TECHNICAL REPORT

Oxford Flood Alleviation Scheme Model calibration report

Prepared for

Environment Agency

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Contents

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Figure(s)

Document History

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SECTION 1

Introduction

This technical note presents the calibration results for the model updated under the Oxford FAS study. For details of the model updates refer to technical report "Oxford FAS Model Update Report (CH2M, November 2015).

The following calibration and validation modelling has been undertaken to improve confidence in the model outputs:

1. Re-calibration of the July 2007 event, following the recommendations made by Black and Veatch Limited (B&V) when using the Mott MacDonald model for Initial assessment modelling in December 2014 (see extract below).

> In undertaking this work, some items were identified that warrant further attention in any future model recalibration:
>
> - Mott MacDonald's model calibration and verification used water level observations for ten locations on the Thames (upstream and downstream levels at five locks) and four other points (one each for the Seacourt Stream, Bulstake Stream, Hinksey Stream and Castle Mill Stream). No floodplain water level observations were used in the model calibration. Floodplain water levels in the July 2007 flood at 35 locations were used for the calibration of the ISIS-Tuflow model used in the Oxford FRMS[6]. It would be valuable to consider these floodplain water level observations in any future model recalibration work. This is particularly important when considering how accurately the model captures the distribution of flow across the floodplain and smaller channels.
> - For the July 2007 event, moving downstream along the Thames, there is an initial flood peak predicted by the model on the 22nd July that occurs progressively earlier and higher in comparison to the observed water levels. The difference is greatest at Iffley and Sandford Locks, where the modelled peak on the 22nd is noticeably higher than the second peak on the 25th July. In the observed data, the second peak is generally higher. The reasons for the large first peak in the model should be investigated, especially as it is not apparent in the calibration results for the Oxford FRMS model.
> - The observed water levels at Sandford Lock (upstream and downstream) presented by Mott MacDonald in Figure 6.3 and Figure 6.4 of their flood mapping report[7] do not match the observed levels we derived from tackle sheets as part of our 2008 work on the Oxford FRMS (and used in this report), nor the peak levels quoted in Table 6.5 of their report. The Sandford Lock water levels should be double-checked to ensure the correct observed levels are used for comparison.

2. Validation of the re-calibrated model to the winter 2013/14 flood event.
3. Additional validation using the 2003 flood event.

SECTION 2

Calibration model files

The same 1D model has been used for all calibration events, with inflows and gate operations controlled with IED files. The 2D model components are also the same for the 2003 and 2007 events, but the winter 2013/14 event includes additional files to represent the 3 culverts under Willow Walk (installed since 2007) and the temporary defences which were deployed at Osney Island and Hinksey Park (See Figure 1 for locations). Figure 2 details the model extent and key locations. Table 1 details the key model files for calibration.

Table 1: Model files

Event	1D Model	IED File	Additional 2D shapefiles	Comment
January 2003	Oxford_CH2M_R	2003_from_FF	n/a	Assumes Wolvercote Radial gates open
July 2007	Oxford_CH2M_R	2007_from_FF 2007_Gates_v1	n/a	Wolvercote Radial gates closed and Operation of Osney Bridge Bucks (timings taken from Osney Lock Tackle sheets
Winter 2013/14	Oxford_CH2M_R	13_14_v1	1d_nwk_estry_CH2M_willow 2d_bc_sx_estry_CH2M_willow 2d_zsh_2014_defences	Inclusion of Willow Walk culverts and temporary defences. Wolvercote Radial gates open

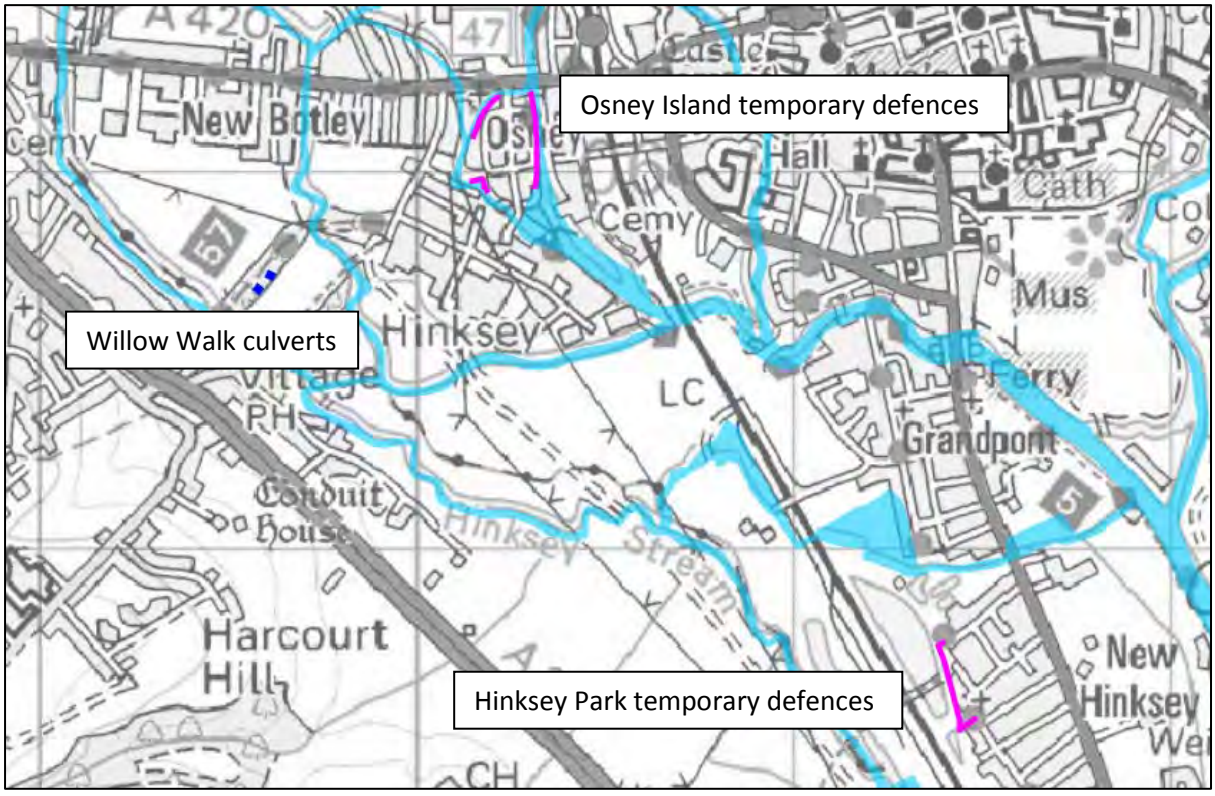


Figure 1: Location of Willow Walk culverts and 2013/14 temporary defences.

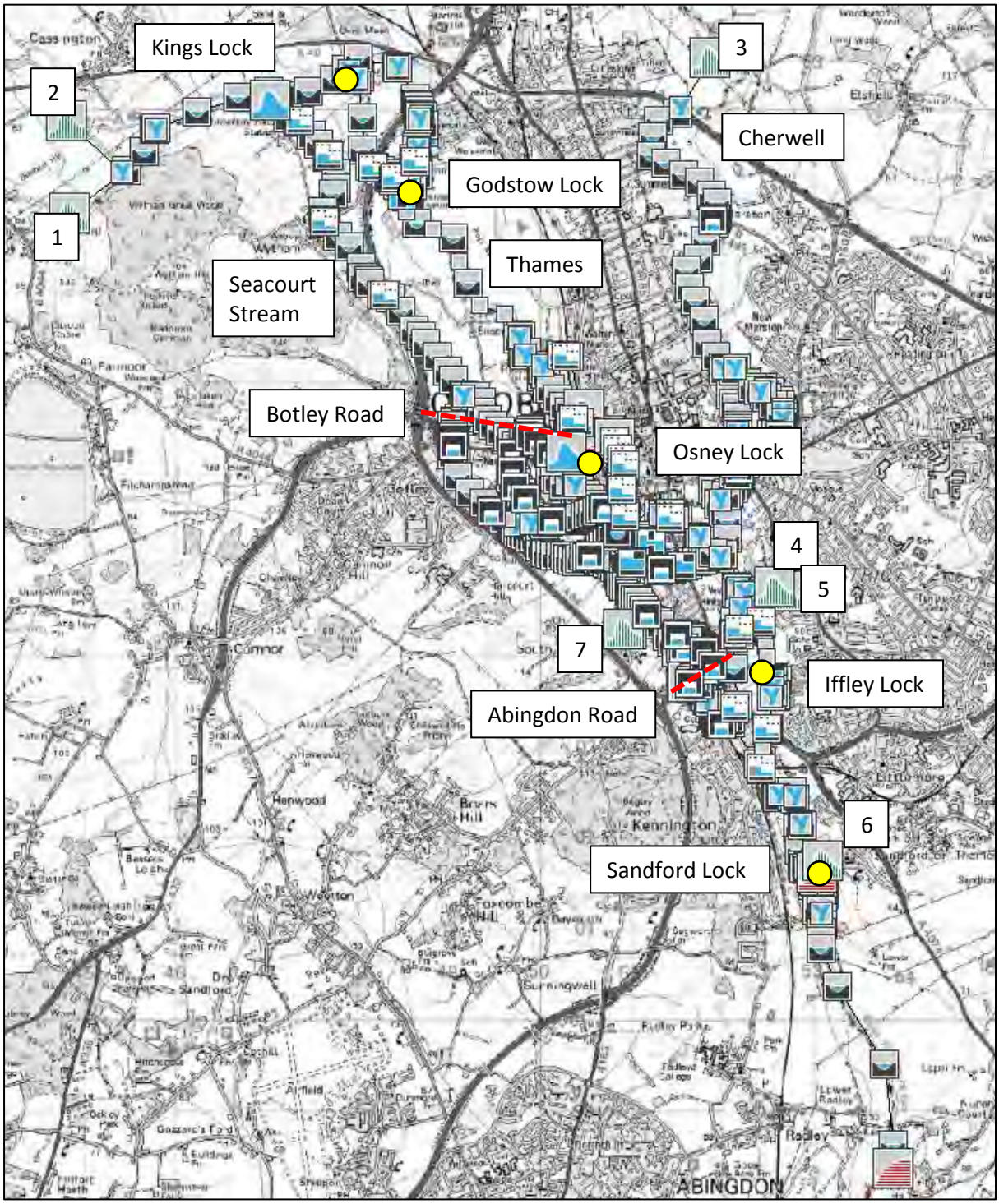


Figure 2: Model extent, key locations and inflow boundaries

SECTION 3

Calibration Data

3.1 Events Modelled

The calibration events modelled and 'model time zero' taken for the events are detailed in Table 2.

Table 2: Calibration Event start date

Calibration Event	Start Date
January 2003	26/12/2002 14:00:00
July 2007	17/07/2007 07:45:00
Winter 2013/14	24/12/2013 00:00:00

3.2 Inflow locations

The model contains 3 main inflow locations as detailed in Figure 2. Inflows were derived at these locations using outputs from the Oxford Flood Forecasting models, gauge records and the current high-flow ratings. The main inflow locations are as follows:

1. River Thames upstream of Evenlode confluence (upstream gauge 39008 Eynsham and Farmoor)
2. Evenlode at Thames confluence (gauge ref 39034 Cassington)
3. Cherwell at A40 (upstream gauges 39021 Cherwell @ Enslow and 39140 Ray @ Islip)

The model includes 4 additional minor inflow locations:

4. Upstream of Longbridge's Loop Reach (node 47.SL, no flow from flood forecasting model)
5. Upstream of Donnington Bridge (node Iffug, no flow from flood forecasting model)
6. Upstream of Sandford Lock (node Sanug, included in flood forecasting model)
7. Upstream limit of Hinksey Ditch (Hinug, no flow from flood forecasting model)

The peak flows for the calibration events are detailed in Table 3.

Table 3: Peak inflows for calibration events

Inflow	January 2003	July 2007	Winter 2013/14
Thames	110	133	116
Evenlode	23	75	27
Cherwell	54	68	57
47.SL	-	-	2 (constant)
Iffug	-	-	2 (constant)
Sanug	3.5	3.2	3 (constant)
Hinug	-	-	2 (constant)

3.3 Oxford Flood Forecasting Model

The calibration events for 2007 and 2003 events were simulated for the Oxford Flood Forecasting model study (2007) and are considered to be the best estimate of flow for those events. The latest flood forecasting model "OxfordThames_41.dat" was used to extract flows from model nodes 50.079 (Thames), 50.EVEN (Evenlode) and CH.082d (Cherwell).

Figure 3 details the 2007 event inflow hydrographs extracted from the flood forecasting model (solid lines). The inflows used in the Mott MacDonald model (based on a detailed hydrological analysis undertaken by JBA, 2013) are presented as dashed lines. The Sandford flow is the modelled flow extracted from the 1D-2D model simulation.

The flow comparison shows large differences in the Thames and Cherwell inflows. The Thames inflow from the Mott MacDonald model is based on recorded flow at Eynsham. It has been established that the gauge at Eynsham is influenced by flows from the Evenlode. This is particularly evident in the first peak of the inflow (approximately 22nd July) when the flows from the Evenlode are high. The flood forecasting model is based on a rating at Farmoor gauge, upstream of the Evenlode influence.

For the Cherwell, it appears that the Enslow gauged flow has been directly scaled by a factor of 1.6 to provide the model inflow at the A40 in the Mott MacDonald model (with no adjustment for attenuation). The inflow taken from the flood forecasting model, however, routes the flows from Enslow gauging station on the Cherwell and Lower Arncot on the Ray.

The anomalies in the Thames and Cherwell inflows from the Mott MacDonald model result in the model predicting a double peak, with a higher first peak, which does not agree with recorded levels and was noted as a concern by Black and Veatch in their 2014 initial assessment report.

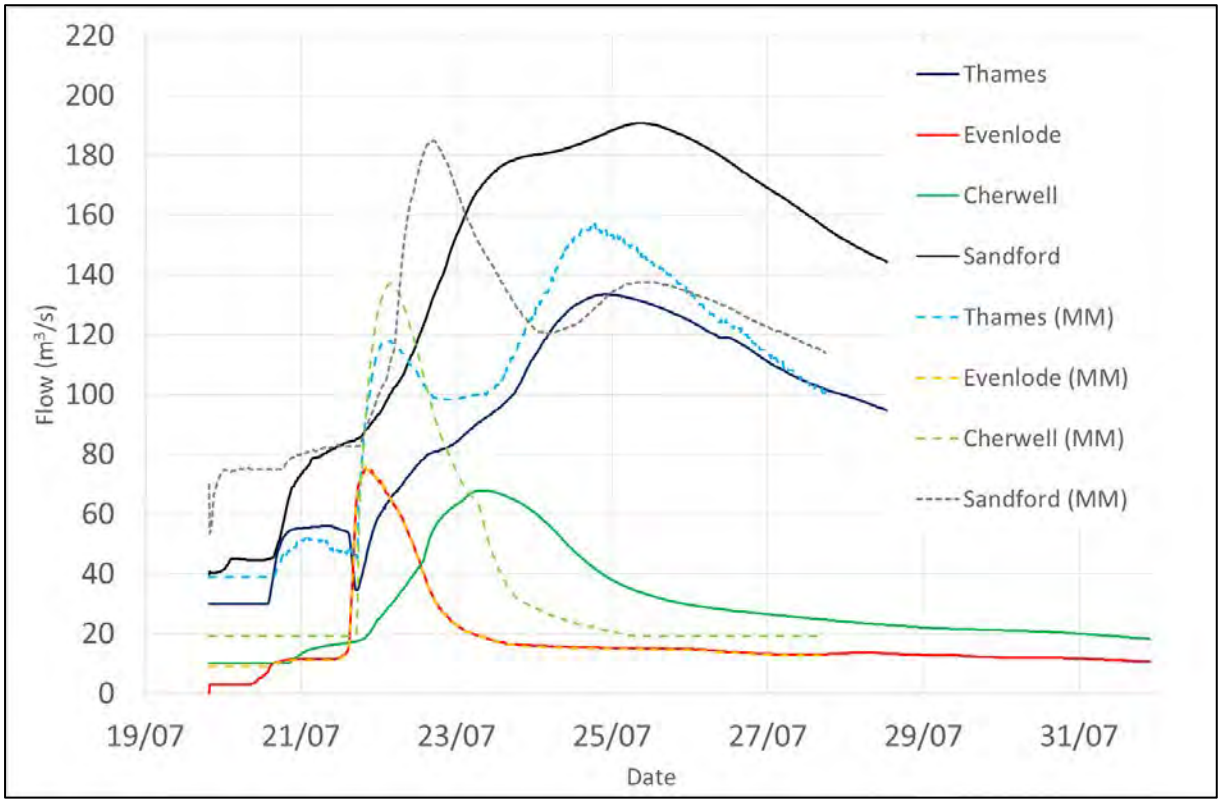


Figure 3: Calibration inflows – 2007 event

Figure 4 presents the 2003 event inflow hydrographs extracted from the flood forecasting model. The Sandford flow is the modelled flow extracted from the 1D-2D model validation run.

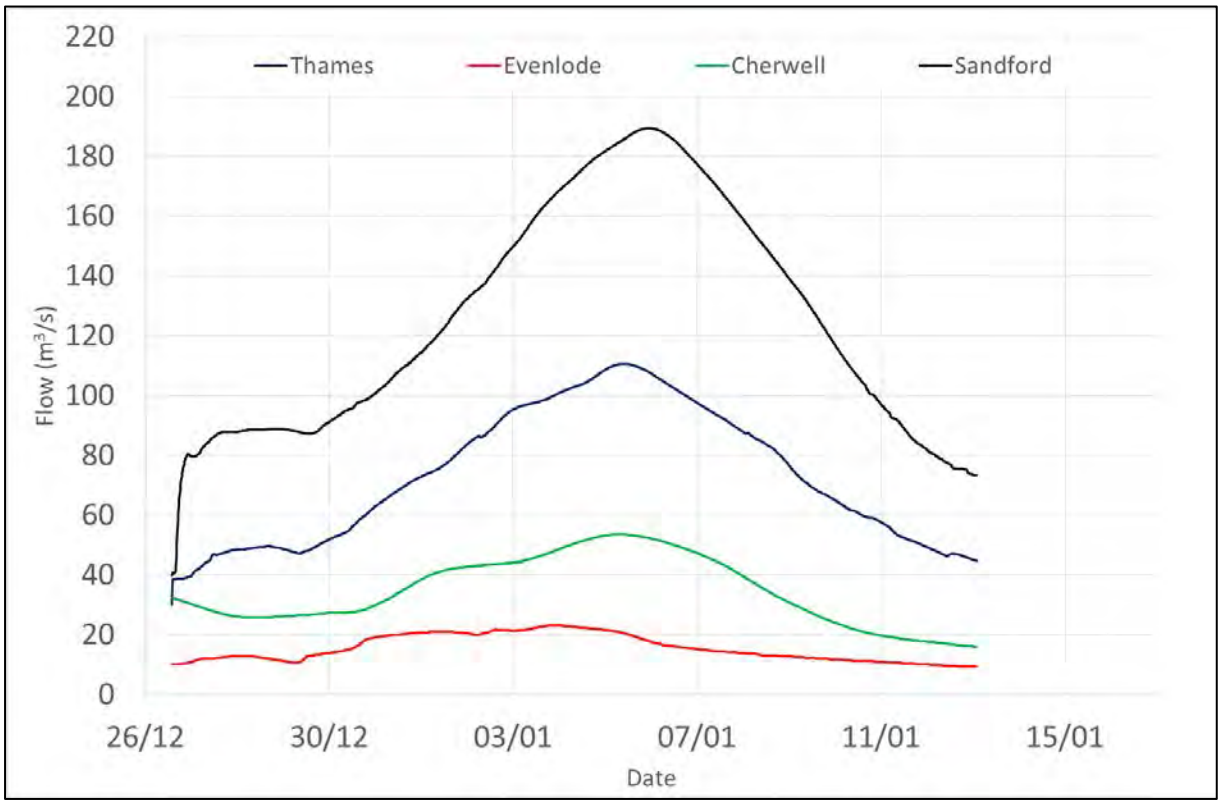


Figure 4: Calibration inflows – 2003 event

3.4 Gauge records and high flow ratings (Winter 2013/14)

The flood forecasting model had not been configured for the 2013/14 event, so inflows have been derived from gauge records and high flow ratings. The flood forecasting model was used to simulate the derived flows and extract inflows for the 1D-2D model.

The high flow ratings used to derive flows for the Thames and Evenlode from level records are detailed in Table 4.

Table 4: High flow ratings (Thames and Evenlode)

Farmoor	Pinkhill
Q=55.234*(h+0)^0.7803 for h < 1.33 Q=48.364*(h+0)^1.2460 for h < 1.55 Q=37.886*(h+0)^1.8032 for h < 1.76 Q=23.541*(h+0)^2.6449 for h > 1.93 Q=3.1432*(h+0)^5.7072 for h > 2.2	Q = 9.7087*(h+0)^1.8337 for h<2.7 Q = 2.8176*(h+0)^3.0792 for h<3.08 Q = 0.6859*(h+0)^4.3353 for h>3.08
Eynsham	**Cassington (Evenlode)**
Q = 6.3775*(h+0)^2.0819 for h<3.05 Q = 1.3181*(h+0)^3.4957 for h<3.45 Q = 0.1203*(h+0)^5.4289 for h>3.45	Q=20.586*(h+0)^1.879 for h < 0.67 Q=21.665*(h+0)^2.0066 for h < 0.874 Q=27.526*(h+0)^3.7843 for h < 0.98 Q=27.604*(h+0)^3.9252 for h > 0.98

Source: EdenVale Modelling Services (2007) Hydraulic models for Flood Forecasting: Oxford Thames

Figure 5 details the derived flows taken from the high flow ratings for the Thames and Evenlode. The peak flow estimates for the Thames range from 96m^3/s (Pinkhill), 106m^3/s (Eynsham) and 117m^3/s (Farmoor). These differences have not been investigated further and the flow estimate for Farmoor has been used for model calibration.

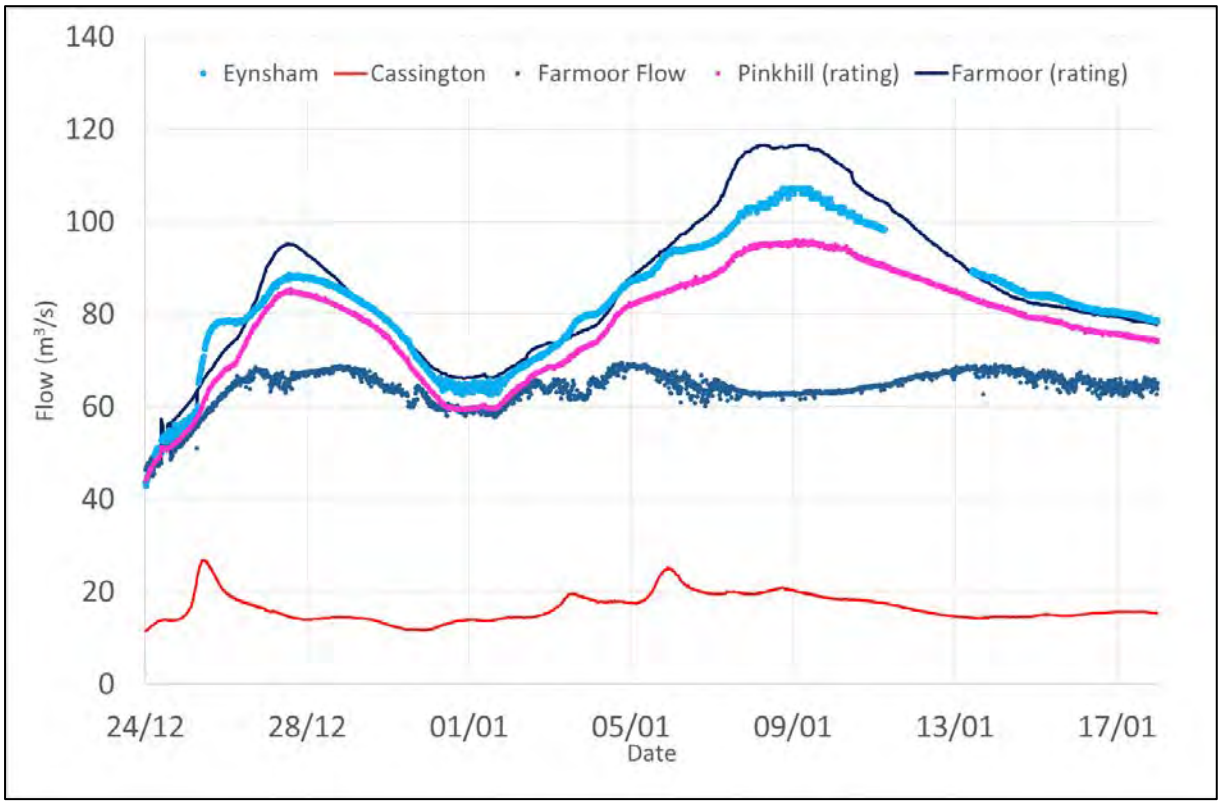


Figure 5: Gauge/high flow rated, Thames and Evenlode – Winter 2013/14 event

The high flow ratings used to derive flows for the Cherwell are detailed in Table 5 and the derived flows detailed in Figure 6. For the Cherwell a tailwater level recorder was installed on the weir in November 2012, and a new high flow rating was derived to better represent bypassing of the gauge. The peak flow estimates for the Cherwell range from 32m^3/s (Head rating) to 45m^3/s (Tail rating). The higher tail-rated flows have been used for model calibration.

Table 5: High flow ratings (Cherwell)

Enslow (head rating) [1]	Enslow Tail [2]
Q=17.857*(h+0)^1.7668 for h<0.71	Q = 7.922*(h-1.1)^1.338 for h < 1.1m
Q=29.465*(h+0)^3.2291 for h<0.88	Q = 7.393*(h-1.1)^2.063 for h < 1.599
Q=37.096*(h+0)^5.0307 for h<1.01	Q = 3.537*(h-1.1)^3.634 for h < 1.924
Q=38.437*(h+0)^1.4625 for h>1.01	Q = 7.953*(h-1.1)^2.396 for h > 1.924

Source [1]: EdenVale Modelling Services (2007) Hydraulic models for Flood Forecasting: Oxford Thames

Source [2]: JBA (2014) Upper Cherwell Flood Forecasting Model

The inflow from the Ray at Islip was directly used for calibration. It is noted that the flow record is unreliable and was poor for 2007 (negative flows recorded by the ultrasonic gauge), resulting in the extension of the Ray up to Lower Arncot in the Flood Forecasting model. However, at the time of modelling the flow record at Lower Arncot was not received and the modelling continued. Potentially the model could be missing flow when levels in the Cherwell are high.

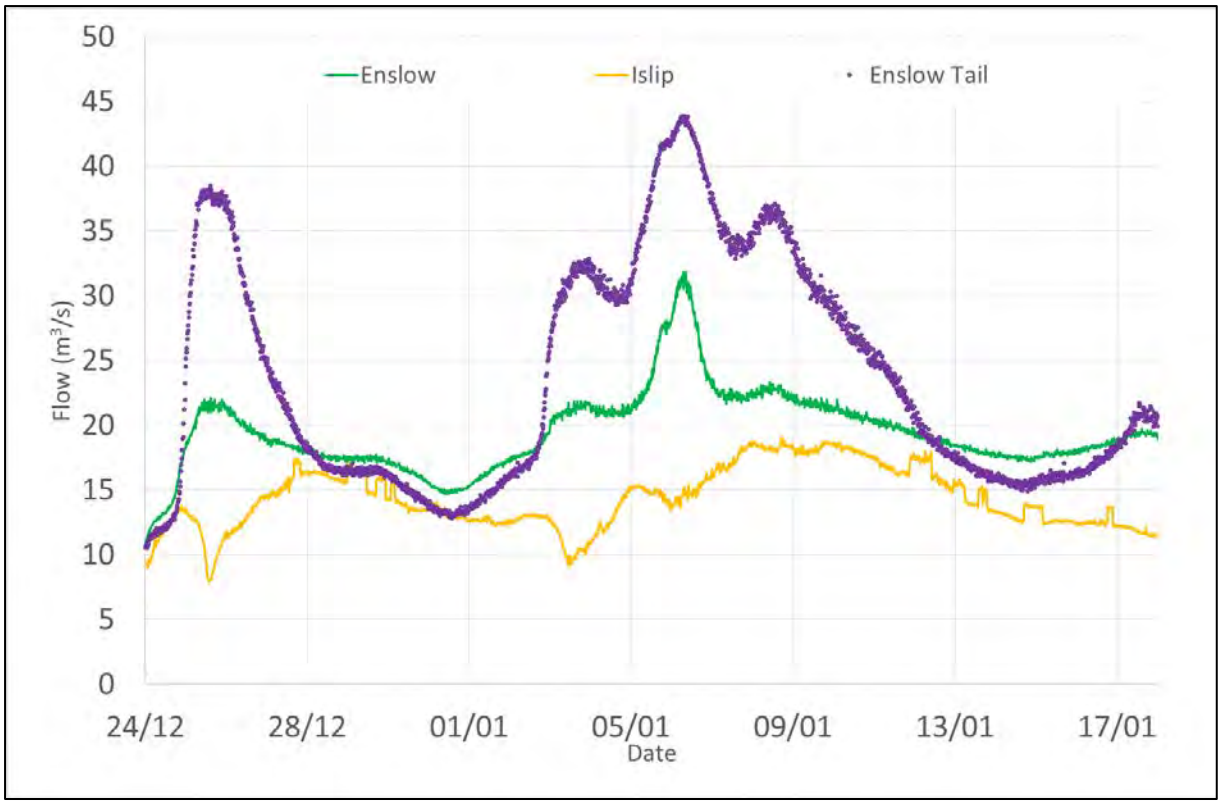


Figure 6: Gauge/high flow rated, Cherwell – Winter 2013/14 event

Figure 7 details the winter 2013/14 event inflow hydrographs extracted from the flood forecasting model. The Sandford flow is the modelled flow extracted from the 1D2D model simulation.

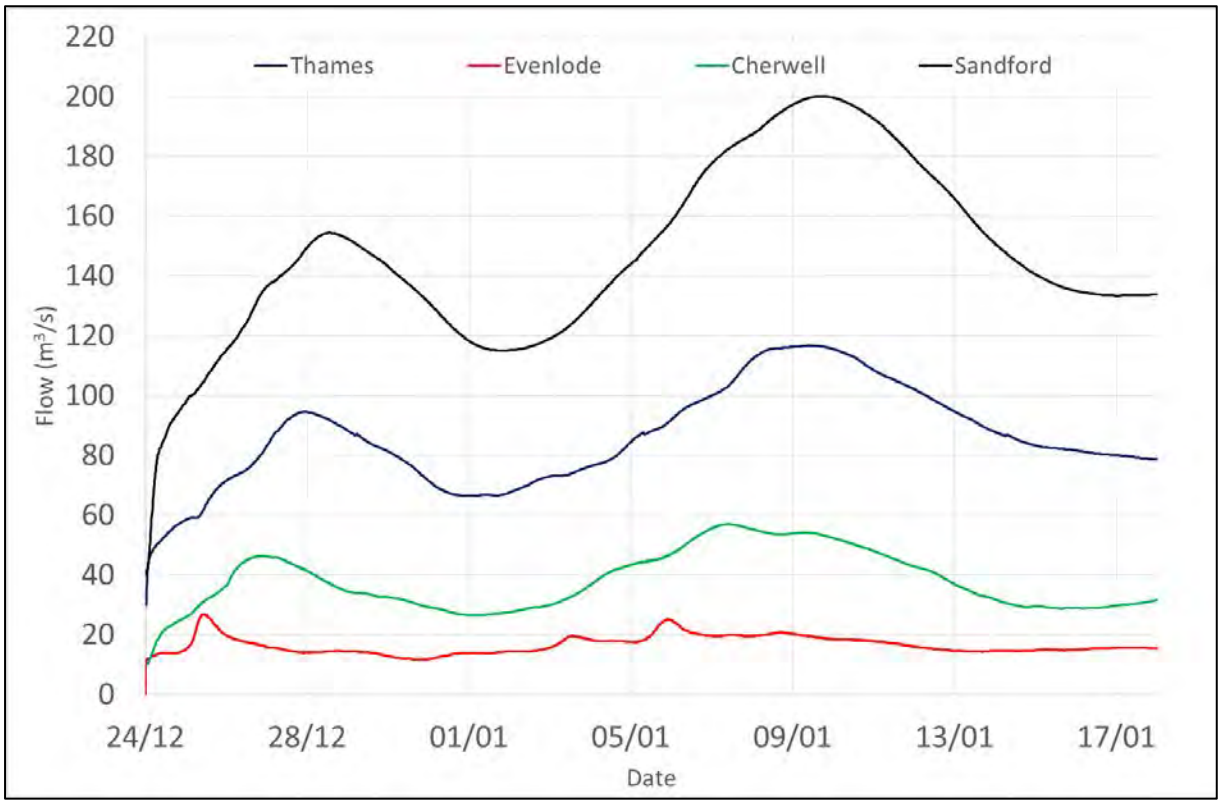


Figure 7: Calibration inflows – Winter 2013/14 event

SECTION 4

July 2007 Calibration Results

Comparison of model performance against the observed data was made against various datasets:

- Telemetry data at locks (head and tail), recorders on Botley Road on the Seacourt Stream (Minns Estate), Bulstake Stream (New Botley), Abingdon Road on Hinksey Stream (Cold Harbour) and Oxford gauge on the Cherwell.
- Flood Extent comparison.
- Post flood survey at 38 locations, based on wrack marks and photographic evidence of flood extents.

Table 6 compares the observed peak water levels from the telemetry stations to modelled water levels. Generally there is good agreement with all peak levels within 0.13m apart from the comparisons at Sandford Lock (head and tail), where telemetry data was not available and water levels exceed the top of the gauge board for high flows. Here, comparisons are made against the observed levels presented in the Oxford Initial Assessment Report.

Appendix A includes the time series comparison of the telemetry data and modelled levels. The modelled levels from the Mott MacDonald calibration and flood forecasting model are also included for information.

Table 6: Comparison of observed and modelled water levels – July 2007

Location (model node)	Observed Level (mAOD)	Modelled Level (mAOD)	Difference (m)
Kings Lock Head (50.008)	59.58	59.47	-0.11
Kings Lock Tail (49.050)	59.22	59.11	-0.11
Godstow Lock Head (49.003U)	58.31	58.25	-0.06
Godstow Lock Tail (48.085)	57.99	57.87	-0.12
Osney Lock Head (48.HRU)	56.80	56.75	-0.04
Osney Lock Tail (47.125)	56.40	56.33	-0.07
Iffley Lock Head (TH47_003)	55.40	55.32	-0.08
Iffley Lock Tail (46.052)	54.99	55.01	0.02
Sandford Lock Head (46c_002A)	54.49 [(1)]	54.33	-0.16
Sandford Lock Tail (45.164)	53.97 [(1)]	53.67	-0.30
Minns Estate (47m.26B)	57.12	57.01	-0.11
New Botley (47k.017)	57.14	57.06	-0.08
Cold Harbour (46g.012C)	55.69	55.81	0.12
Ice Rink (47f.103F)	56.24 [(1)]	56.11	-0.13
Cherwell (CH.014)	56.00	56.05	0.05

Source [(1)]: Oxford Initial Assessment Modelling Report, December 2014, Table 6.3

Figure 8 presents a comparison of the modelled flood extent against observed flood records taken from the Environment Agency recorded 2007 flood outlines dataset. Overall there is good agreement with the extents. Insets within Figure 8 show post-flood recorded spot levels which are compared to peak modelled levels from the 2D modelled floodplain in Table 7.

Further detailed comparison of flood extents and post flood recorded levels are made in the Botley Road area (Figure 9 and Table 8) and Hinksey area around Abingdon Road (Figure 10 and Table 9)

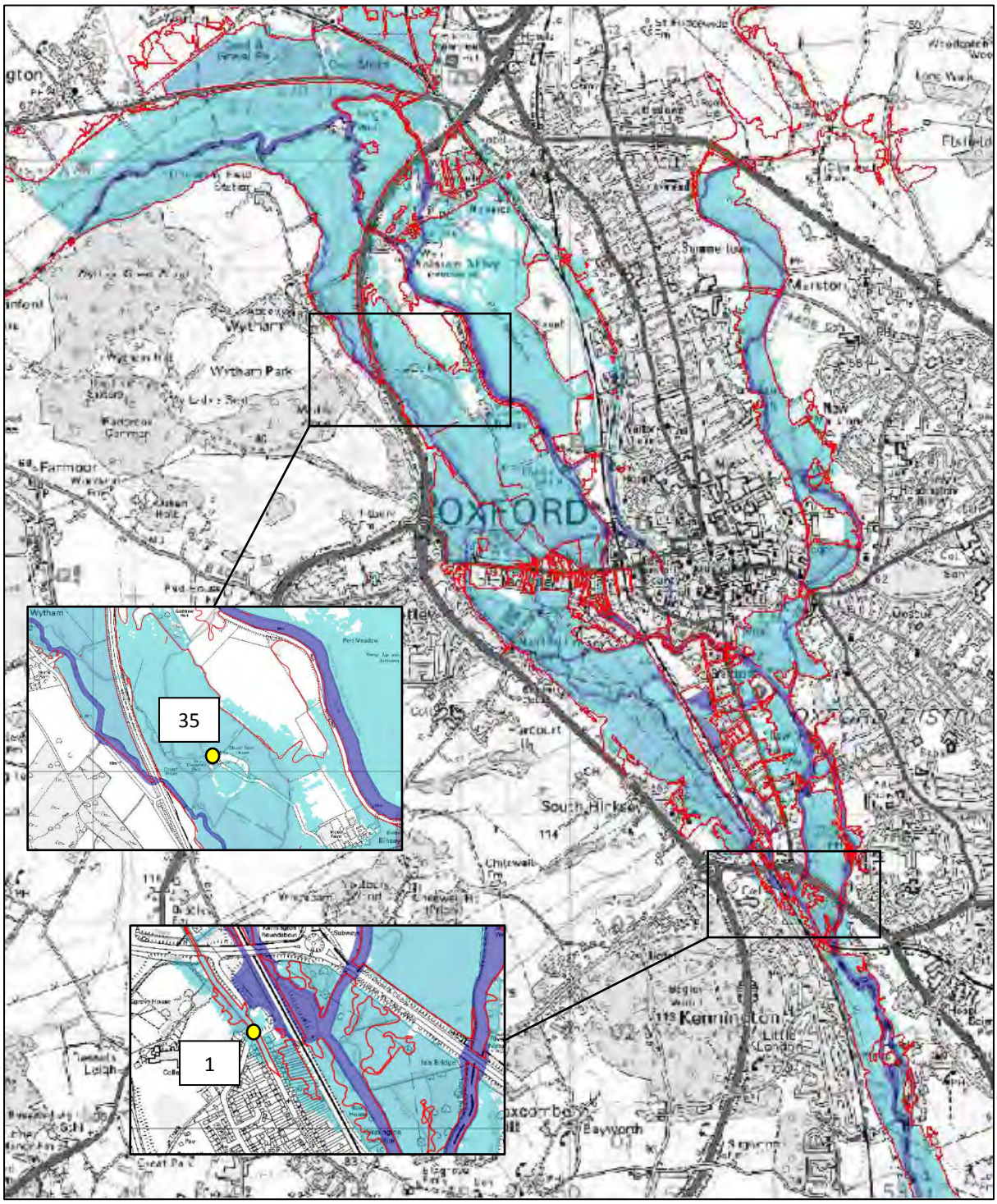


Figure 8: Comparison of 2007 observed and modelled flood extents

Table 7: Comparison of observed and modelled floodplain levels

ID	Ref	Location	Easting	Northing	Observed Level (mAOD)	Modelled Level (mAOD)	Difference (m)
35	9391_4	Church Farm Cottage Binsey	448565	208086	57.87	57.49	-0.38
1	9371_15	Kennington Rd Kennington	451873	203275	55.16	55.60	0.44

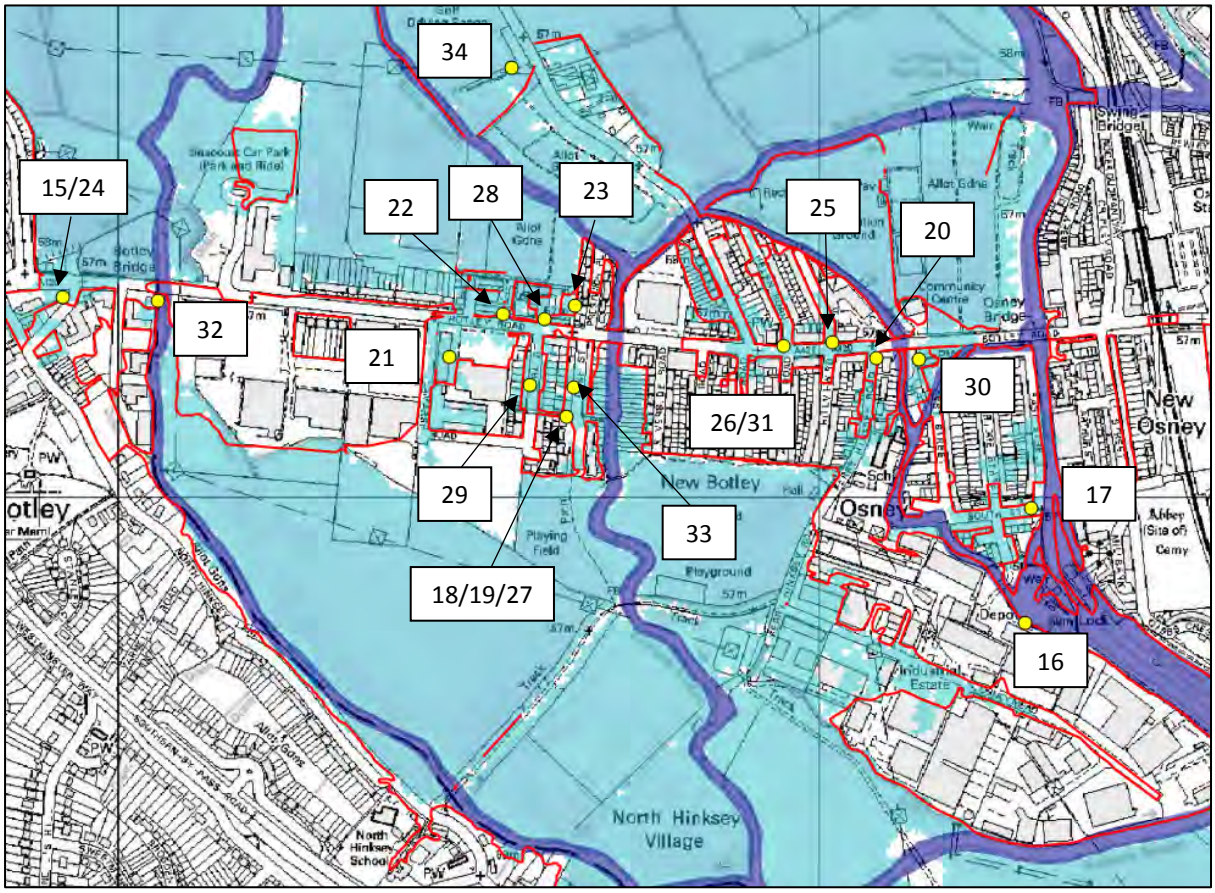


Figure 9: Comparison of 2007 observed and modelled flood extents (Botley Road Area)

Table 8: Comparison of observed and modelled floodplain levels (Botley Road Area)

ID	Ref	Location	Easting	Northing	Observed Level (mAOD)	Modelled Level (mAOD)	Difference (m)
15	9379_3	McDonalds Botley	448921	206286	57.34	57.28	-0.06
16	9379_4	Osney Yard	450294	205821	56.47	56.33	-0.14
17	9379_6	Kingham East St Watermans	450303	205986	56.42	56.45	0.02
18	9379_8	Duke St and Earl St New Botley	449640	206115	57.04	56.89	-0.15
19	9379_8a	Duke St and Earl St	449648	206119	56.97	56.88	-0.09
20	9379_9	Ferry Hinksey Rd Osney	450082	206199	57.11	57.10	-0.01
21	9379_10	Botley Rd	449472	206201	57.31	57.25	-0.06
22	9379_16	Bulstake Close	449550	206261	57.23	57.25	0.02
23	9379_17	Botley Rd north	449653	206274	57.17	57.25	0.08
24	9379_18	Botley Rd	448923	206299	56.92	57.28	0.36
25	9379_20	Henry Rd	450019	206221	57.12	57.11	-0.01
26	9379_23	Helen Rd	449950	206216	57.11	57.12	0.01
27	9379_27	Duke St	449649	206125	56.98	56.89	-0.09
28	9379_28	Osney Court	449609	206255	57.32	57.25	-0.07
29	9379_29	Earl St	449587	206160	57.21	56.96	-0.25
30	9379_30	Botley Rd	450143	206197	56.90	57.07	0.17
31	9379_32	Kingham Carphone Warehouse	449960	206216	57.12	57.12	0.00
32	9379_34	The George	449057	206280	57.22	57.23	0.01
33	9379_36	Duke St	449651	206156	56.97	56.89	-0.08
34	9391_1	Binsey at Golf Driving Range	449562	206613	57.40	57.27	-0.13

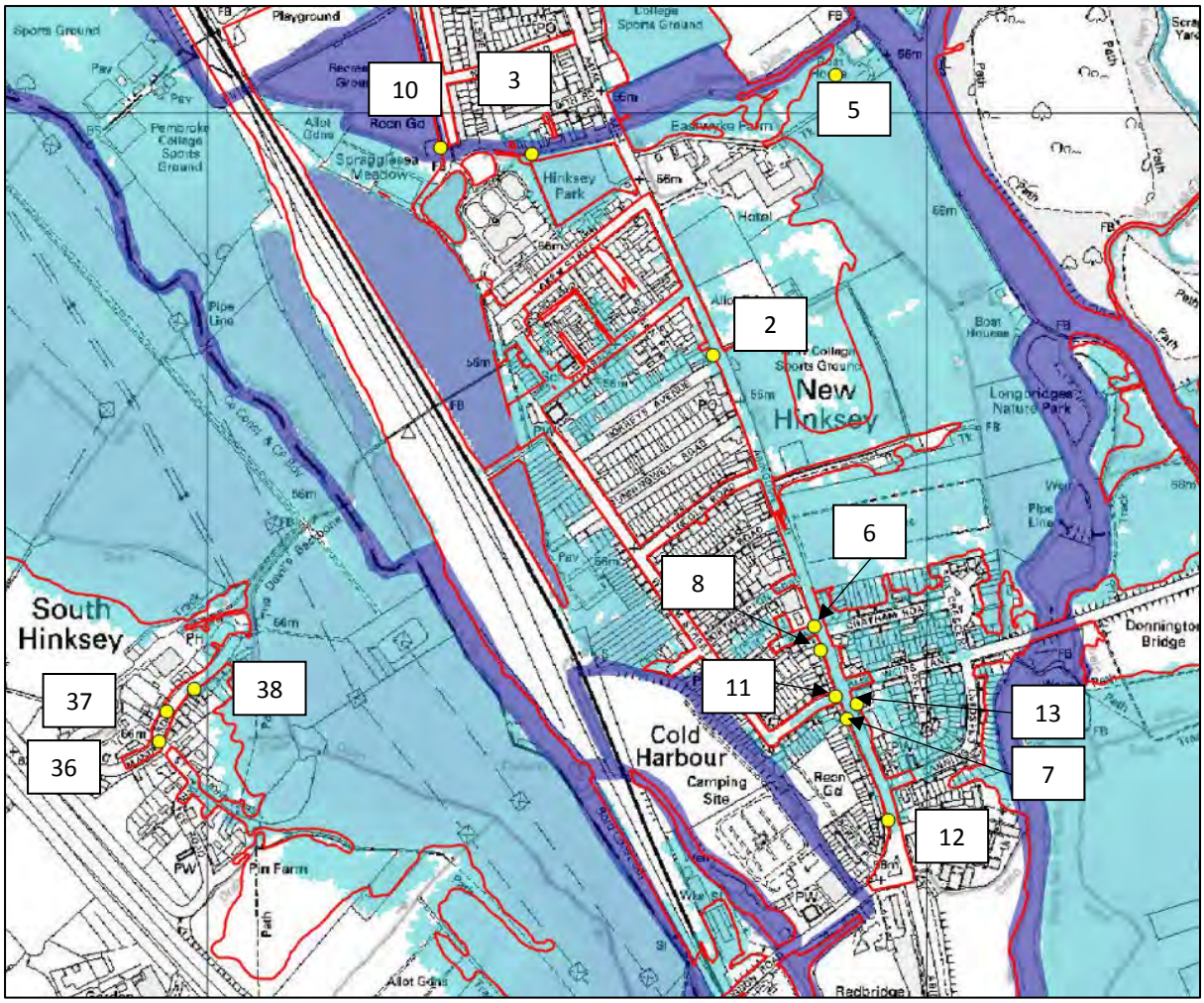


Figure 10: Comparison of 2007 observed and modelled flood extents (Hinksey Area)

Table 9: Comparison of observed and modelled floodplain levels (Hinksey Area)

ID	Ref	Location	Easting	Northing	Observed Level (mAOD)	Modelled Level (mAOD)	Difference (m)
2	9378_10	234 Abingdon Rd New Hinksey	451704	204662	55.23	55.65	0.42
3	9378_12	Eastwyke Ditch in Hinksey Park New Hinksey	451451	204942	55.85	55.94	0.09
4	9378_13	Hinksey Park New Hinksey	451452	204935	55.73	55.93	0.20
5	9378_16	University boathouse New Hinksey	451874	205053	55.55	55.72	0.17
6	9378_17	Oswestry Road New Hinksey	451844	204285	55.51	55.55	0.04
7	9378_21	Abingdon Road looking towards Redbridge	451891	204155	55.45	55.58	0.13
8	9378_22	Abingdon Road New Hinksey	451854	204251	55.48	55.55	0.07
9	9378_22a	Abingdon Rd additional flood level from store keeper	451854	204251	55.54	55.55	0.01
10	9378_23	Area behind Grandpont	451324	204951	56.07	56.05	-0.02
11	9378_24	Wytham St from Abingdon Road New Hinksey	451874	204187	55.45	55.55	0.10
12	9378_31	Abingdon Rd New Hinksey	451947	204016	55.48	55.55	0.07
13	9378_32	Fox & Hounds Pub New Hinksey	451903	204177	55.46	55.55	0.09
14	9378_34	Wytham St New Hinksey	451870	204190	55.48	55.55	0.07
36	09388_1	BV Ref 25018	450933	204125	56.07	56.04	-0.03
37	09388_2	BV Ref 25020	450943	204167	56.06	56.04	-0.02
38	09388_3	BV Ref 25021	450981	204197	56.01	56.04	0.03

The Oxford Flood Risk management Strategy briefing note on Botley Road Bridges included a table of measured flows at Botley Road for the summer 2007 event. Table 10 compares the flows from the OFRM note with the modelled flows. Overall, the total flows show good agreement. However, the modelled flow for the Bulstake Stream is higher than the measured flow and the Thames lower. The actual date and times of the readings is not known, so may not capture the peak flow.

Figure 11 presents the modelled flows at each bridge at Botley Road.

Table 10: Flows at Botley Road, extract from OFRM briefing note

Bridge	Hydraulic Model Flows (Do Minimum Results)			Measured Flows* (Summer 2007)	Estimated Structure Capacity (m^3/sec)	Estimated Watercourse Capacity (m^3/sec)	Modelled
	2 yr	75 yr	100 yr				
Osney Bridge -River Thames	54	63	64	55	55	*55*	47
Osney Ditch	4	14	15	17	31	25	15
Bulstake Stream	14	36	37	29	88	41	46
Botley Road Bridge - Seacourt Stream	10	36	37	17	93	27	21
Castle Mill Stream	14	20	20	*20***	*20***	*20***	12
Total	**96**	**169**	**173**	**138**	**287**	**168**	**141**

* Real-time flows taken using Acoustic Doppler Current Profiler (ADCP) during the 2007 Summer Floods
** Maximum capacity of Castle Mill Stream used as per hydraulic modelling results

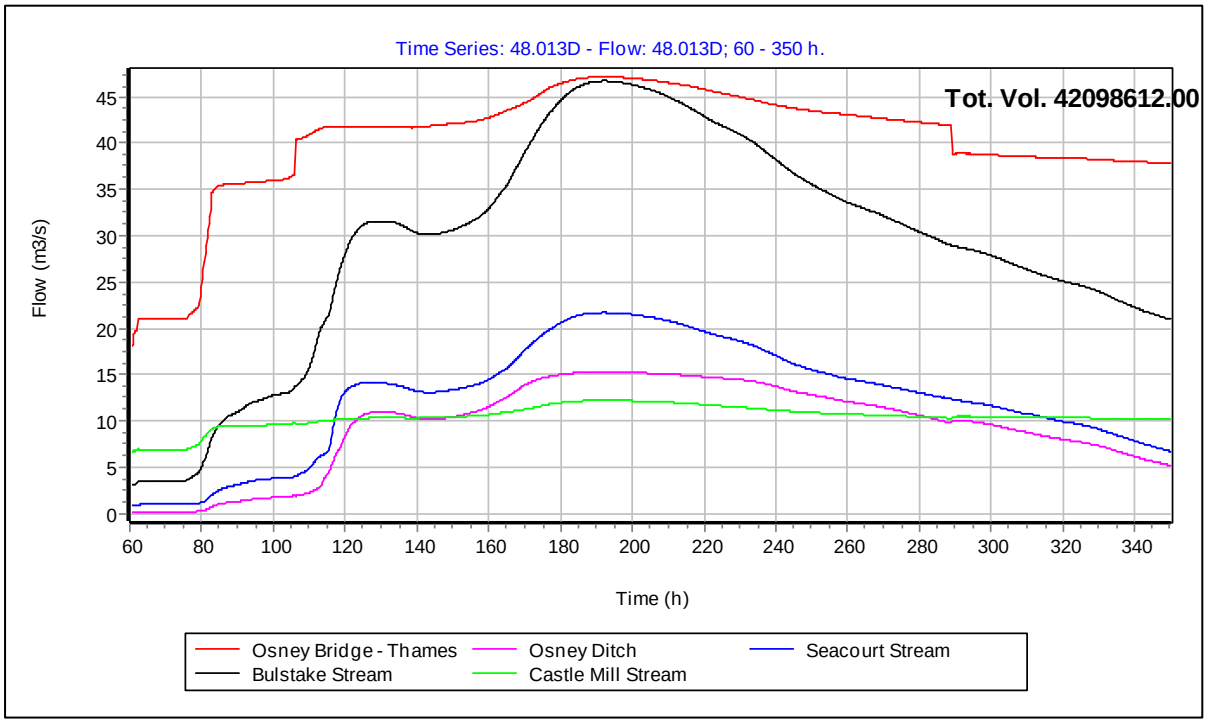


Figure 11: Modelled flows at Botley Road , 2007

SECTION 5

Model Validation Results (winter 2013/14 and 2003)

Table 11 and Table 12 compare the observed peak water levels from the telemetry stations to modelled water levels for winter 2013/14 and January 2003 event.

For 2013/14, generally there is good agreement with all peak levels within 0.15m, apart from at the Oxford Gauge on the Cherwell. This is likely to be due to missing flows from the Ray as discussed in Section 3.4. The impacts of a missing flow could also be attributed to lower levels than observed at the Locks downstream of Osney.

For 2003, there is good agreement with all peak levels within 0.13m. Telemetry was not available at Minns Estate, Ice Rink and the Cherwell Oxford gauge. Observed levels at Sandford Lock were taken from the OFRMS Hydraulic Modelling Report (head) and Sandford Lock level survey (tail).

Figure 12 presents a comparison of the modelled flood extent for 2003 against observed flood records taken from the Environment Agency recorded flood outlines dataset. Overall there is good agreement with the extents. Recorded flood outlines for the 2013/14 event are not available to compare against modelled extents.

Appendix B and C includes the time series comparison of the telemetry data and modelled levels. The modelled levels from the flood forecasting model are also included for information.

Table 11: Comparison of observed and modelled water levels – Winter 2013/14

Location (model node)	Observed Level (mAOD)	Modelled Level (mAOD)	Difference (m)
Kings Lock Head (50.008)	59.47	59.45	-0.02
Kings Lock Tail (49.050)	59.08	59.08	0.01
Godstow Lock Head (49.003U)	58.23	58.22	-0.02
Godstow Lock Tail (48.085)	57.90	57.84	-0.06
Osney Lock Head (48.HRU)	56.70	56.70	0.00
Osney Lock Tail (47.125)	56.45	56.30	-0.15
Iffley Lock Head (TH47_003)	55.47	55.39	-0.08
Iffley Lock Tail (46.052)	55.18	55.06	-0.12
Sandford Lock Head (46c_002A)	54.49	54.35	-0.13
Sandford Lock Tail (45.164)	53.85	53.72	-0.13
Minns Estate (47m.26B)	57.09	56.96	-0.13
New Botley (47k.017)	57.03	57.00	-0.04
Cold Harbour (46g.012C)	55.70	55.77	0.07
Ice Rink (47f.103F)	n/a	56.11	n/a
Cherwell (CH.014)	56.32	56.00	-0.33

Table 12: Comparison of observed and modelled water levels – January 2003

Location (model node)	Observed Level (mAOD)	Modelled Level (mAOD)	Difference (m)
Kings Lock Head (50.008)	59.42	59.44	0.01
Kings Lock Tail (49.050)	59.13	59.07	-0.05
Godstow Lock Head (49.003U)	58.30	58.20	-0.09
Godstow Lock Tail (48.085)	57.95	57.82	-0.13
Osney Lock Head (48.HRU)	56.71	56.67	-0.05
Osney Lock Tail (47.125)	56.38	56.26	-0.12
Iffley Lock Head (TH47_003)	55.42	55.33	-0.09
Iffley Lock Tail (46.052)	55.09	55.01	-0.09
Sandford Lock Head (46c_002A)	54.39 (1)	54.32	-0.07
Sandford Lock Tail (45.164)	53.68 (2)	53.66	-0.02
Minns Estate (47m.26B)	n/a	56.94	n/a
New Botley (47k.017)	56.92	56.97	0.04
Cold Harbour (46g.012C)	55.74	55.67	-0.07
Ice Rink (47f.103F)	n/a	56.06	n/a
Cherwell (CH.014)	n/a	55.97	n/a

Source (1): OFRMS Hydraulic Modelling Report, 2009, Table 4.4

Source (2): 2002/3 Flood levels Sandford Lock level survey, Survey 8515, 27 October 2005

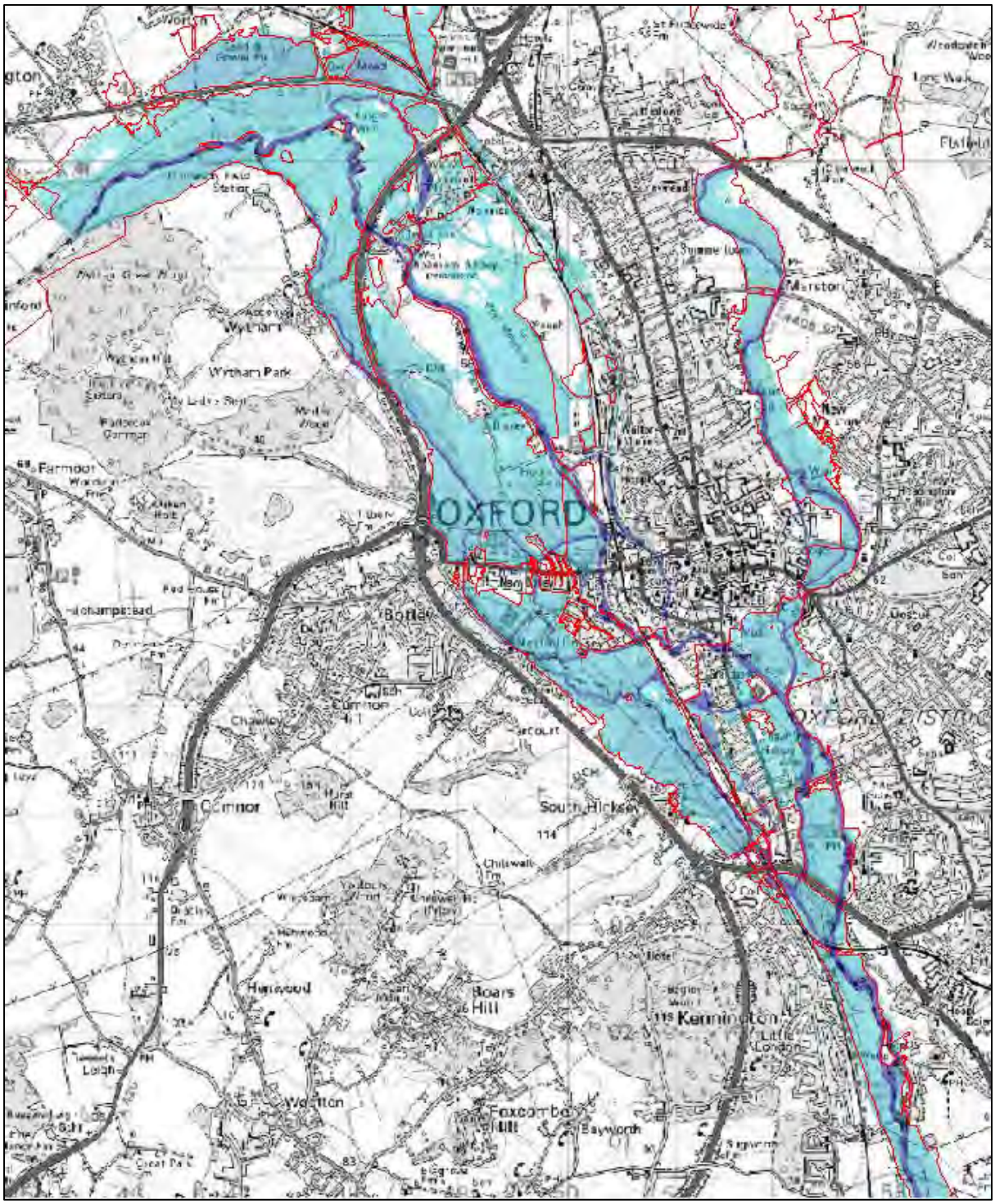


Figure 12: Comparison of 2003 observed and modelled flood extents

SECTION 6

Findings and Conclusions

6.1 Findings

During the re-calibration and validation exercise, attention has been drawn towards particular elements of the model which have a significant impact on water levels and/or flood extents. These include:

- Values adopted for channel roughness in the River Thames can have a significant effect on the volume of water spilling out into the floodplain. This has been observed to be particularly important upstream of Kings Weir and between Godstow and Osney Locks.
- The split of flows across the different channels along the Botley Road and into the centre of Oxford is sensitive to many factors, including the roughness values adopted in the River Thames, coefficients of approach velocity on structures, bank levels, and floodplain conditions.
- Representation of buildings. Where these were previously represented as stubs, it has prevented flooding from occurring in some areas, but once these stubs have been removed, new (albeit small) areas of flooding have been observed to occur.

During the model update, roughness values and coefficients of approach velocity on structures were compared between previous modelling studies undertaken by Mott MacDonald and Black & Veatch. The values adopted in the calibration model generally sit between these values.

The findings will be considered further in terms of a limited number of sensitivity runs once the preferred scheme has been identified and modelled. This will enable us to investigate and quantify the uncertainties inherent in the baseline model, which will inform the final outline designs.

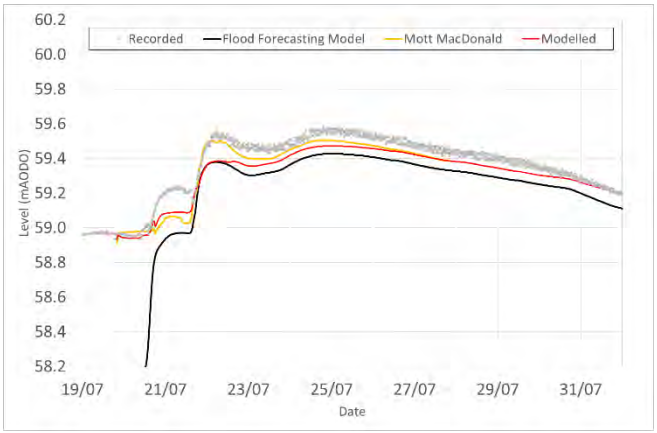
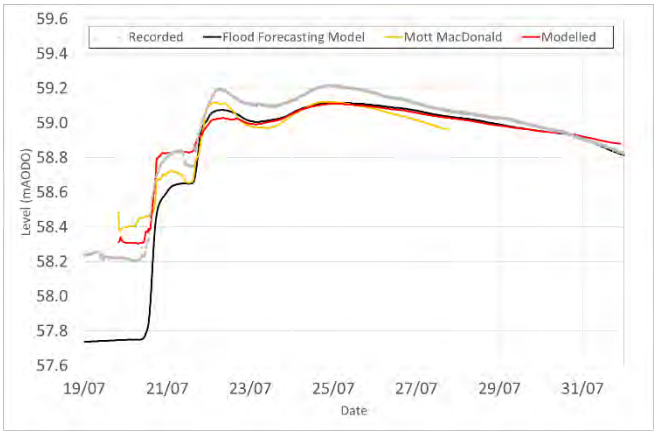
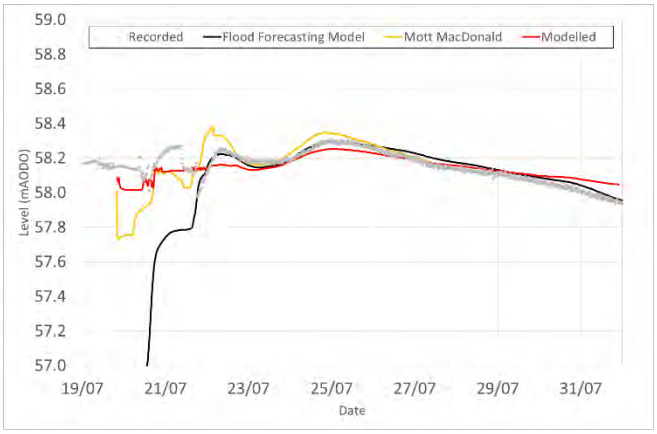
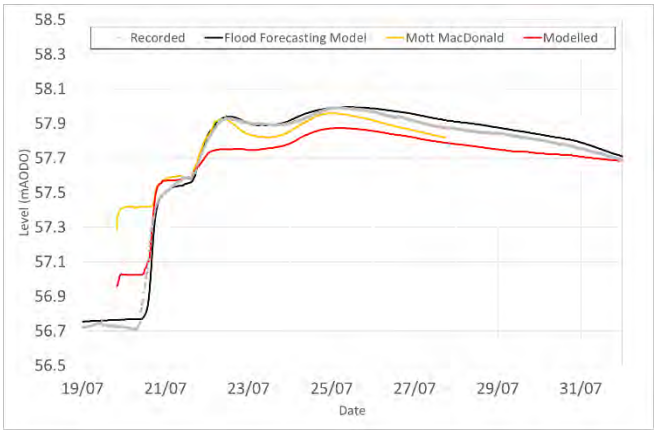
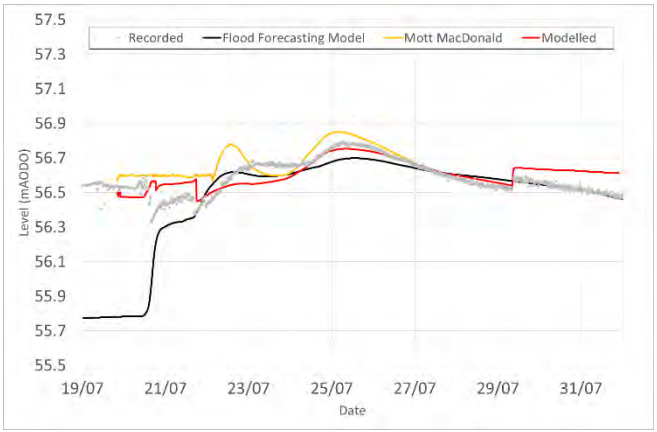
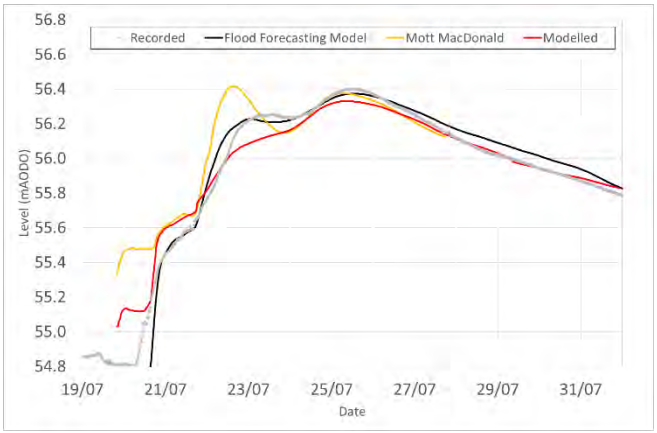
6.2 Conclusions

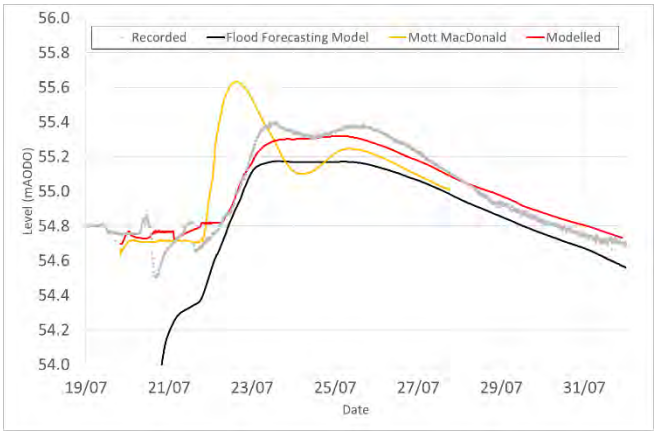
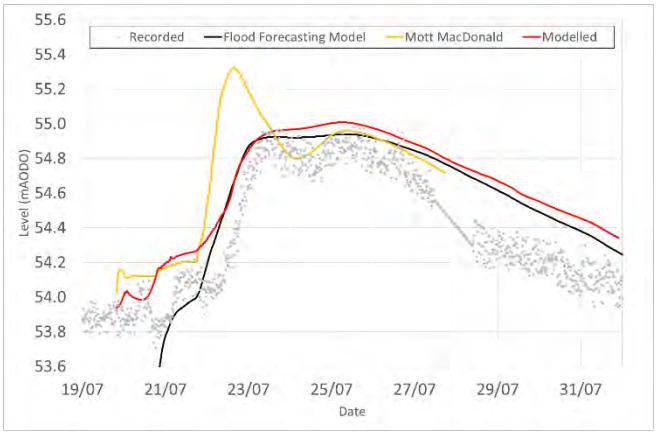
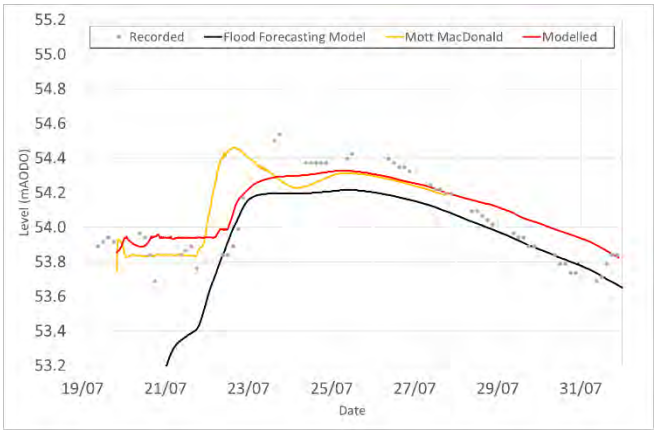
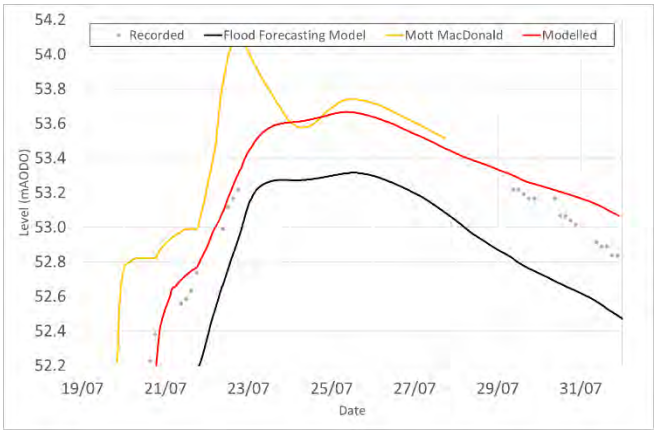
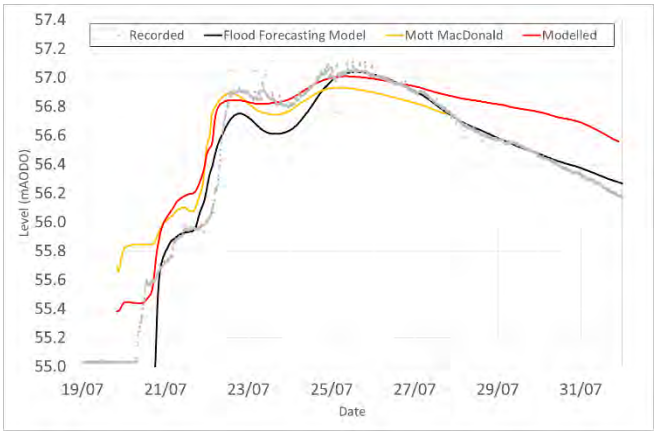
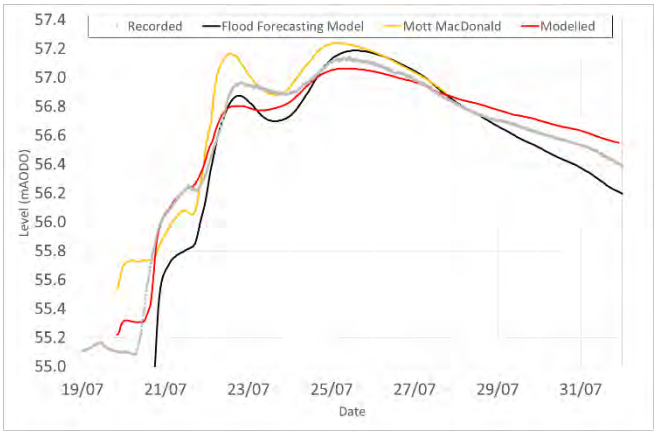
The calibration and validation work undertaken by CH2M has greatly improved the performance of the model when compared with observed events, particularly for the 2007 flood. The successful validation of the re-calibration of the model against the 2003 event and the most recent 2013/14 provides further confidence in the model's schematisation and baseline parameter set. The model's improved performance is a result of the following changes implemented by CH2M:

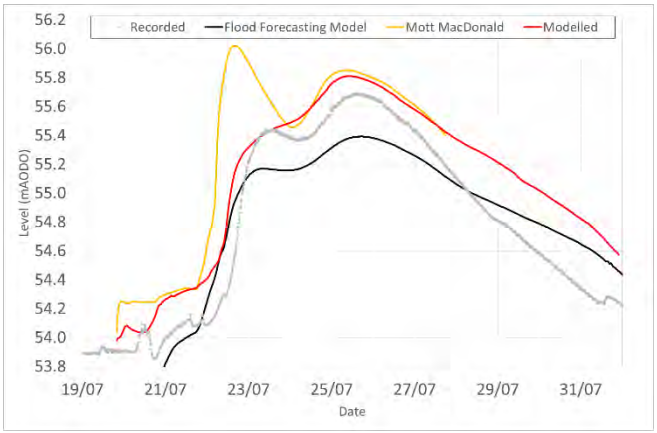
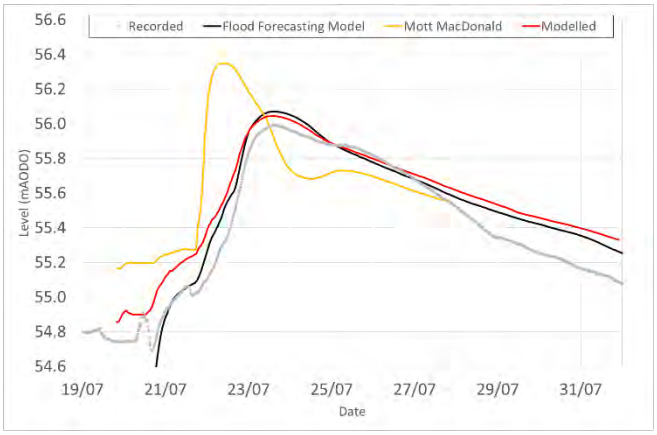
- Improved model inflows, with special care being taken to review and reconstruct appropriate inflows for each calibration and validation event;
- Improved model parameters (for example, channel roughness);
- Improved model schematisation (for example, by incorporating more recent survey).

Given the successful outcome of the re-calibration and validation exercise, the calibrated model is now considered to be suitable for supporting the development of options and their outline design.

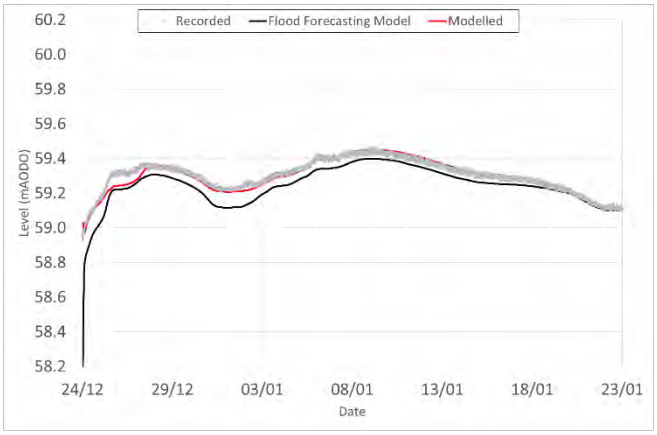
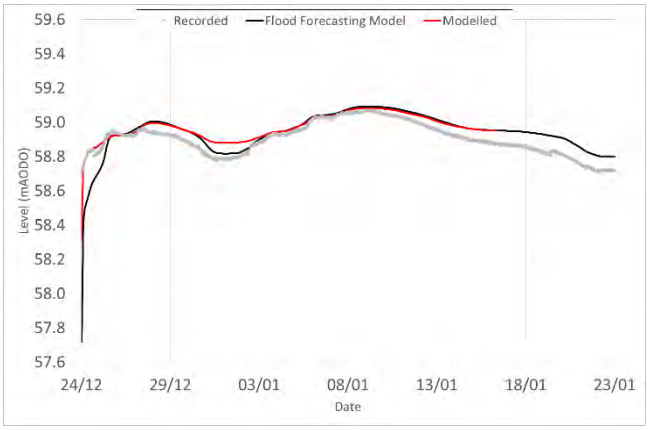
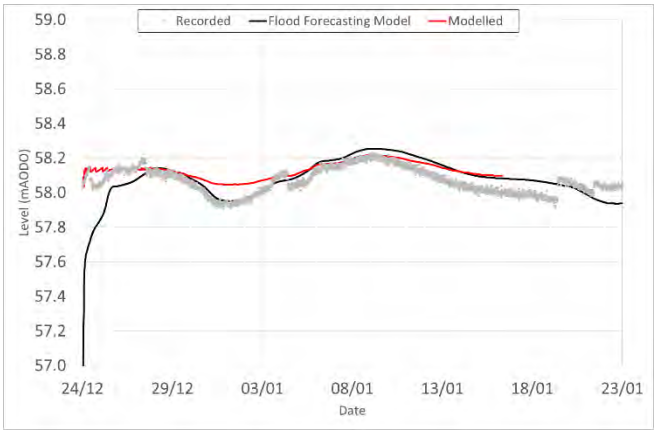
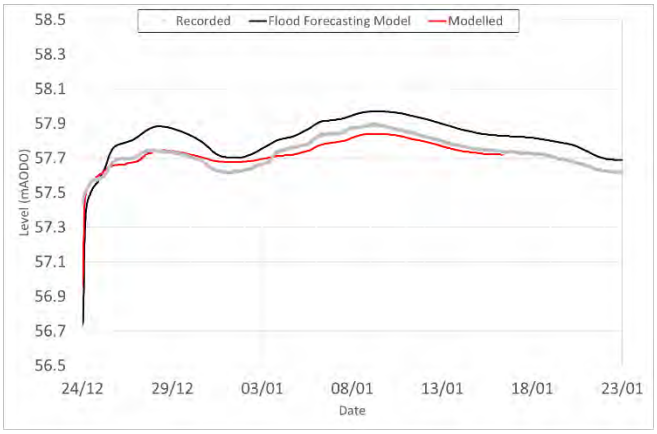
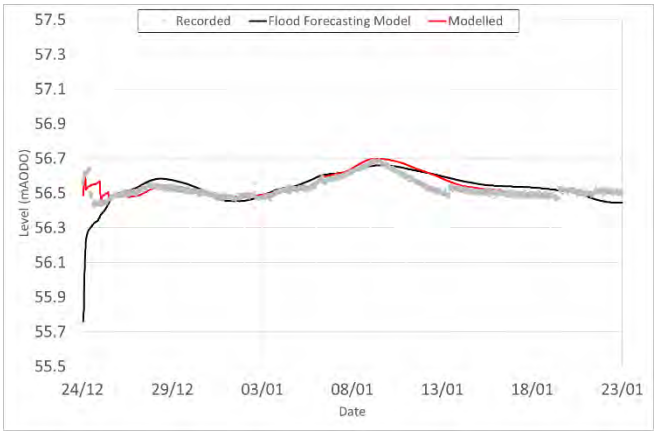
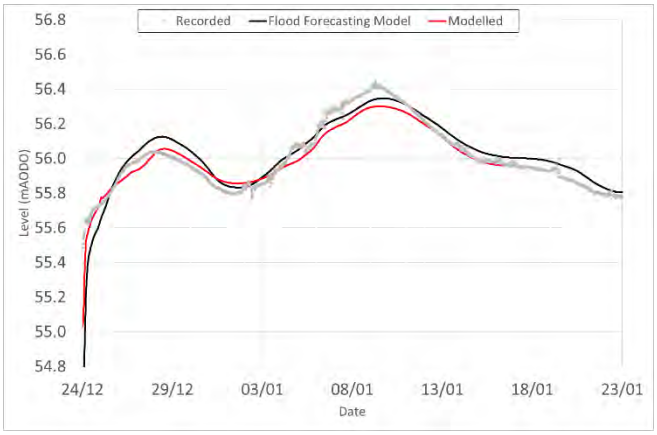
Appendix A
2007 Calibration plots

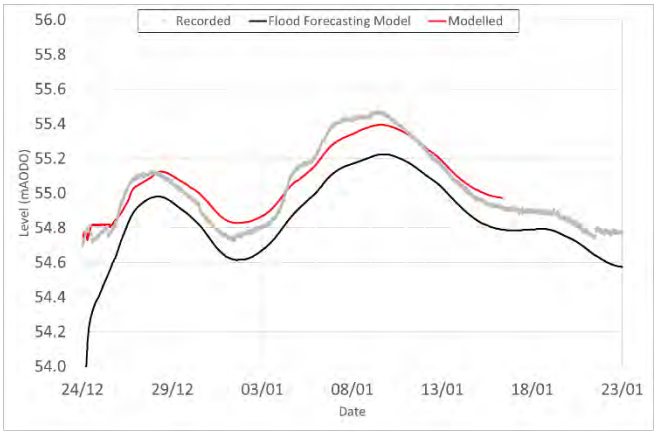
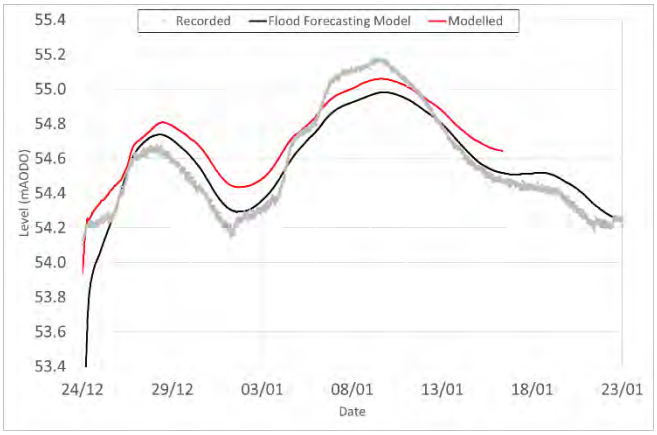
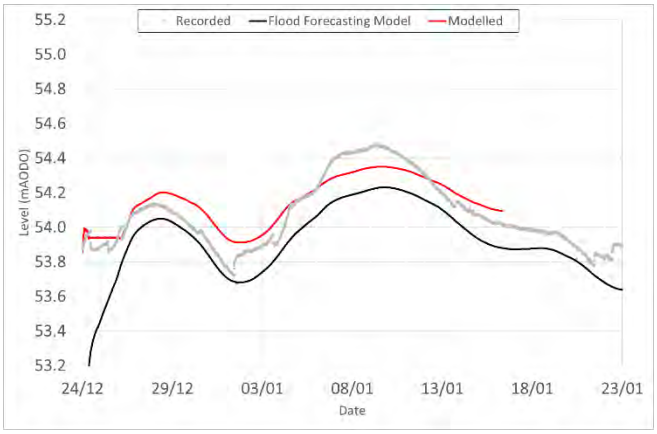
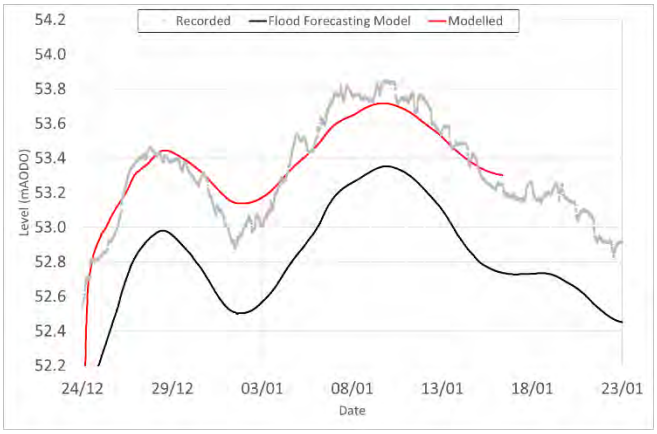
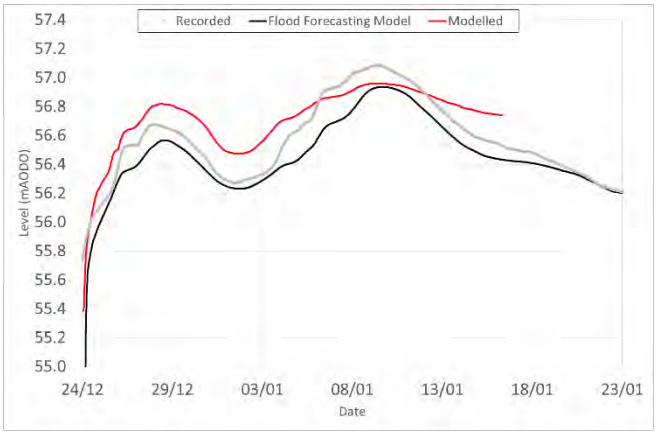
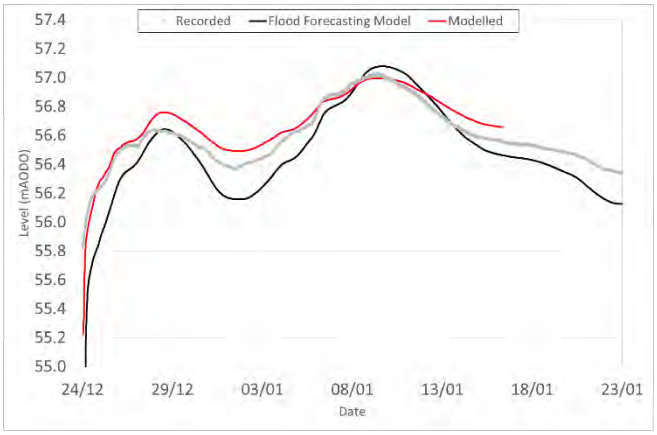
July 2007	Start Date (model time zero) 17/07/2007 @07:45
Kings Lock Head	Kings Lock Tail
	
Godstow Lock Head	Godstow Lock Tail
	
Osney Lock Head	Osney Lock Tail
	

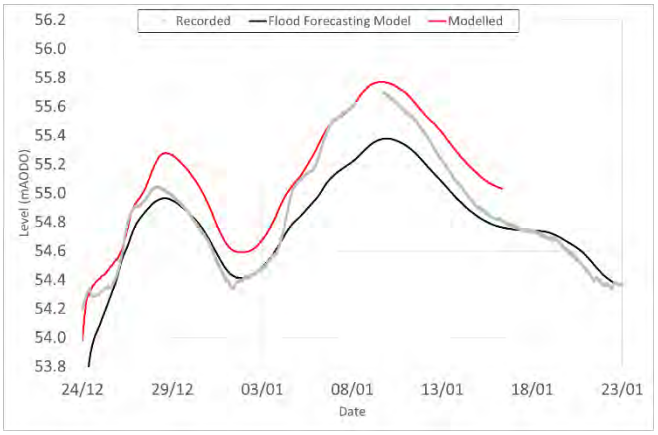
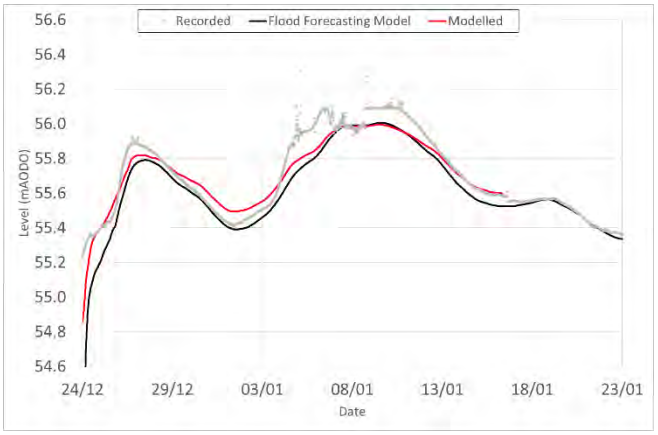
July 2007	Start Date (model time zero) 17/07/2007 @07:45
Iffley Lock Head	Iffley Lock Tail
	
Sandford Lock Head	Sandford Lock Tail
	
Minns Estate	New Botley
	

July 2007	Start Date (model time zero) 17/07/2007 @07:45
Cold Harbour	Oxford Gauge (Cherwell)
	

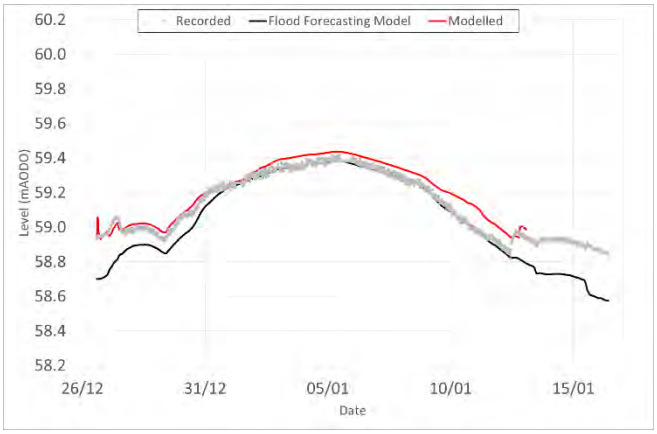
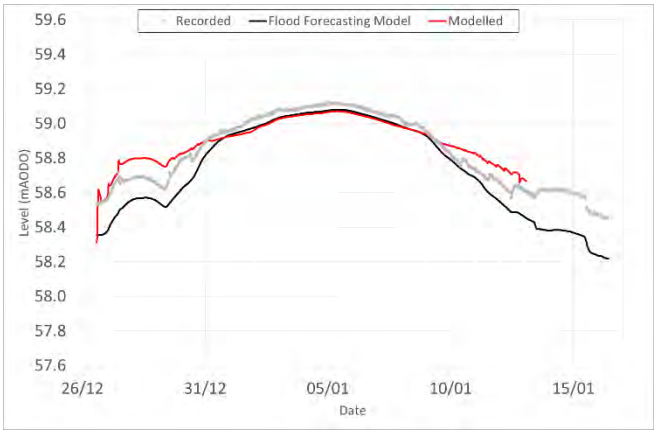
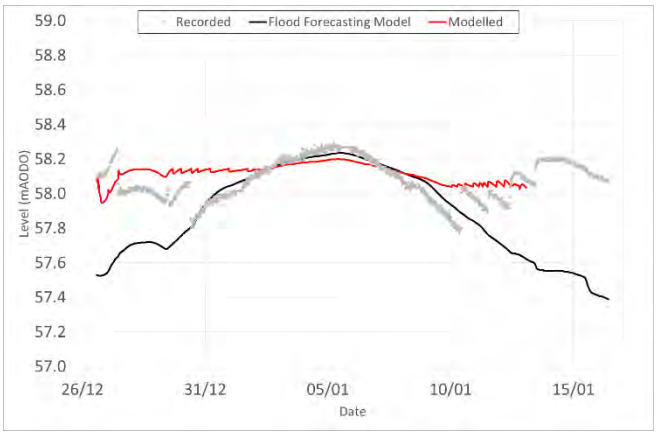
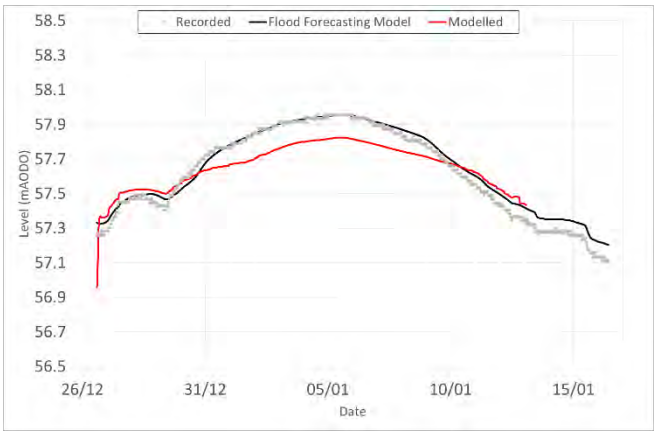
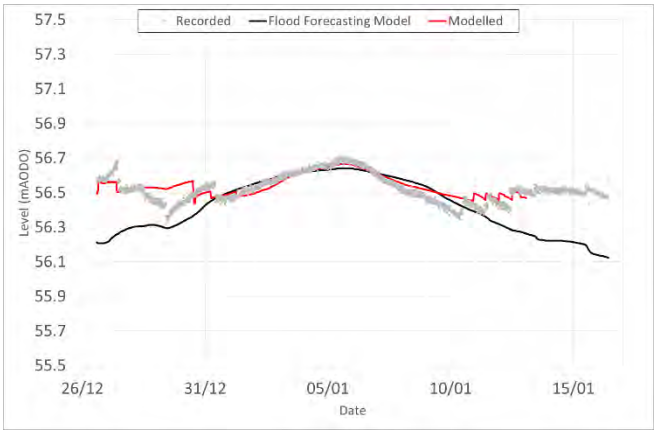
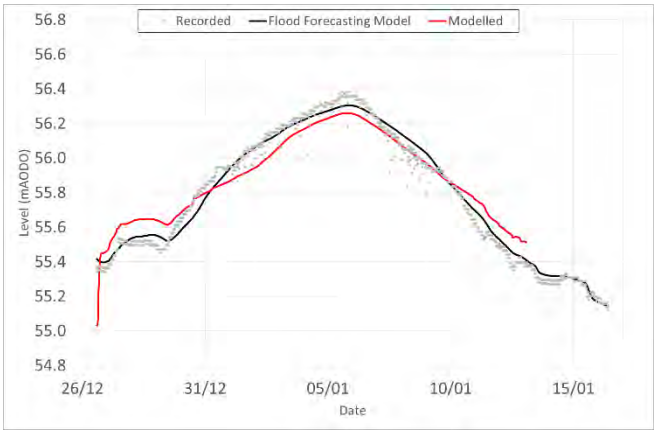
Appendix B
Winter 2013/14 Calibration plots

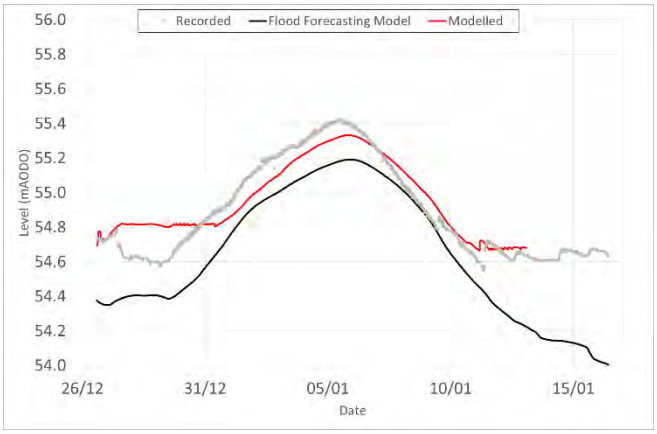
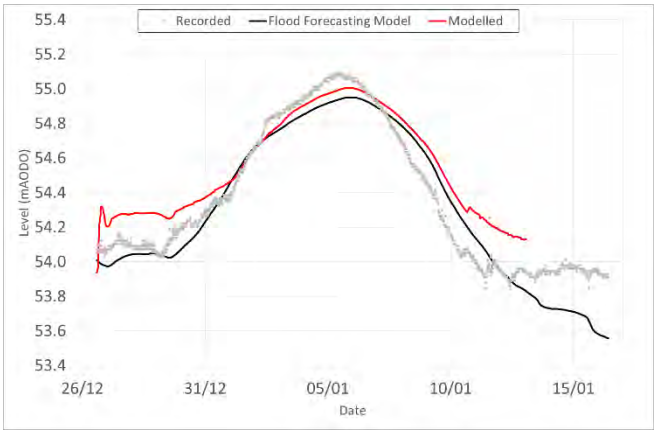
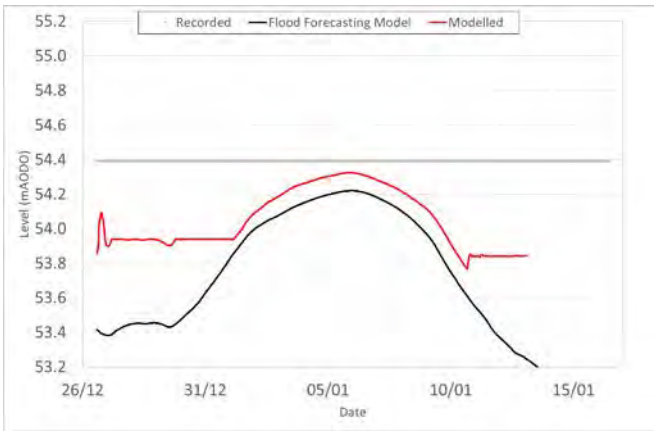
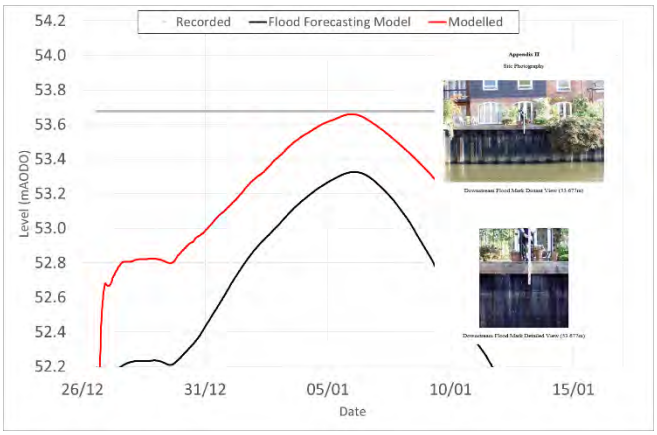
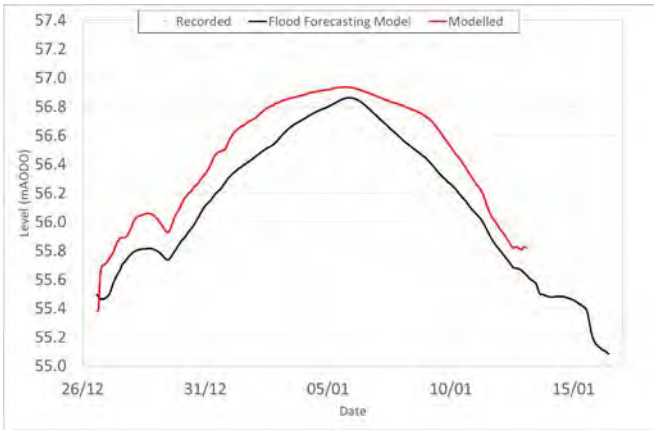
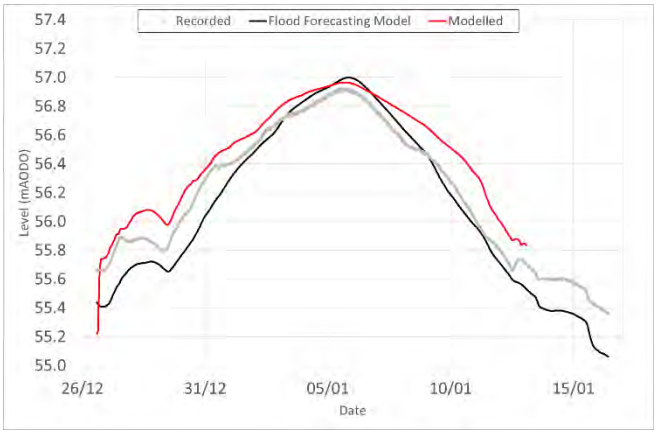
Winter 2013/14	Start Date (model time zero) 24/12/2013 @00:00
Kings Lock Head	Kings Lock Tail
	
Godstow Lock Head	Godstow Lock Tail
	
Osney Lock Head	Osney Lock Tail
	

Winter 2013/14	Start Date (model time zero) 24/12/2013 @00:00
Iffley Lock Head	Iffley Lock Tail
	
Sandford Lock Head	Sandford Lock Tail
	
Minns Estate	New Botley
	

Winter 2013/14	Start Date (model time zero) 24/12/2013 @00:00
Cold Harbour	Oxford Gauge (Cherwell)
	

Appendix C
January 2003 Calibration plots

January 2003	Start Date (model time zero) 26/12/2002 14:00:00
Kings Lock Head	Kings Lock Tail
	
Godstow Lock Head	Godstow Lock Tail
	
Osney Lock Head	Osney Lock Tail
	

January 2003	Start Date (model time zero) 26/12/2002 14:00:00
Iffley Lock Head	Iffley Lock Tail
	
Sandford Lock Head	Sandford Lock Tail
	
Minns Estate	New Botley
	

January 2003	Start Date (model time zero) 26/12/2002 14:00:00
Cold Harbour	Oxford Gauge (Cherwell)