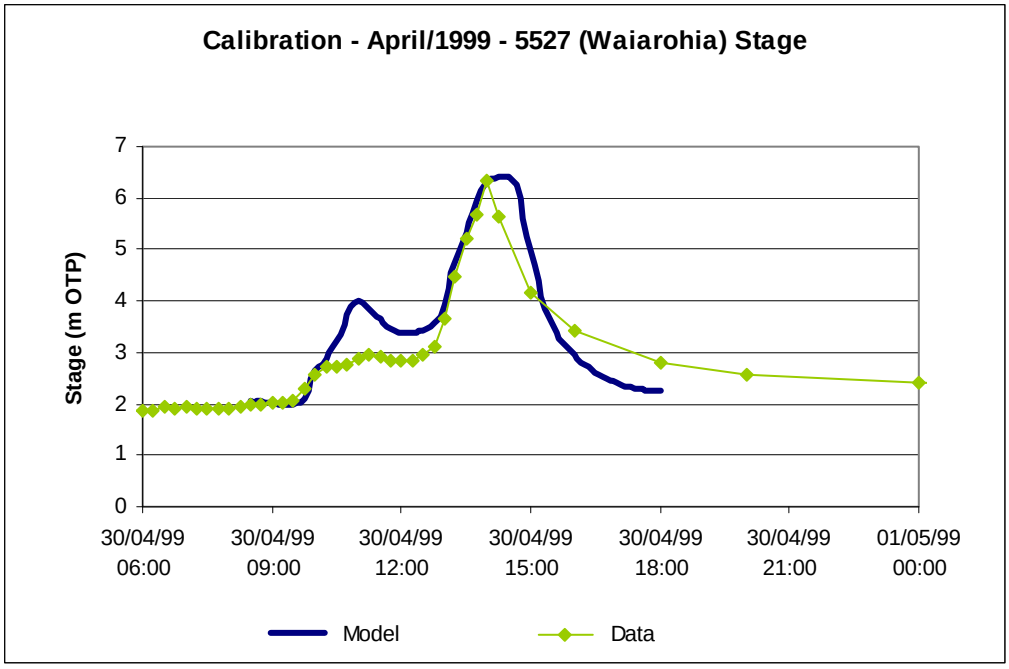


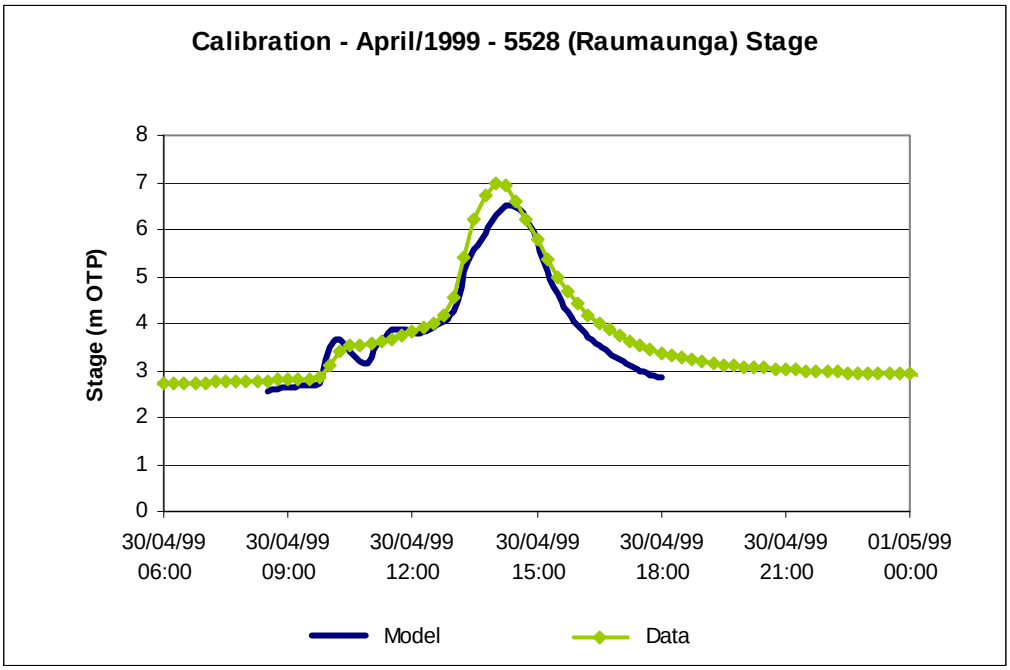
4.1.3 Calibration Event: April 1999

The following graphs demonstrate the modelled results ("Model") against the observed data ("Data").

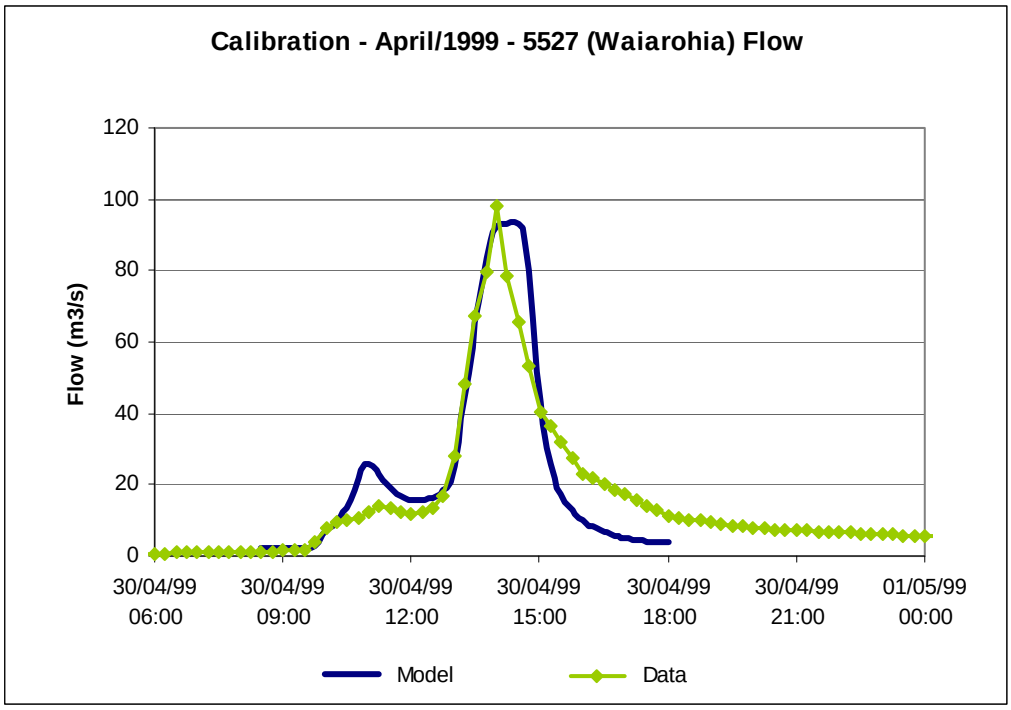
4 Results Summary

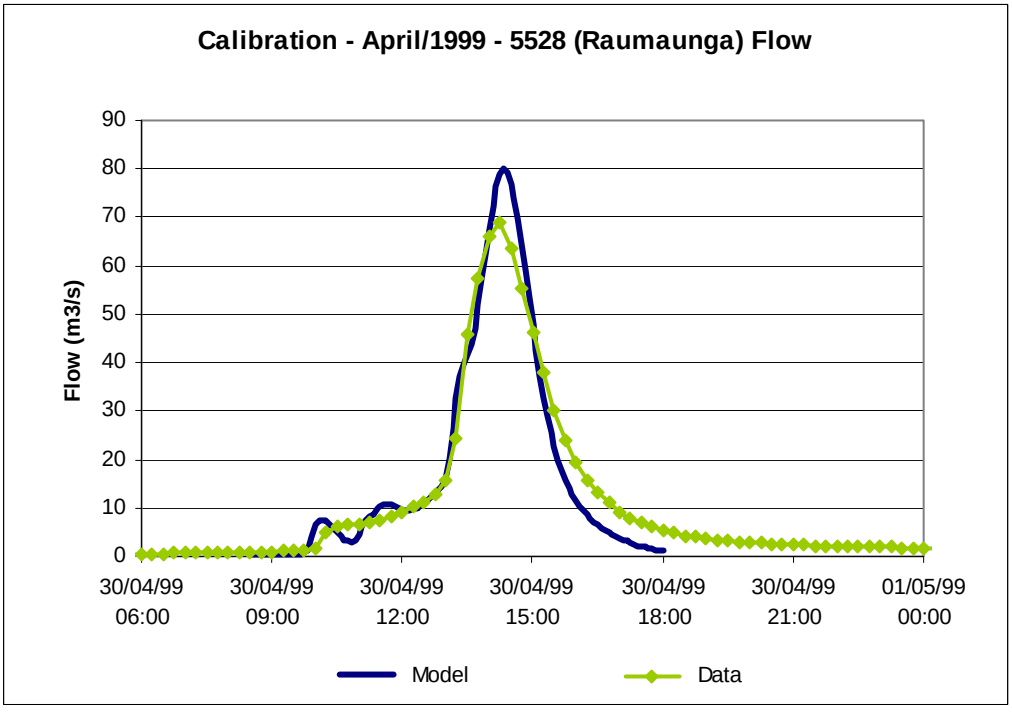
Figure 4-5 Flow/Stage Stations





4 Results Summary





The following tables summarize the calibration results as shown in the above graphs.

4 Results Summary

Table 4-3 Calibration/Verification Summary

Volume (m3)	Waiarohia (5527)		Raumaunga (5528)	
	Model	Survey	Model	Survey
30/04/1999 09:00:00	4307.5	1041501.15	588.1	835633.35
30/04/1999 18:00:00	847859.9	1902467.7	623405.1	1486233.9
Volume (m3)	**843552.4**	**860966.6**	**622816.9**	**650600.5**
Difference (%)	**-2.0%**		**-4.3%**	

Peak Flow (m3/s)	93.71	98.224	79.93483	68.979
Difference (m3/s)	-4.516305		10.95583	
Difference (%)	**-4.6%**		**15.9%**	
Peak Flow (m3/s, 2D check)	100.198		80.791	
Peak Time	30/04/1999 14:20	30/04/1999 14:00	30/04/1999 14:20	30/04/1999 14:15
Difference (hh:mm:ss)	**00:20:00**		**00:05:00**	

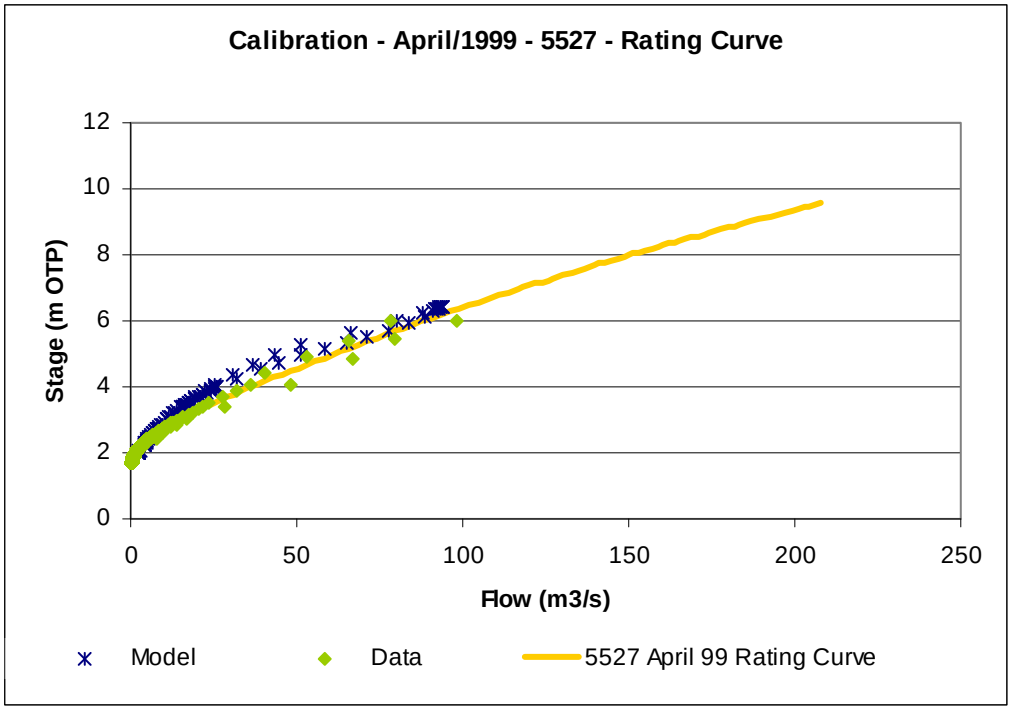
Max Flood Level (m)	6.42	6.35	6.51	6.97
Difference (m)	**0.07**		**-0.46**	
Max Flood Level (2D check, m)	6.72		6.637	

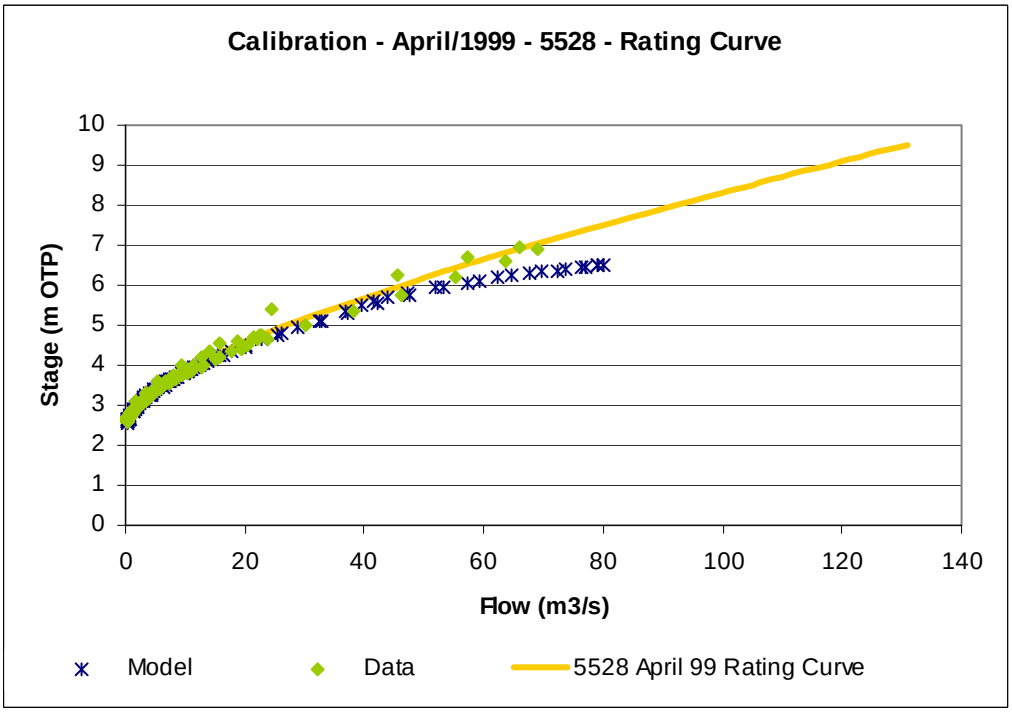
Table 4-4 Level Survey Points

Calibration Site	Node (IWRS)	Surveyed Level (m OTP)	Model Level (m OTP)	Difference (m)
Rust Ave Bridge (u/s)	WAI_3410	8.90	8.898	0.00
Lovers Lane Bridge (u/s)	WAI_3775	6.34	6.46	0.12
Lovers Lane Bridge (d/s)	WAI_3785	5.97	5.904	-0.07
Caflet Park (u/s of Water St Bridge)	WAI_3974	5.00	5.073	0.07
Lower Tawera Rd Bridge (u/s)	WAI_4463	4.70	4.739	0.04
Lower Tawera Rd Bridge (d/s)	WAI_4467	4.40	4.247	-0.15
Woods St Bridge (u/s)	WAI_4916	2.05	2.096	0.05
Commerce St (lower end)	01_12_12879	1.85	1.973	0.12

4 Results Summary

Figure 4-6 Rating Curves



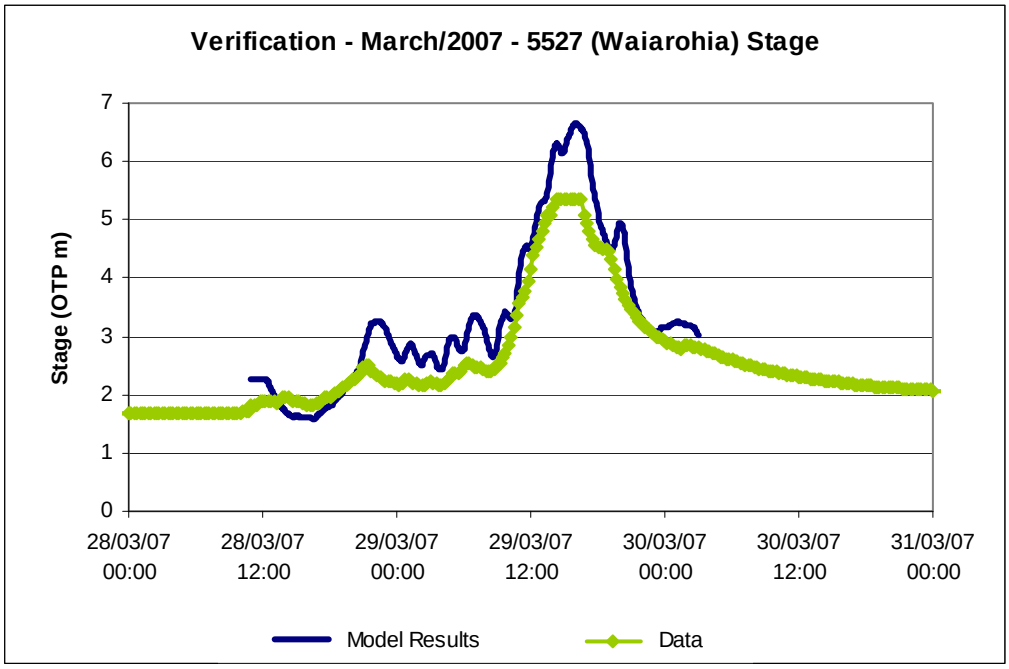


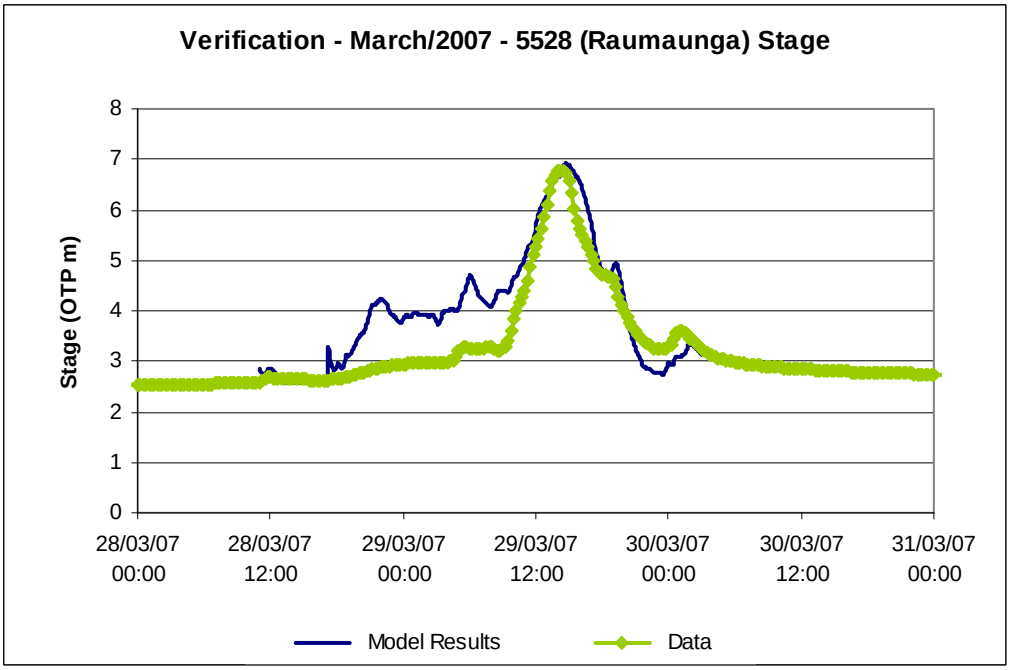
4 Results Summary

4.1.4 Verification Event: March 2007

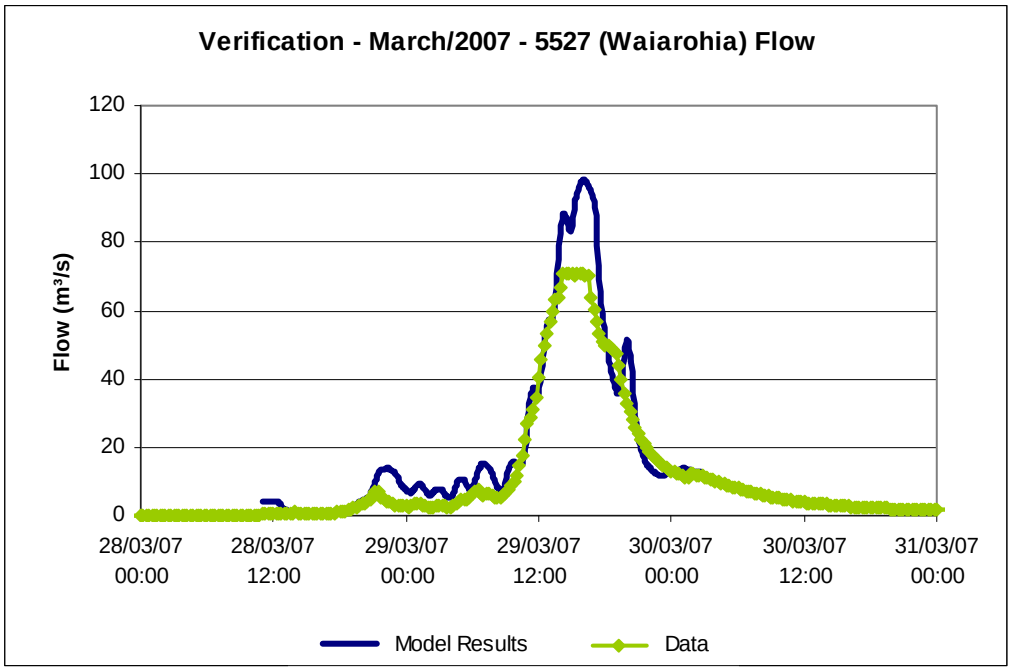
Following graphs demonstrate the modelled results against the observed data ("Data").

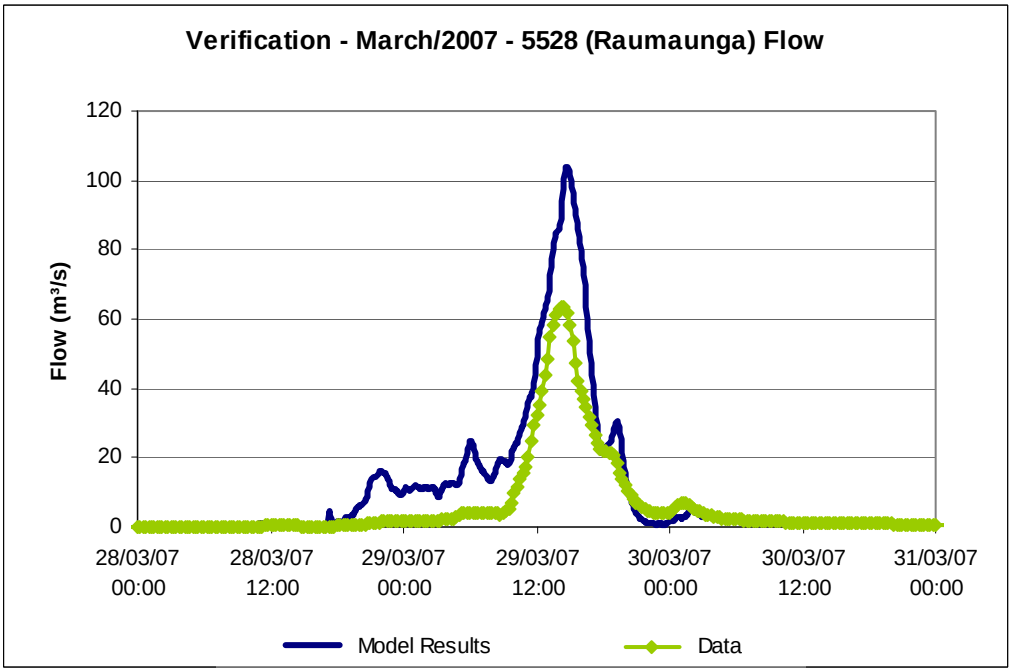
Figure 4-7 Flow/Stage Stations





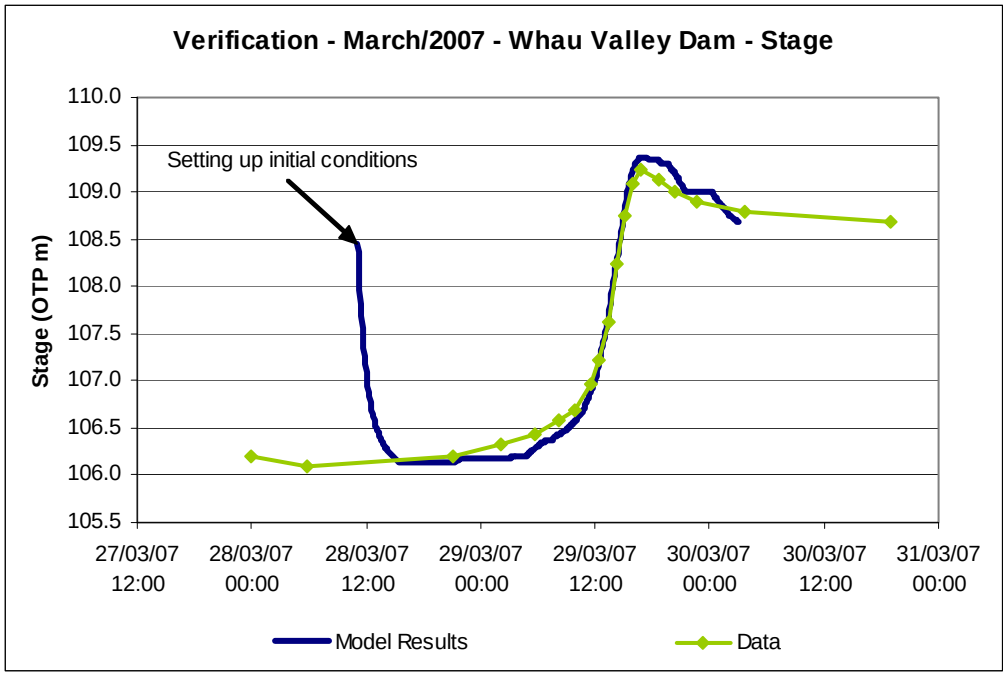
4 Results Summary





Note that the gauge 5527 stage records missed the peak period, as confirmed by NRC.

4 Results Summary



Level Survey Points

There is some information recovered from photographs taken during the storm and surveyed afterwards.

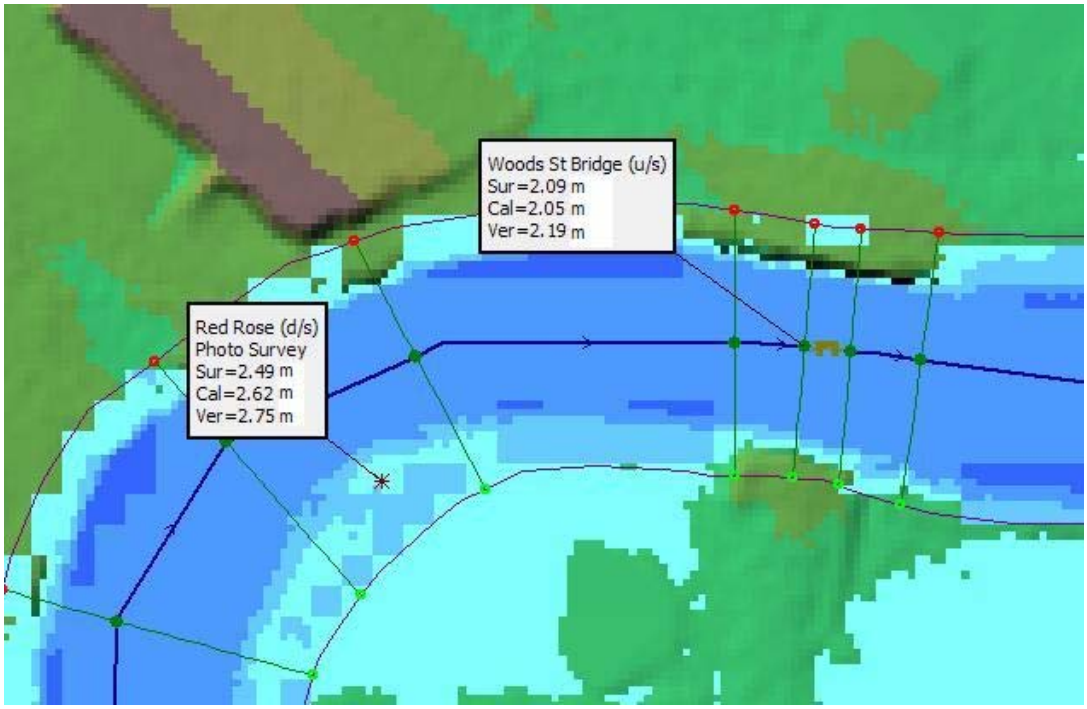
Table 4-5 Level Survey Points

	Survey for event March 2007			Verification March 2007	
Name	X	Y	Survey	Model Level	Model Flow
Raumaunga Stream	1719005.975	6045339.304	5.24	5.13	102.3
Auto Craft at confluence	1719182.309	6045309.033	4.54	4.92	107.2
Red Rose (d/s)	1719501.529	6045336.187	2.49	2.75	166.2
Whangarei Intermediate School	1719024.372	6046113.914	8.38	9.33	109.1
Whareora Rd	1720858.503	6048574.485	19.84	19.00	286.6

See figure below where flood levels for survey, calibration and verification are shown.

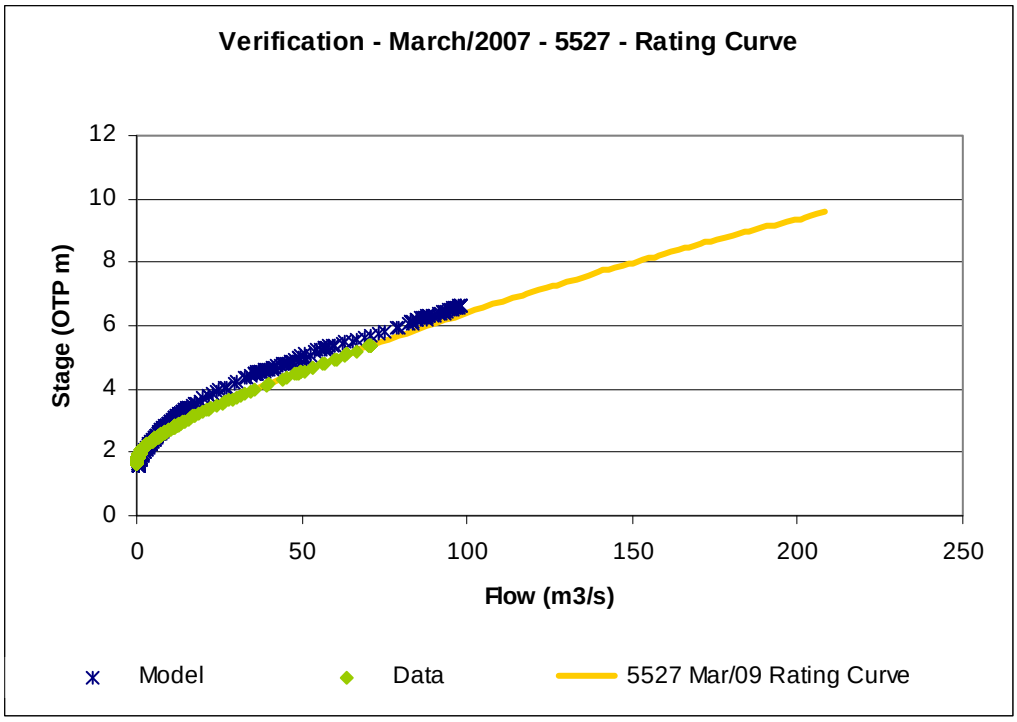
4 Results Summary

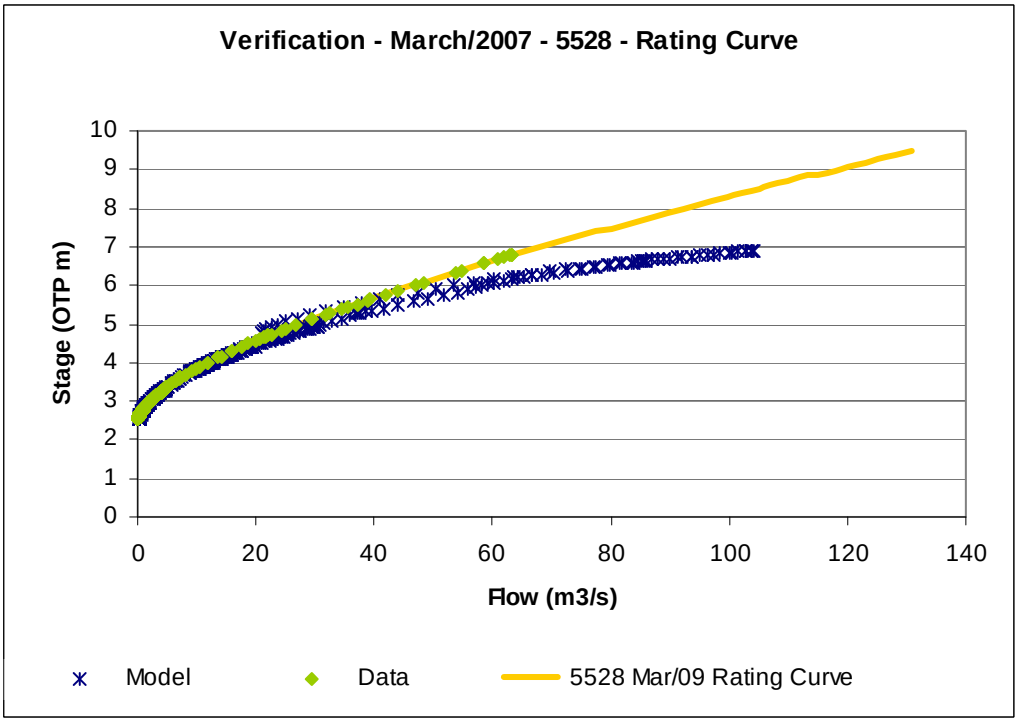
Figure 4-8 Example Survey/Calibration/Verification



4 Results Summary

Figure 4-9 Rating Curves





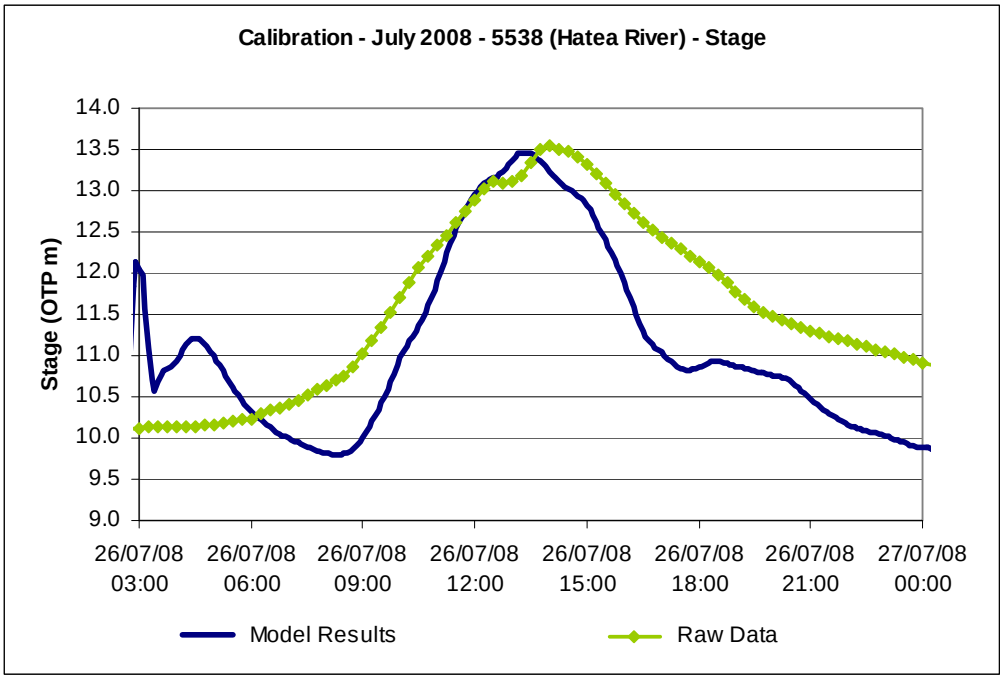
4 Results Summary

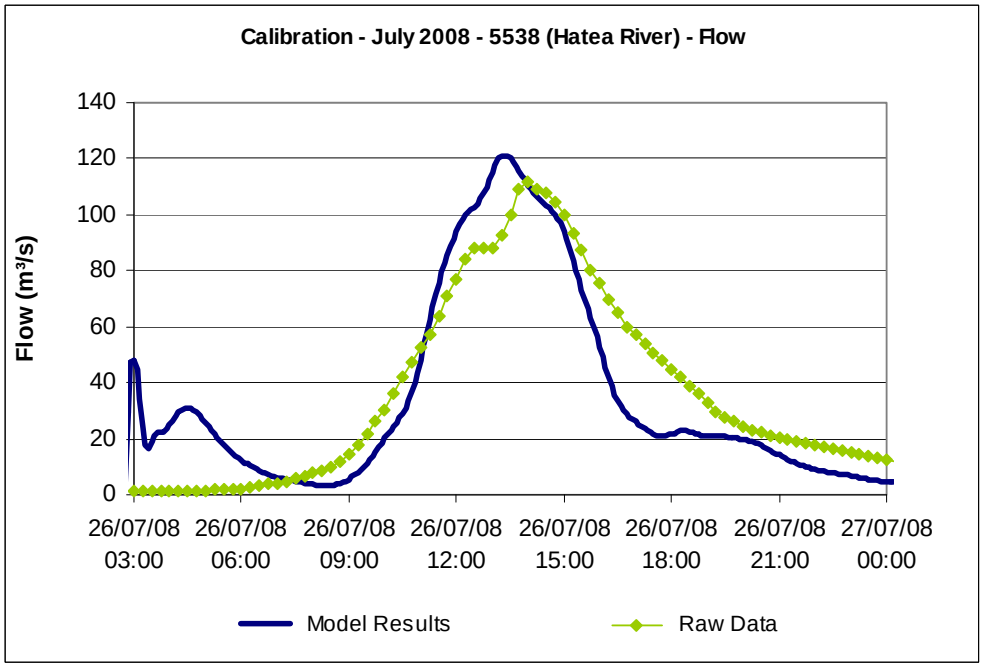
4.2 Hatea River (Catchment 05)

4.2.1 Calibration Event: July 2008

Following graphs demonstrate the modelled results against the observed data ("Raw Data").

Figure 4-10 Flow/Stage Stations





4 Results Summary

The following tables summarize calibration results as displayed in the above graphs:

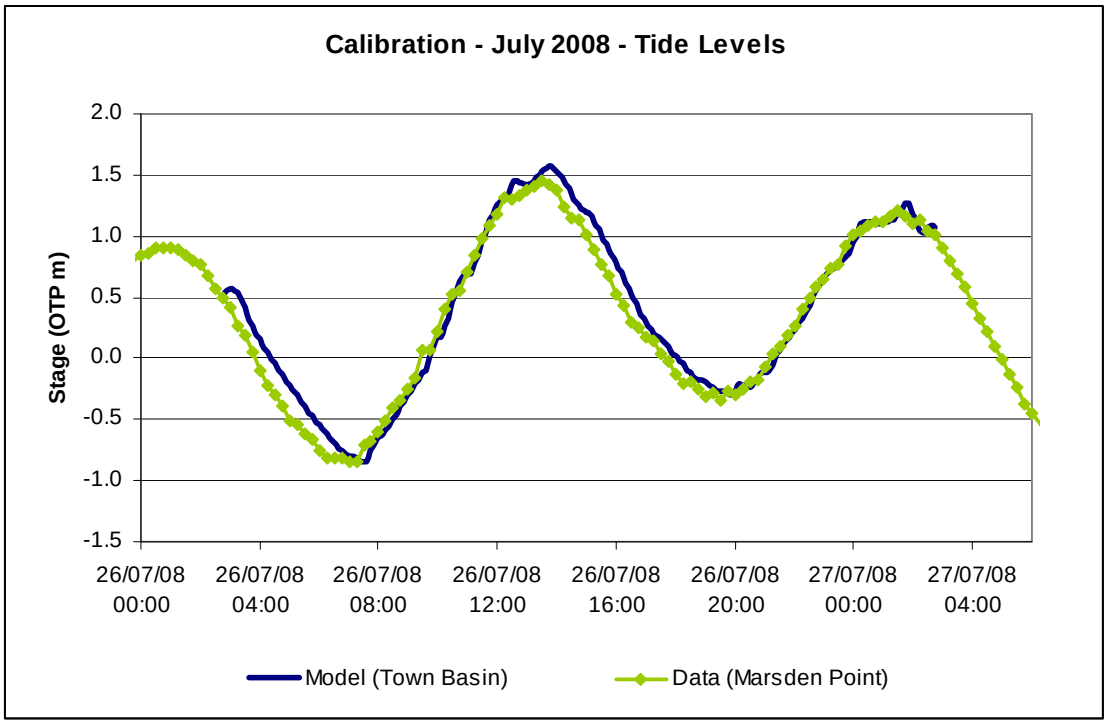
Table 4-6 Calibration/Verification Summary

Volume (m3)	Hatea River (station 5538)	
	Model	Survey
26/07/2008 07:00:00	323472.9	1170799.65
27/07/2008 00:00:00	2720117.8	3970714.95
Volume (m3)	**2396644.9**	**2799915.3**
Difference (%)	**-14.4%**	

Peak Flow (m3/s)	121.0	111.7
Difference (m3/s)	9.2	
Difference (%)	**8.3%**	
Peak Time	26/07/2008 13:20	26/07/2008 14:00
Difference (hh:mm:ss)	**- 00:40:00**	

Max Flood Level (m)	13.46	13.55
Difference (m)	**-0.09**	
Max Flood Level (2D check, m)	13.45	

Figure 4-11 Tide Levels



4 Results Summary

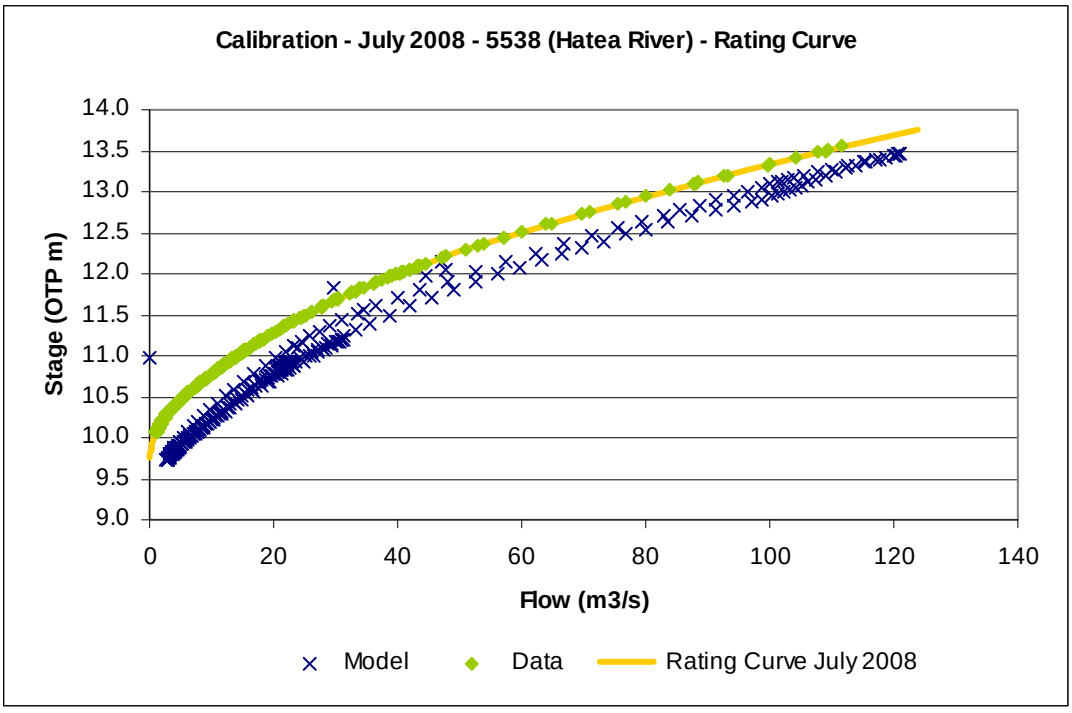
Level Survey Points

Surveyed points are not available for the calibration or verification events, but were obtained for the March 2007 event.

Table 4-7 Level Survey Points

Whareora Rd (at Koromiko Lane, about 800m upstream of 5538)				
Data Source	X (m)	Y (m)	Level (OTP m)	Flow (m3/s)
Survey (March 2007)	1720858.50	6048574.49	19.84	
Model (Calibration: July 2008)	1720858.50	6048574.49	19.00	286.60
Model (1st Verification: March 1995)	1720858.50	6048574.49	18.20	118.95
Model (2nd Verification: March 1988)	1720858.50	6048574.49	18.20	118.95

Figure 4-12 Rating Curves



4 Results Summary

4.2.2 1st Verification Event: March 1995

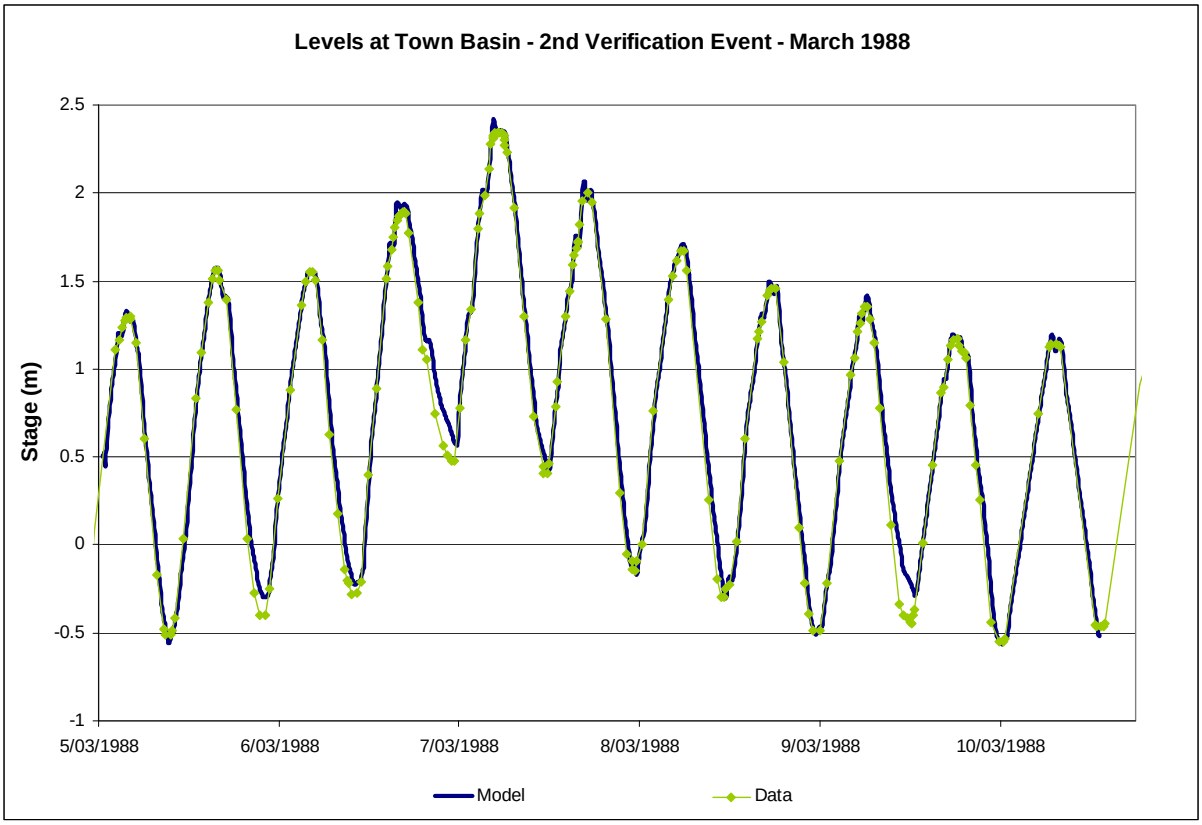
Flow/Stage Stations

There are no hydrograph records; the gauge at Whareora Rd was destroyed in the storm. However it's known that the max flood level is about 10.30m relative to the site datum. The model hydrograph and levels at the gauge 5538 are included below.

Table 4-8 Whareora Rd Level Comparison

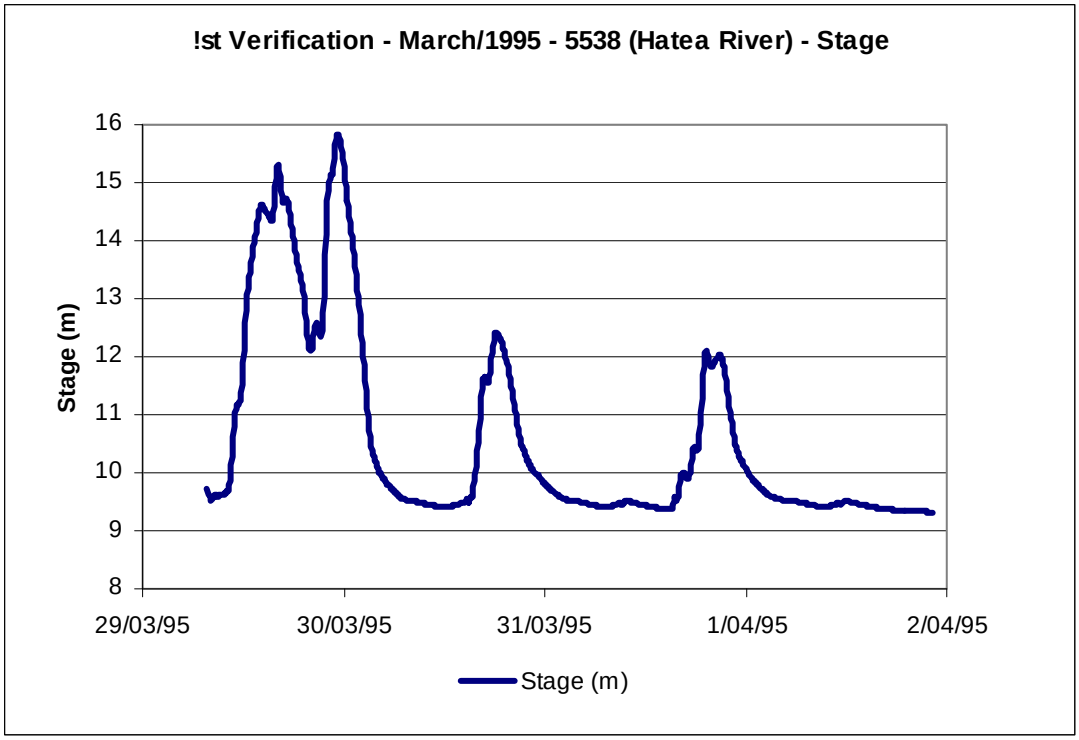
Max Flood Level at Whareora Rd (5538)		
Gauge data	15.851	m
Model result	15.826	m
Difference	-0.025	m

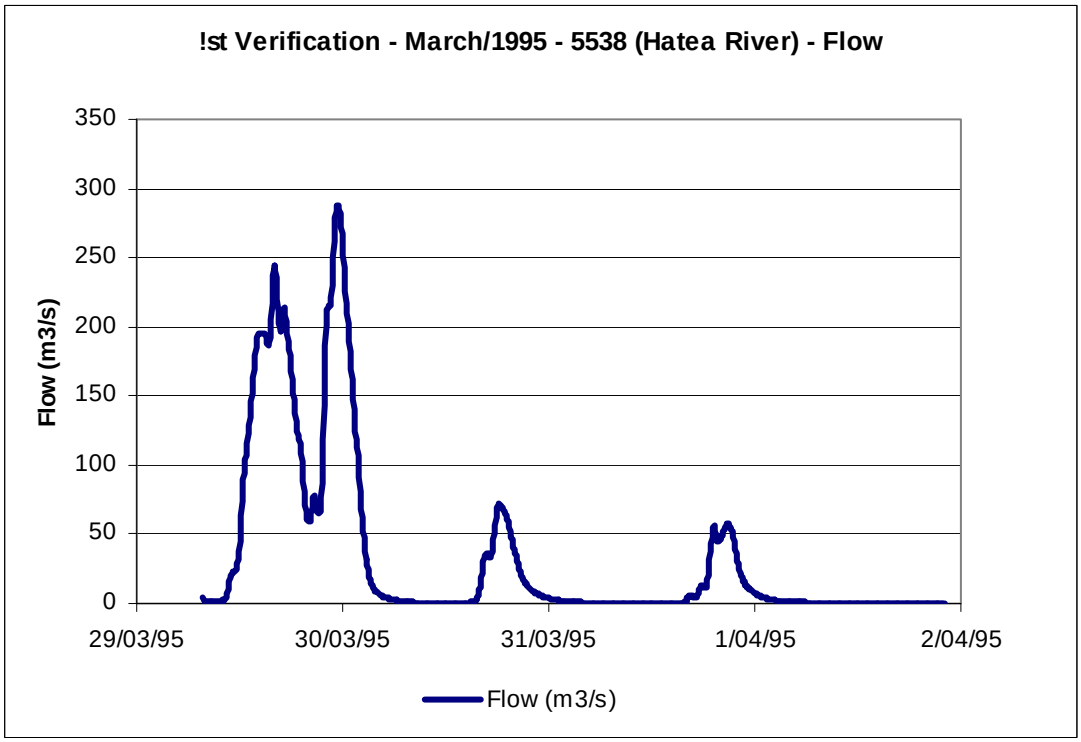
Figure 4-13 Tide Levels



4 Results Summary

Figure 4-14 Modelled Stage and flow



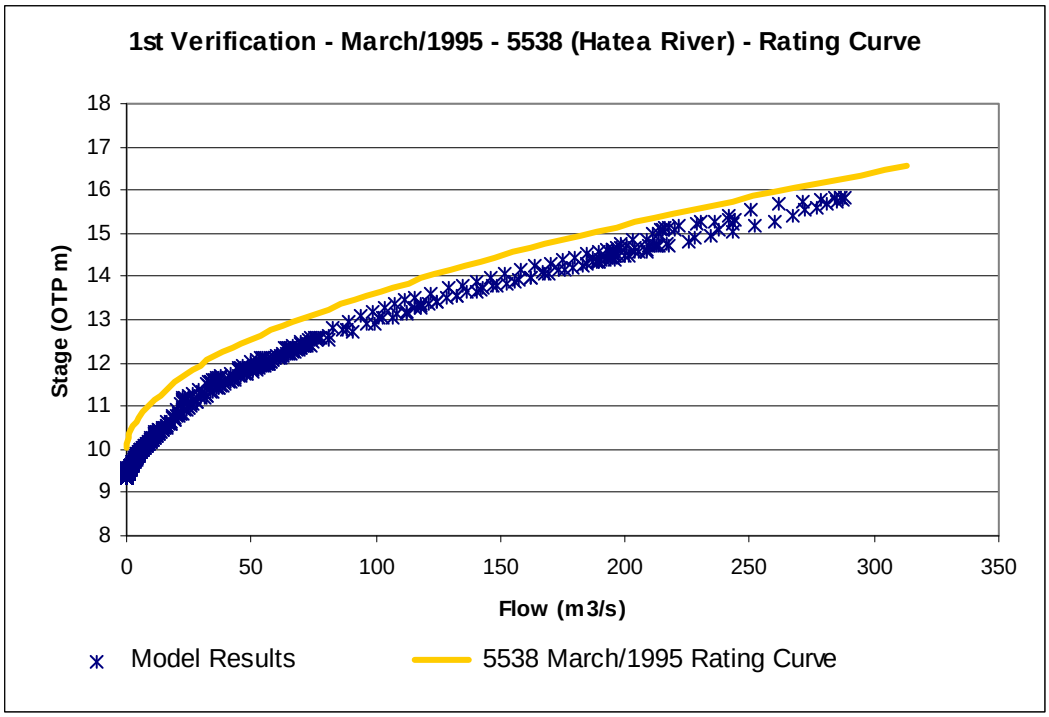


4 Results Summary

Level Survey Points

No level survey available in Hatea River catchment for this event. Refer to section 4.2.1.

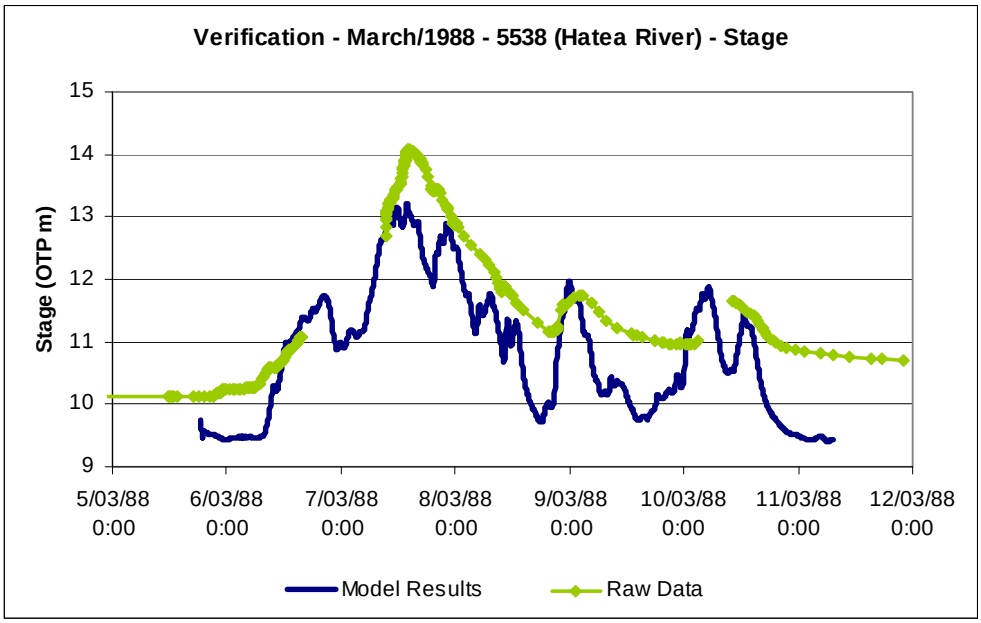
Table 4-9 Rating Curves

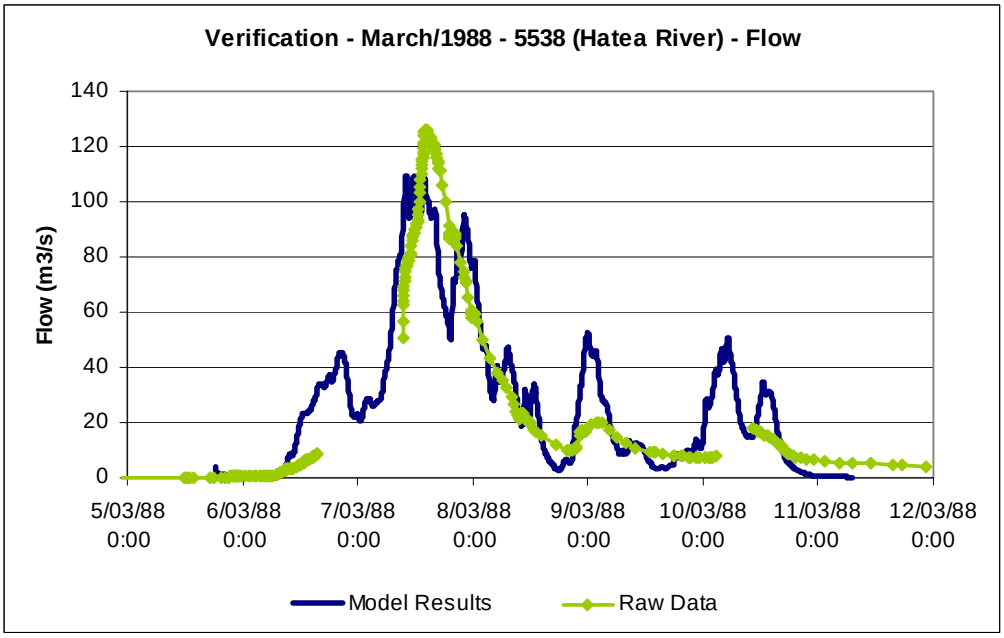


4 Results Summary

4.2.3 2nd Verification: March 1988

Figure 4-15 Flow/Stage Stations



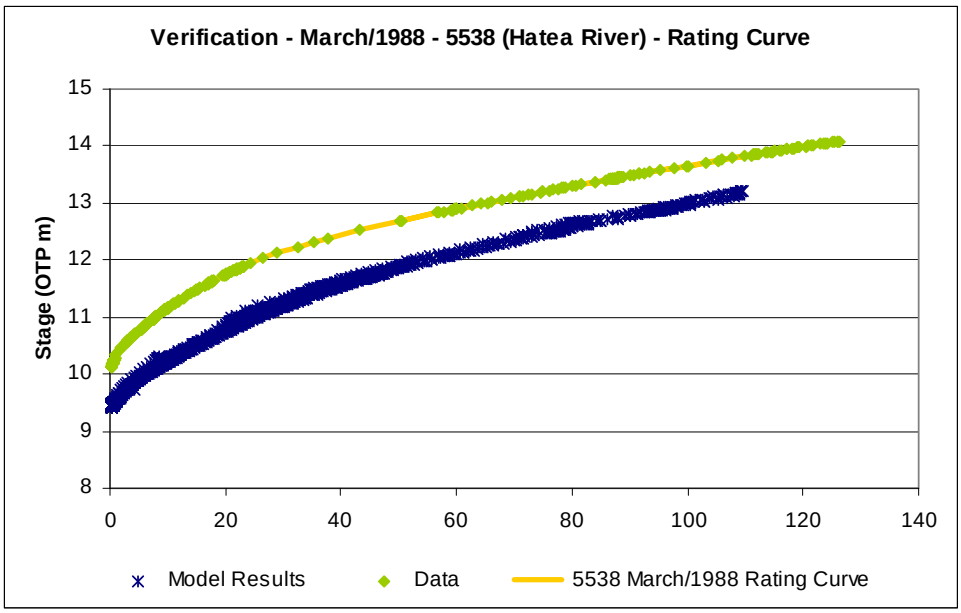


Level Survey Points

No level survey was available in Hatea River catchment for this event during the project time. Refer to section 4.2.1.

4 Results Summary

Table 4-10 Rating Curves

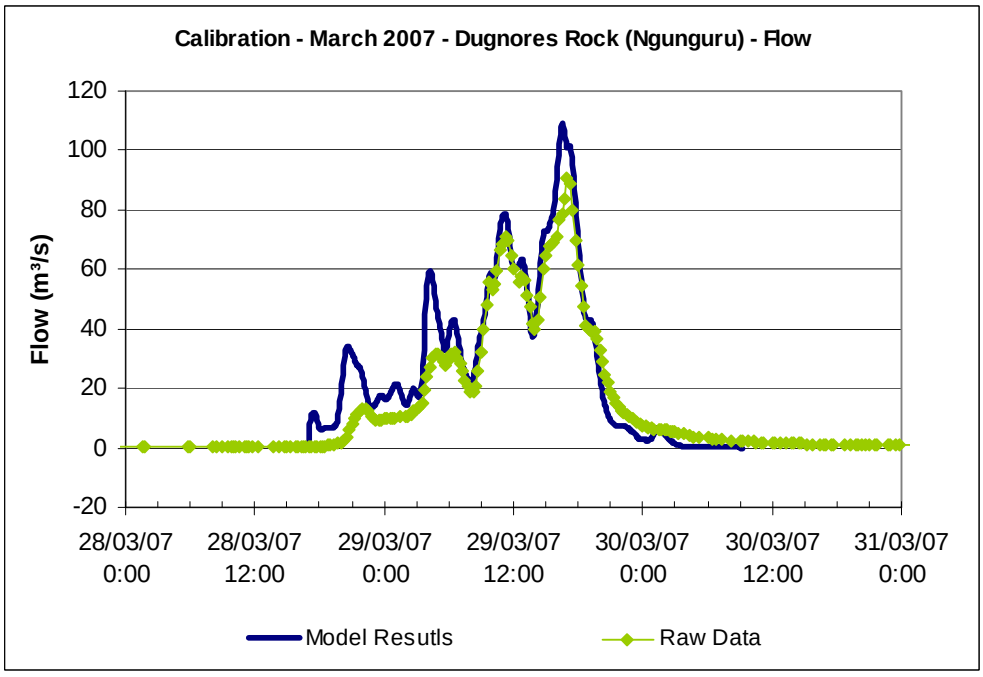


4.3 Ngunguru River (Catchment 17)

4.3.1 Calibration Event: March 2007

The following graphs demonstrate the modelled results against the observed data ("Raw Data").

Figure 4-16 Flow/Stage Stations



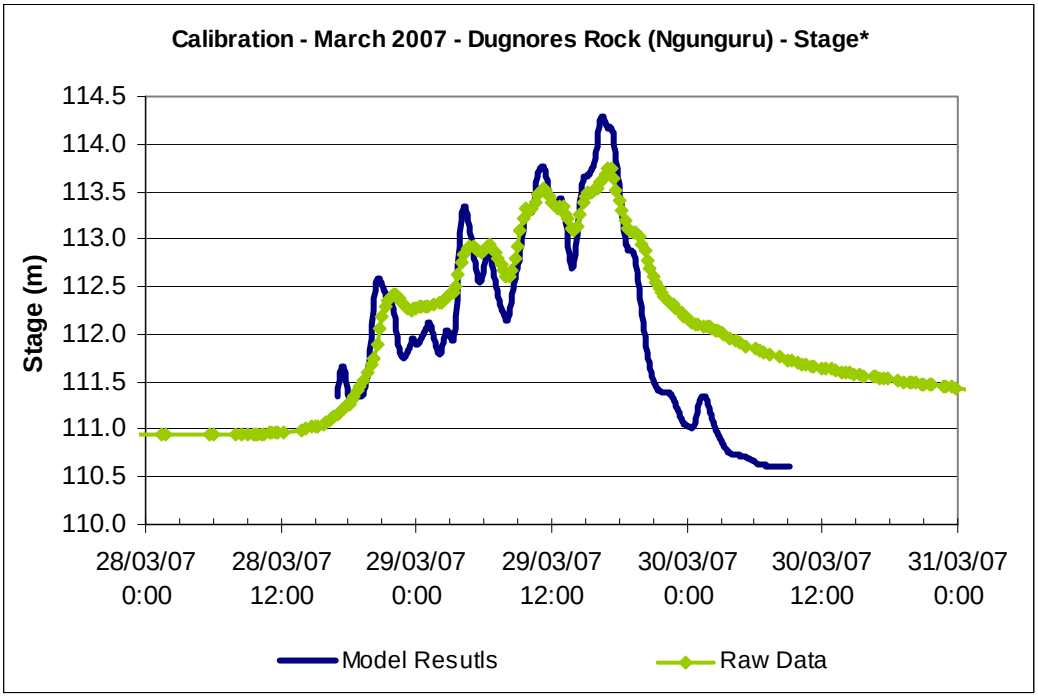
4 Results Summary

Table 4-11 Calibration Summary Results

Volume (m3)	Ngunguru at Dugmores Rock	
	Model	Survey
29/03/2007 00:00	419245	156111
30/03/2007 00:00	4073066	3352062
Volume (m3)	**3653821**	**3195950**
Difference (m3)	457871	
Difference (%)	**14%**	
Peak Flow (m3/s)	108.9	90.7
Difference (m3/s)	18.2	
Difference (%)	**20.1%**	
Peak Time	29/03/2007 16:30	29/03/2007 17:00
Difference (hh:mm:ss)	**- 00:30:00**	

This Stage/Flow station is located outside of the available LiDAR area. Due to this, all cross sections outside of LiDAR were assumed with a trapezoidal shape based on the 20m contours and aerial photo. Levels and slope are derived from the 20 m contours for upper catchment routing purposes. For this reason, modelled water levels outside of LiDAR were not accurate and not considered for calibration. However, since information is available, they are shown in the following graph to compare the shape and characteristics of the time series. The comparison does show similarities fairly well.

Figure 4-17 Stage Station



4 Results Summary

Table 4-12 Flood Level Survey Points

Flood Survey	Model		Survey	NGUNGURU - CALIBRATION EVENT - March/2007		
Surveyed Point (ID_Name_Level)	**Ground Level (m OTP)**	**Stage (m OTP)**	**Stage (m OTP)**	**Diff. (m)**	Memo:	*In general it's a good match between model and survey.*
ID=1000_FLD=5.912	6.175	6.172	5.912	0.260		
ID=1048_FLD=3.821	3.789	3.949	3.821	0.128		
ID=1049_FLD=3.597	3.701	3.968	3.597	0.371	*Border of flood (it might have 2D features, ID=1048 is quite close and it's a better match)*	
ID=1066_FLD=4.86	4.943	4.936	4.86	0.076		
ID=1067_FLD=5.146	5.35	5.165	5.146	0.019		
ID=1076_FLD=5.437	5.88	5.299	5.437	-0.138		
ID=1090_FLD=6.249	6.182	6.171	6.249	-0.078		
ID=1119_FLD=4.972	4.928	6.172	4.972	1.200	*Same chainage ID=1000, but different surveyed levels. Level of ID=1000 makes more sense.*	
ID=1133_FLD=3.698	2.482	3.744	3.698	0.046		
ID=1135_FLD=3.57	1.853	3.474	3.57	-0.096		
ID=1185_FLD=4.935	4.727	4.926	4.935	-0.009		
ID=1186_FLD=4.79	4.628	4.944	4.79	0.154	*Just upstream of a spill (road), added a low point in spill for earlier flows (as a culvert under the road)*	
ID=1197_FLD=3.146	2.495	3.456	3.146	0.310	*Over a road (dry) border of flood extent. Check flood level next to it.*	

Surveyed points labelled as FLD (Flood Level Data) appeared to have a better match with the model than the STK# points (Flood Marker Stake with number). Point Survey data verification indicated that FLD points were probably more reliable than STK# points.

The verification event also has been refined with 2D modelling for critical areas. Results with 2D indicate that, in general, surveyed points have a better match with the 2D refined areas. The table below shows STK# for verification in the Ngunguru River catchment.

4 Results Summary

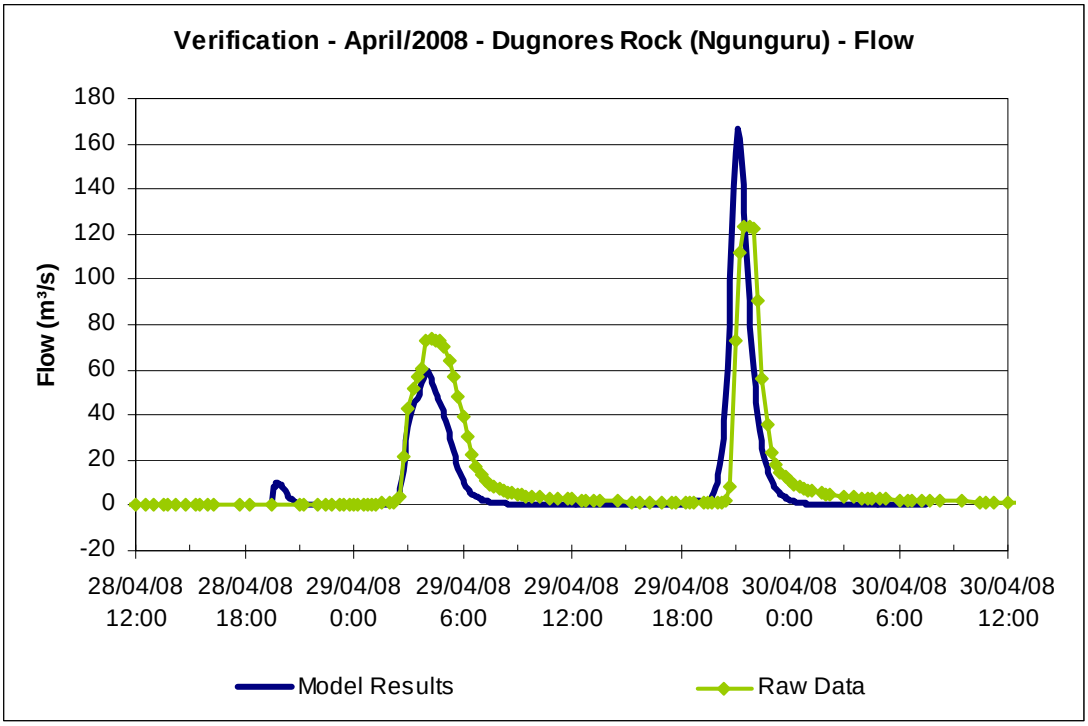
Table 4-13 Flood Marker Stake Level Survey Points

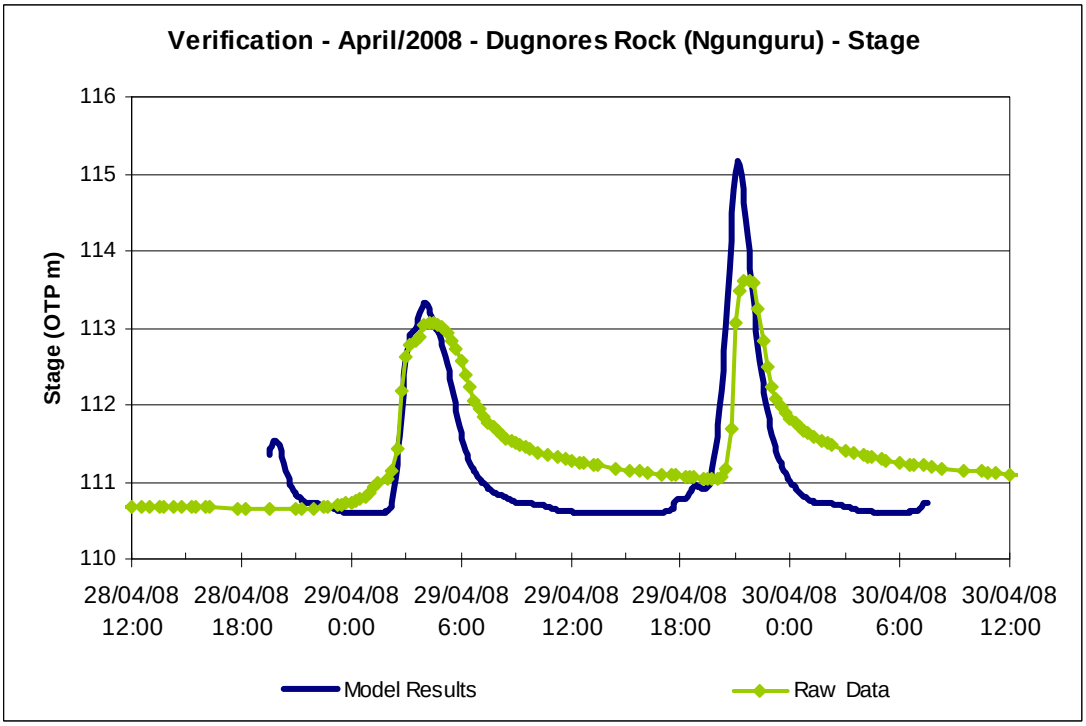
Flood Survey		Model	Survey		NGUNGURU - CALIBRATION EVENT - March/2007	
Surveyed Point (ID_Name_Level)	Ground Level (m OTP)	Stage (m OTP)	Stage (m OTP)	Diff. (m)	**Memo:**	*Analysis indicated that, in general, STK points are less reliable than FLD points.*
ID=1001_STK1=5.827	6.133	5.700	5.827	-0.127	*Controlled by the Bridge DS. Compare with ID=1000*	
ID=1006_STK2=6.031	6.032	5.693	6.031	-0.338	*Controlled by the Bridge DS. Compare with ID=1000*	
ID=1020_STK9=4.557	3.722	3.904	4.557	-0.653	*Outside of bend in river. 2D features.*	
ID=1052_STK10=4.241	3.872	3.383	4.241	-0.858	*Compare with ID=1048 and 1049*	
ID=1112_STK9=4.53	3.722	3.904	4.530	-0.626	*Outside of bend in river. 2D features.*	
ID=1113_STK10=4.231	3.872	3.383	4.231	-0.848	*Compare with ID=1048 and 1049*	
ID=1116_STK1=5.831	6.133	5.700	5.831	-0.131	*Controlled by the Bridge DS. Compare with ID=1000*	
ID=1120_STK2=6.024	6.032	5.693	6.024	-0.331	*Controlled by the Bridge DS. Compare with ID=1000*	
ID=1132_STK12=2.828	1.874	2.899	2.828	0.071	*Compare with ID=1133*	
ID=1135b_STK13=1.93	1.485	2.782	1.925	0.857	*Against level in ID=1135*	
ID=1137_STK11=4.72	4.745	4.431	4.720	-0.289	*Compare with ID=1066*	
ID=1143_STK8=7.993	6.995	7.313	7.993	-0.680		
ID=1147_STK6=6.8785	6.691	6.127	6.885	-0.758	*2D features.*	
ID=1152_STK5=6.6455	6.587	6.303	6.644	-0.341	*2D features.*	
ID=1159_STK4=7.7675	7.563	6.630	7.765	-1.135	*2D features of storgae area*	
ID=1160_STK3=6.083	5.811	6.346	6.089	0.257	*2D features of storgae area*	
ID=1165_STK14=6.205	6.32	5.698	6.205	-0.507	*Controlled by the Bridge DS. Compare with ID=1000*	
ID=1166_STK15=6.145	6.573	5.700	6.154	-0.454	*Controlled by the Bridge DS. Compare with ID=1001*	
ID=1208_STK12=2.836	1.874	2.899	2.836	0.063	*Compare with ID=1133*	
ID=1213_STK13=1.935	1.62	2.782	1.935	0.847	*Against level in ID=1135*	
ID=1216_STK8=8.006	6.995	7.313	8.006	-0.693		
ID=1217_STK14=6.213	6.32	5.698	6.213	-0.515	*Controlled by the Bridge DS. Compare with ID=1000*	

4 Results Summary

4.3.2 Verification Event: April 2008

Figure 4-18 Flow/Stage Stations





This Stage/Flow station is located outside of the available LiDAR area. Due to this, all cross sections outside of LiDAR were assumed with a trapezoidal shape based on the 20m contours and aerial

photo. Levels and slope are derived from the 20 m contours for upper catchment routing purposes. For this reason, modelled water levels outside of LiDAR were not accurate and not considered for calibration. However, since information is available, they are shown in the following graph to compare the shape and characteristics of the time series. The comparison does show similarities fairly well

Level Survey Points

No level survey is available for Ngunguru River catchment for this event.

4.4 Otaika River (Catchment 03)

4.4.1 Verification Event: March/2007

Flow/Stage Stations

No flow/stage times series was available for Otaika River catchment for this event.

Table 4-14 Flood Level Survey Points

Surveyed Point (ID_Name_Level)	Ground Level (m OTP)	Model Level (m OTP)	Surveyed Level (m OTP)	Diff. (m)	2D Model Levels (m OTP)	Diff. 2D (m)
ID=1012_FLD=8.096	7.36	7.974	8.096	-0.12	7.97	-0.13
ID=1013_FLD=4.644	4.707	3.759	4.644	-0.89	3.83	-0.82
ID=1042_FLD=2.834	2.125	3.75	2.834	0.92	3.82	0.98
ID=1044_FLD=2.771	1.857	3.735	2.771	0.96	3.80	1.03
ID=1055_FLD=4.426	3.978	4.318	4.426	-0.11	4.34	-0.08
ID=1061_FLD=3.921	3.742	3.604	3.921	-0.32	3.78	-0.14
ID=1063_FLD=4.039	4.203	3.774	4.039	-0.27	3.92	-0.12
ID=1071_FLD=13.098	12.957	13.447	13.098	0.35	13.45	0.35
ID=1076_FLD=13.285	12.919	13.446	13.285	0.16	13.45	0.16
ID=1077_FLD=13.522	13.154	13.539	13.522	0.02	13.54	0.02
ID=1082_FLD=10.091	9.294	9.659	10.091	-0.43	9.67	-0.43
ID=1084_FLD=2.759	2.228	2.659	2.759	-0.10	2.66	-0.09
ID=1089_FLD=2.724	2.17	2.659	2.724	-0.07	2.66	-0.06
ID=1098_FLD=2.768	2.223	2.796	2.768	0.03	2.80	0.03
ID=1101_FLD=2.672	3.21	3.376	2.672	0.70	3.30	0.63
ID=1105_FLD=2.554	2.84	3.612	2.554	1.06	3.61	1.05
ID=1109_FLD=2.159	1.425	2.46	2.159	0.30	2.47	0.31
ID=1115_FLD=2.218	1.181	2.46	2.218	0.24	2.47	0.25
ID=1127_FLD=13.321	12.625	13.625	13.321	0.30	13.63	0.31

4 Results Summary

Surveyed points labelled as FLD (Flood Level Data) appeared to have better match with the model than the STK# points (Flood Marker Stake with number) do. Point Survey data verification indicated that FLD points were probably more reliable than STK# points.

The verification event also has been refined with 2D model for critical areas. Results with 2D indicate that, in general, surveyed points have a better match with the 2D refined areas. The table below shows STK# for verification in Ngunguru River catchment.

The table below shows STK# for verification in Otaika River catchment.

Table 4-15 Flood Marker Stake Level Survey Points

Surveyed Point (ID_Name_Level)	Ground Level (m OTP)	Model Level (m OTP)	Surveyed Level (m OTP)	Diff. (m)	2D Model Levels (m OTP)	Diff. 2D (m)
ID=1006_STK1=3.967	4.118	3.76	3.967	-0.21	3.91	-0.06
ID=1007_STK2=3.365	3.227	3.75	3.365	0.39	3.82	0.45
ID=1008_STK2=3.348	3.227	3.75	3.348	0.40	3.82	0.47
ID=1011_STK3=8.3135	7.54	8.074	8.314	-0.24	8.08	-0.24
ID=1016_STK4=4.605	4.505	3.604	4.605	-1.00	4.51	-0.10
ID=1022_STK6=17.411	16.996	17.534	17.411	0.12	17.54	0.13
ID=1024_STK5=13.53	12.625	13.625	13.53	0.10	13.63	0.10
ID=1026_STK7=2.955	2.725	2.806	2.955	-0.15	2.81	-0.15
ID=1058_STK4=4.586	4.505	3.604	4.586	-0.98	4.51	-0.08
ID=1066_STK1=3.953	4.118	3.76	3.953	-0.19	3.91	-0.04
ID=1111_STK8=2.1075	1.436	2.46	2.108	0.35	2.47	0.36

Rating Curves

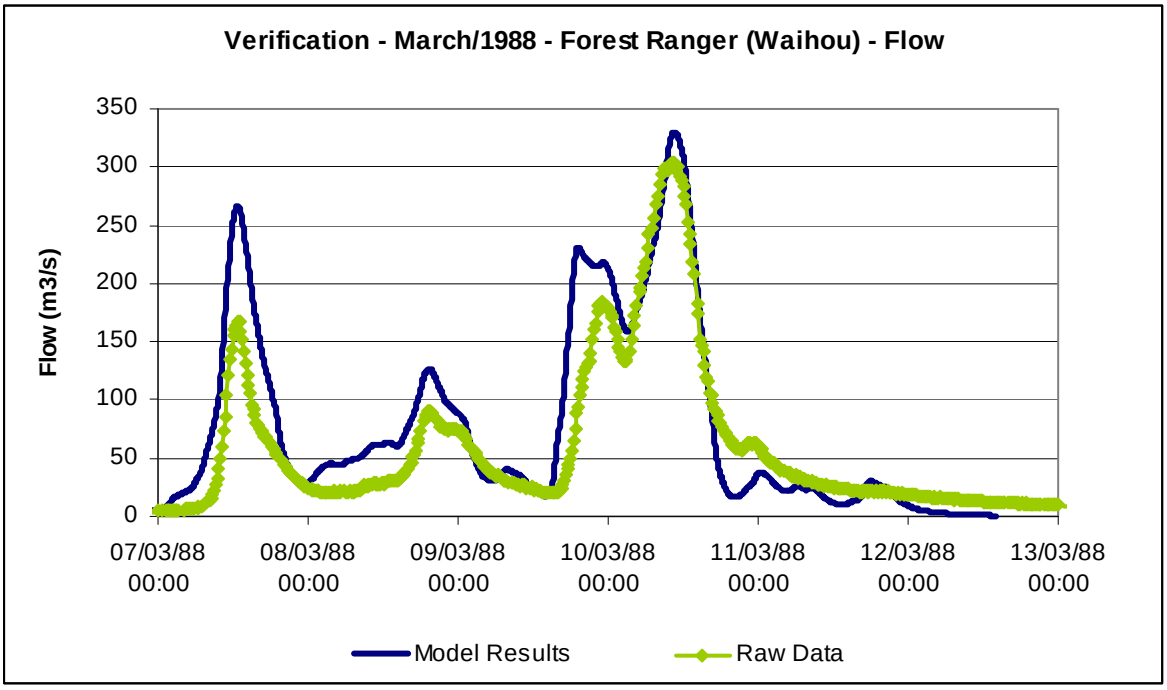
No Rating curve is available for Otaika River catchment for this event.

4 Results Summary

4.5 Waihou River (Catchment 07)

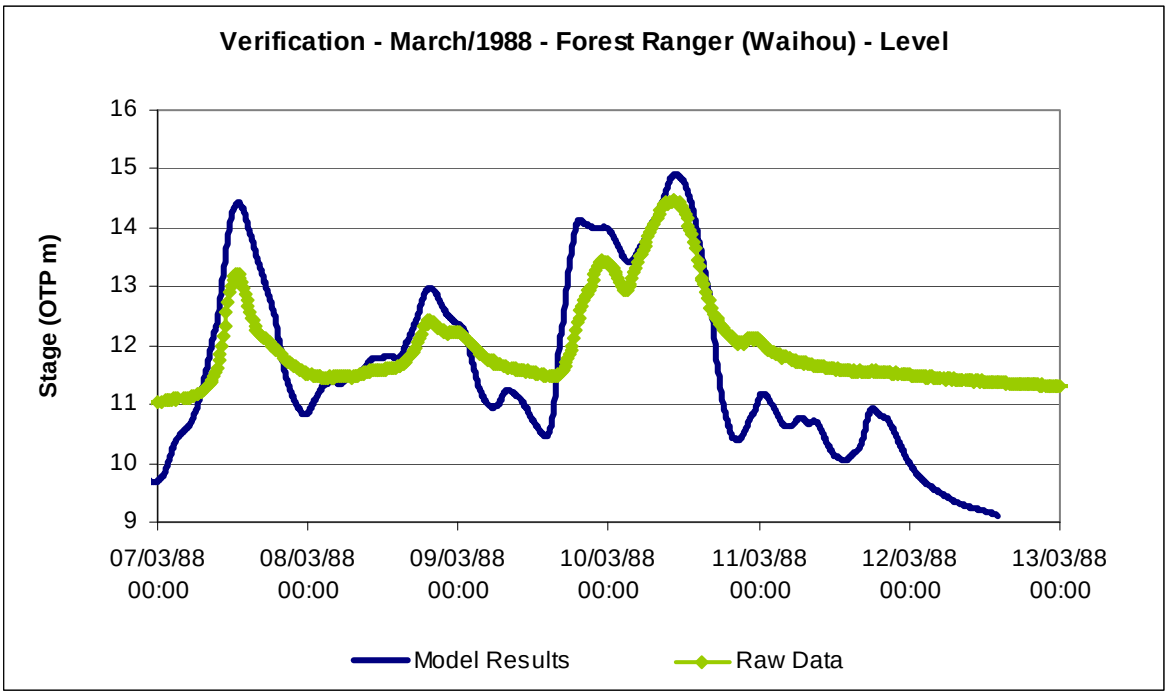
4.5.1 Verification Event: March/1988

Figure 4-19 Flow/Stage Stations



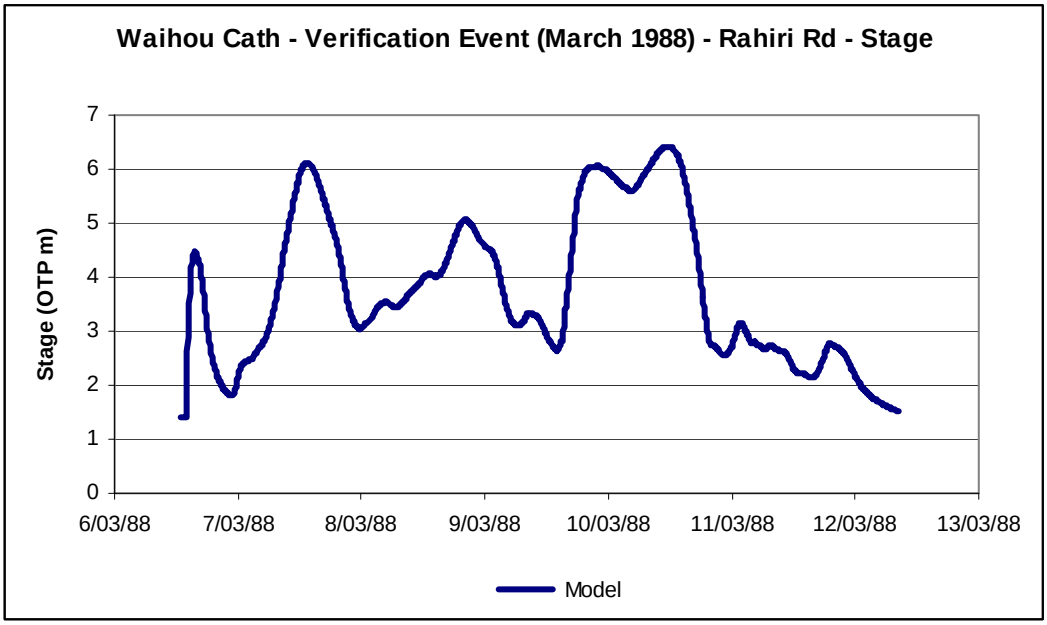
This Stage/Flow station is located outside of the available LiDAR area. Due to this, all cross sections outside of LiDAR were assumed with a trapezoidal shape based on the 20m contours and aerial photo. Levels and slope are derived from the 20 m contours for upper catchment routing purposes. For this reason, modelled water levels outside of LiDAR were not accurate and not considered for calibration. However, since information is available, they are shown in the following graph to compare the shape and characteristics of the time series. The comparison does show similarities fairly well

4 Results Summary



As requested, levels, flows and rating curves for Waihou River at Rahiri Rd and SH1 are included below.

Figure 4-20 Modelled Level, Flow and Stage at Rahirir Rd



4 Results Summary

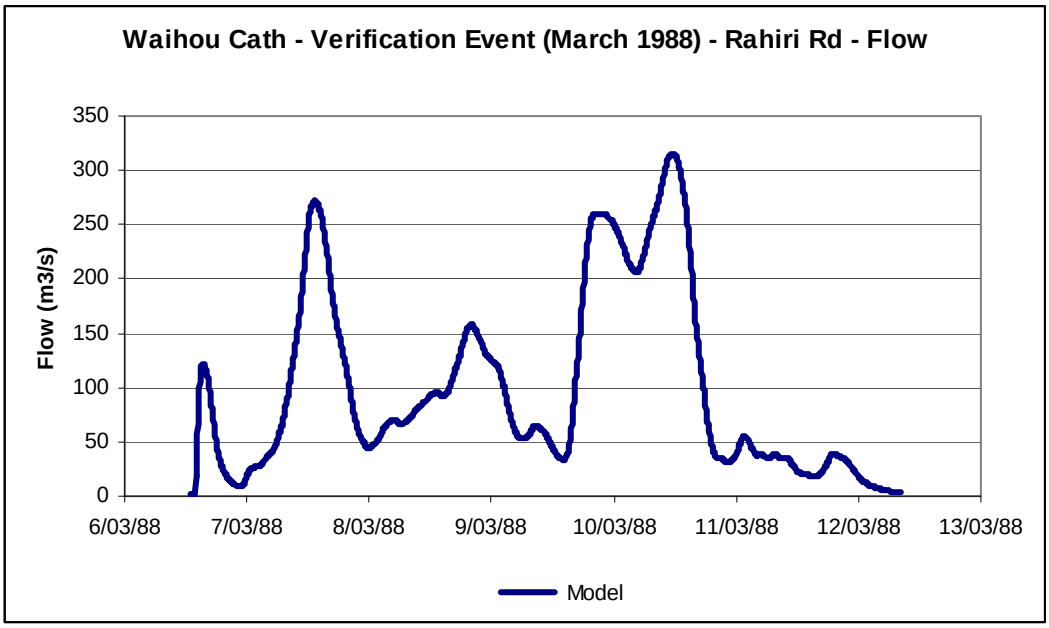
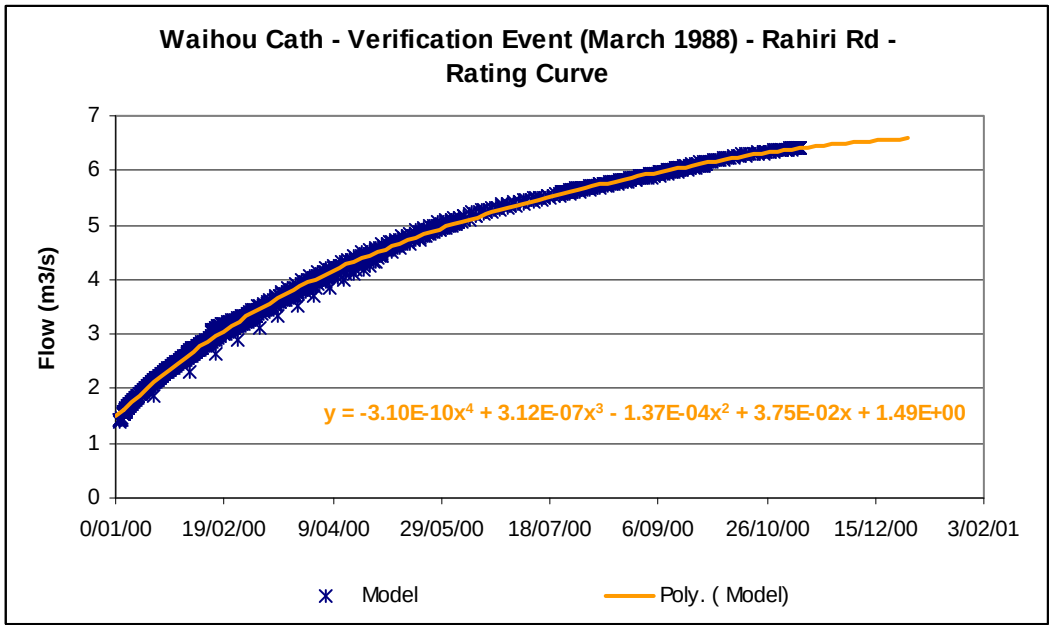


Figure 4-21 Rating Curves



Level Survey Points

No level survey available for Waihou River catchment for this event.

4 Results Summary

Rating Curves

Since levels and cross section shapes near gauge site were derived from 20m contour and not actually representative of the gauge site, it is not appropriate to produce stage/flow rating curve at the gauge site.

4.6 Wairau River (Catchment 08)

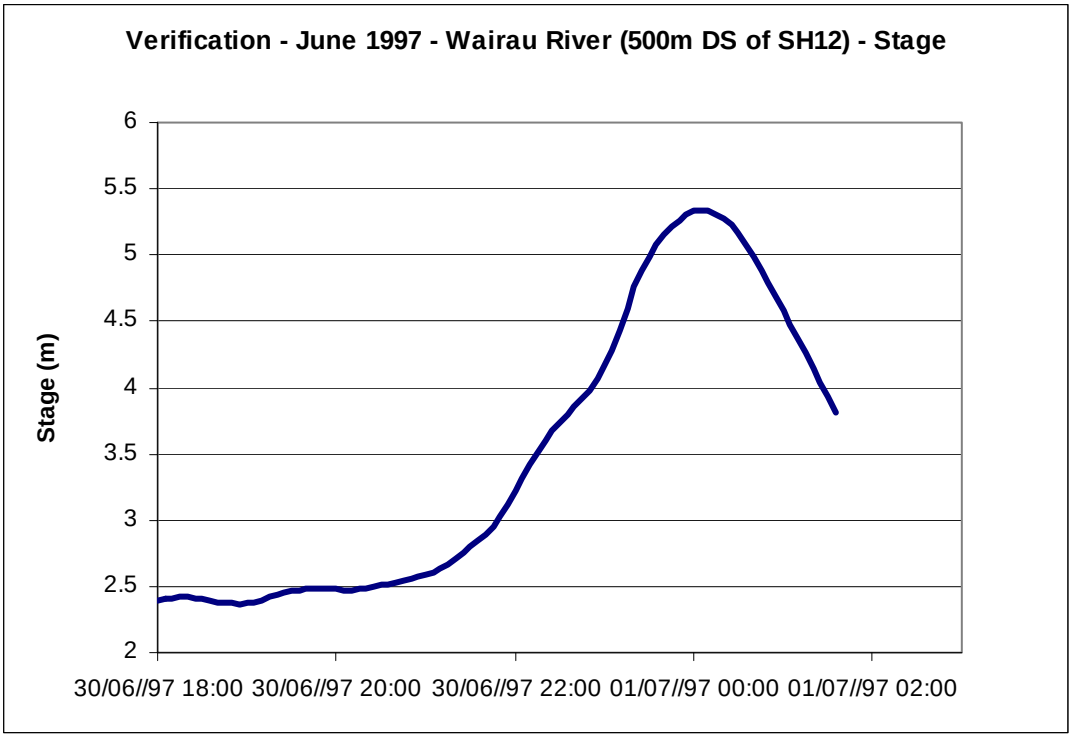
4.6.1 Verification Event: June/1997

Flood levels were not available. Model verification was intended to analyse flood extents against local knowledge on this event.

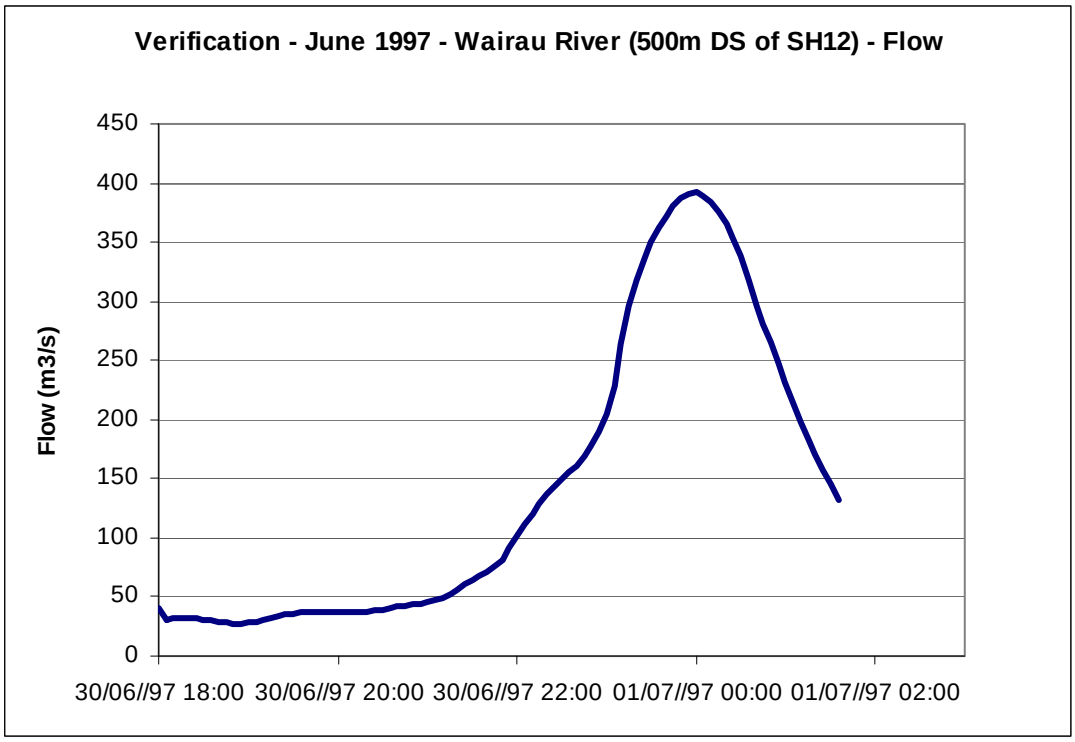
No tide levels were available. Therefore a 2 year design tide levels were used with catchment peak flow to meet maximum tidal level at the river mouth.

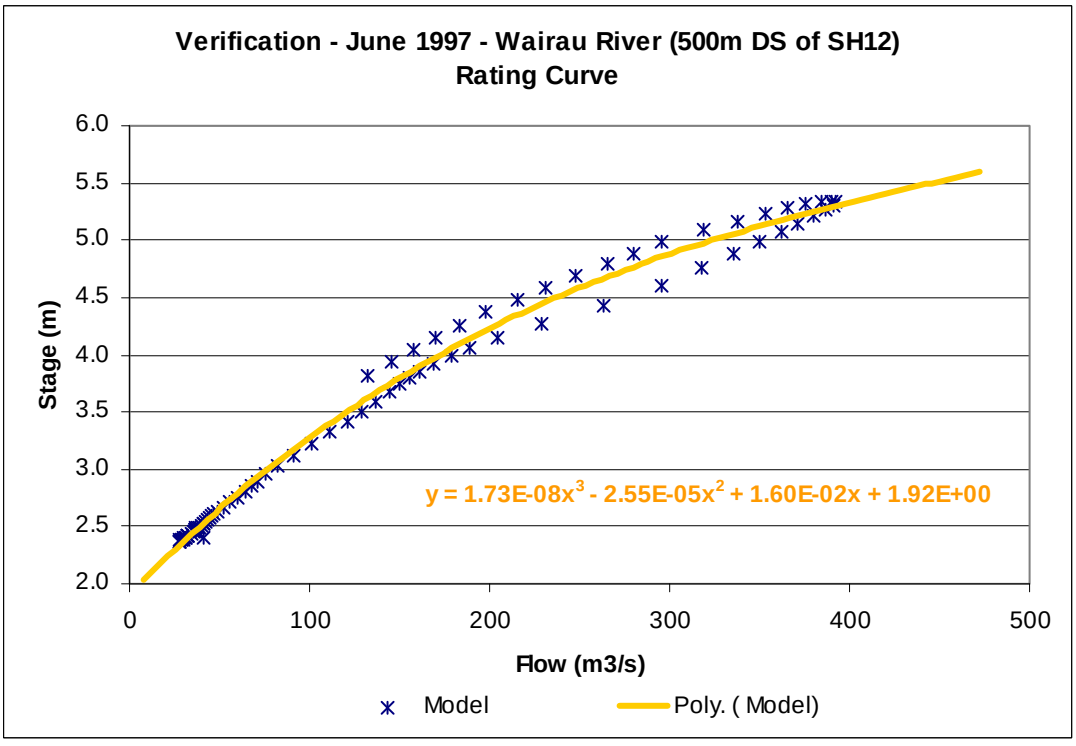
The following graphs shows a stage, flow and rating curve in an arbitrary location 500m downstream of SH12, in the lower part of the catchment.

Figure 4-22 Stage, Flow and Rating Curve



4 Results Summary





. The following figure shows the location and cross section shape.

4 Results Summary

Figure 4-23 Location of the Stage, Flow and Rating curve

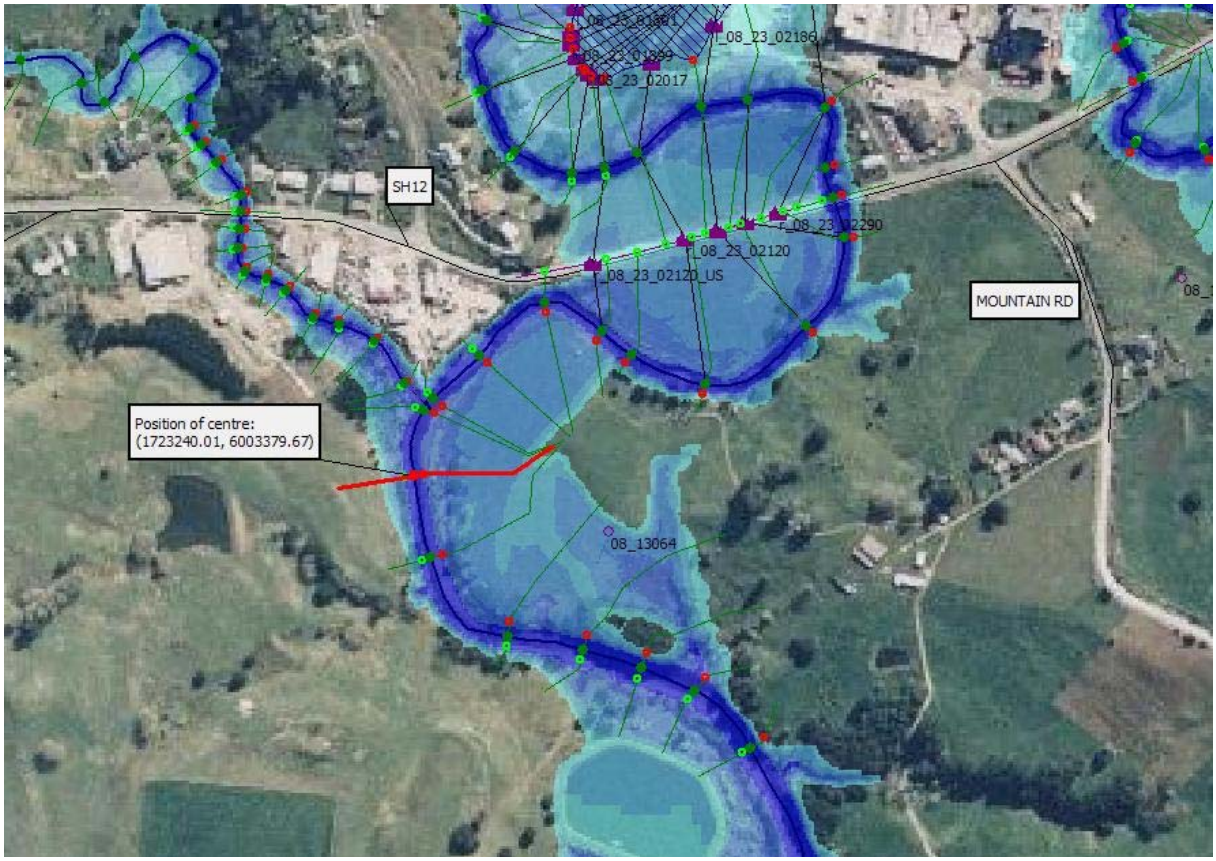
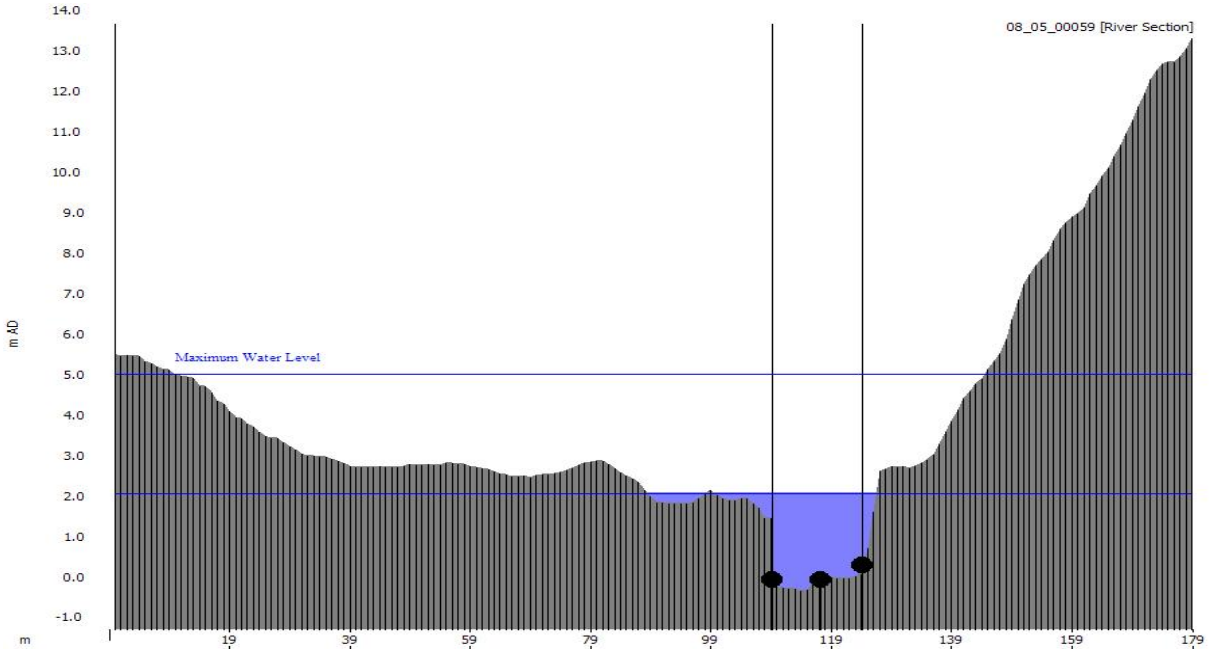


Figure 4-24 Cross Section



4 Results Summary

Flow/Stage Stations

No flow/stage records were available for Wairau River catchment for this event.

Level Survey Points

No level survey available for Wairau River catchment for this event.

Rating Curves

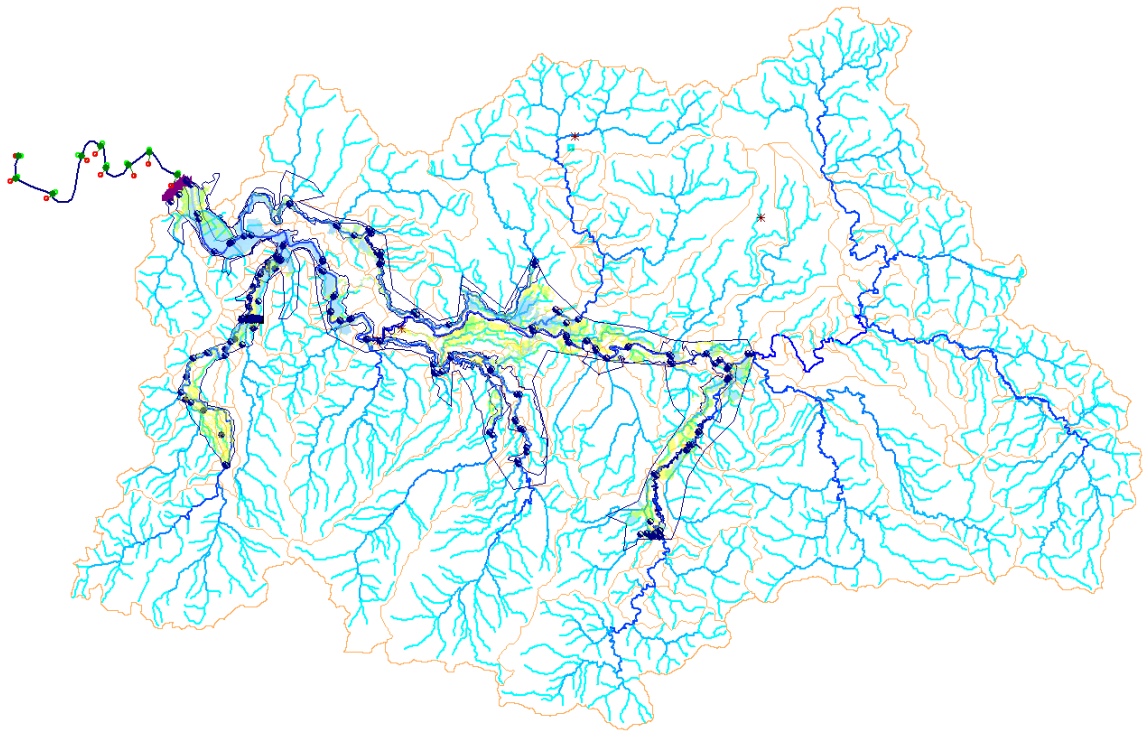
No Rating curve is available for Wairau River catchment for this event.

4.7 Waima and Punakitere Rivers (Catchment 21)

Waiama and Punakitere Rivers Catchment (priority 4) is the biggest catchment in the Priority Rivers project (517 km²) and it contains many rivers and tributaries.

The 2009 LiDAR covers about 62 km^2 of the most important areas within this catchment. In order to best utilise the available LiDAR and other information to identify key flood risk areas, a full 2D model was developed.

Figure 4-25 Waima Punakitere Stream Network



4 Results Summary

4.7.1 Verification Event: July 1989

Flow/Stage Stations

There were three Stage stations; two of which are also flow stations:

Table 4-16 Gauge Sites

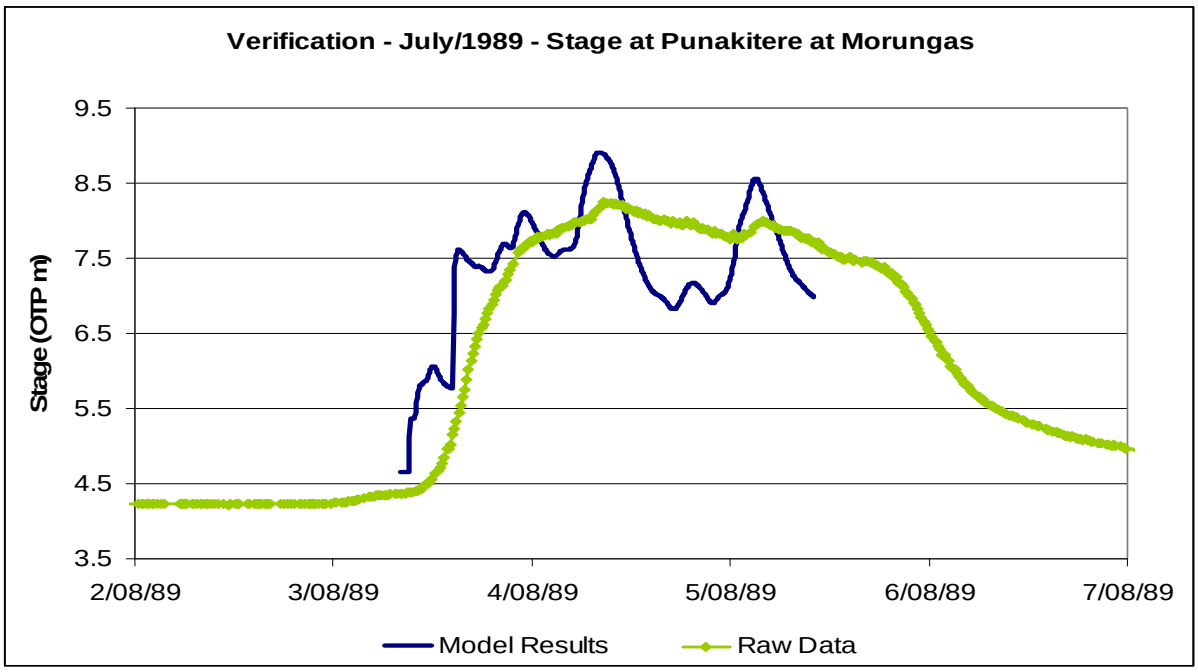
Gauge Number	Site Name	Catchment	Type	Site Datum	Unit	Remarks
47538	Morungas Reach	Punakitere	Stage	2.999	mm	Short term site re-located upstream due to (minimal) tidal effect. No gauging done, and no rating curve derived. Site d/s confluence with Otaua River
47527	Opahi Pond	Punakitere	Stage	Requested from NIWA	mm	Flows expressed in L/s
			Flow		lt/s	
47540	Waikaka at Totara Trees	Punakitere	Stage	Not surveyed (stage bottom of V)	mm	V-notch weir for low flows. Stage higher than 300mm would overtop weir. Record useful to establish response time in upper catchment. Flows in L/s
			Flow		lt/s	
5801	Marsden Point	Waiarohia - Hatea	Tide	-1.68mOTP	mm	

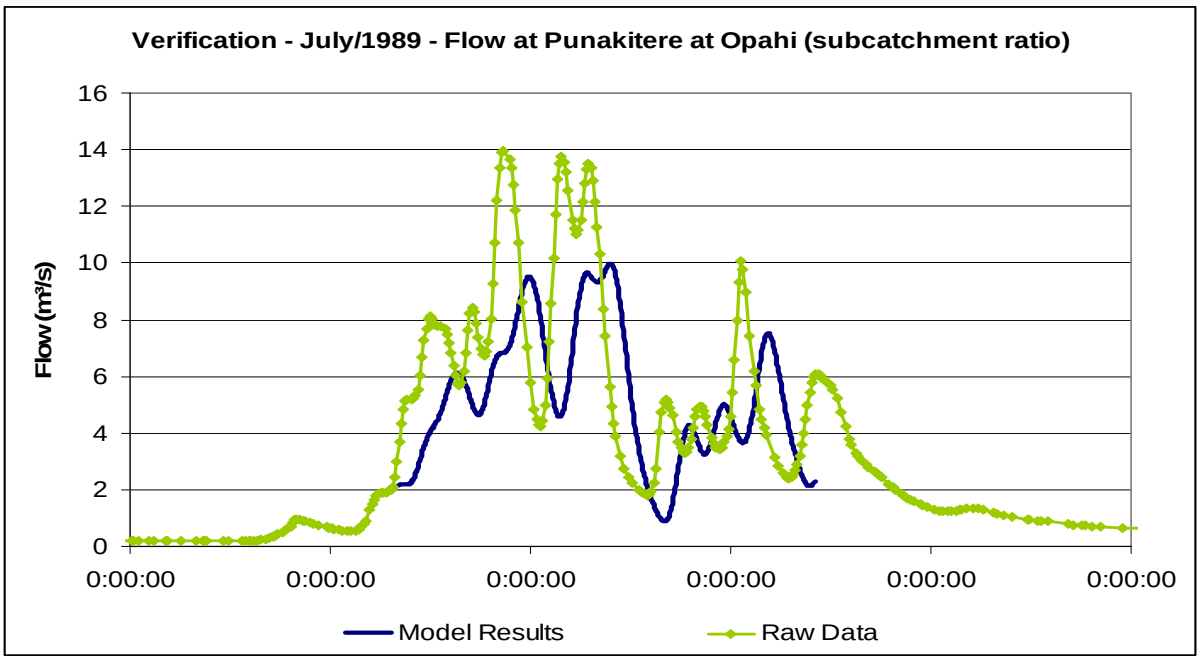
Within the above observed flow/level gauges, only gauge 47538 could be used for level comparison. This was due to:

- Station 47527 and 47540 having no datum available.
- Station 47538 is a well located and valuable station, but it only has stage records. Results and records are shown in the graphs below.
- Flow gauge 47527 is located far in the upper catchment with a catchment area of about 10.4km². This catchment is part of a model subcatchment of about 18.4km² where a hydrological model applied as an input for the hydraulic model. No direct flow can be compared. However, flow hydrograph scaled with a ratio of catchment sizes may be used for comparison to reflect hydrological model confidence. Graphs are shown below.
- Station 47540 is also part of an upper subcatchment with a catchment size of 1.7km² approximately. No direct flow comparison can be obtained for calibration.
- Marsden Point tidal level was used as a downstream boundary condition. Verification for this location was not necessary.

4 Results Summary

Figure 4-26 Stage and Flow





Level Survey Points

No level survey available for this event.

4 Results Summary

Rating Curves

There are three rating curves available:

Table 4-17 Rating Curves

Rating curve location	ID	DATUM	Remarks
Punakitere at Opahi	47527	Requested from NIWA	
Punakitere at Taheke	47595	26.015m OTP	
Waikaka at Totara Trees	47540	Not surveyed (stage bottom of V)	Problem with site is diversion of flows along flood plain at high stage >3m. Therefore confidence in flow conversion at high stage is low.

Station 47595 has no observed level or flow data, however, a rating curved was obtained by the client. The site is located on a tributary.

This catchment was modelled with a full 2D for the verification event. Due of the grid size used, 2D grid happened missed to captured tributary bed level and a local grid fault was for of the catchment, the model does not offer a good resolution for small channels like the one that holds this flow station.

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Limitations

URS New Zealand Limited (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Northland Regional Council and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 23rd January 2009.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between January 2009 and February 2011 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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