Hutt River Mouth Extraction - Hydraulic Modelling

Report prepared for Greater Wellington
by

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1. Introduction

Greater Wellington (Flood Protection) currently holds resource consent allowing river bed extraction for the Hutt River downstream of the Estuary Bridge (Figure 1). The consent is due to expire shortly and a new consent will be sought. Investigations into the effects of extraction have included hydraulic modelling of the lower reaches of the river. This report describes the modelling and presents results.

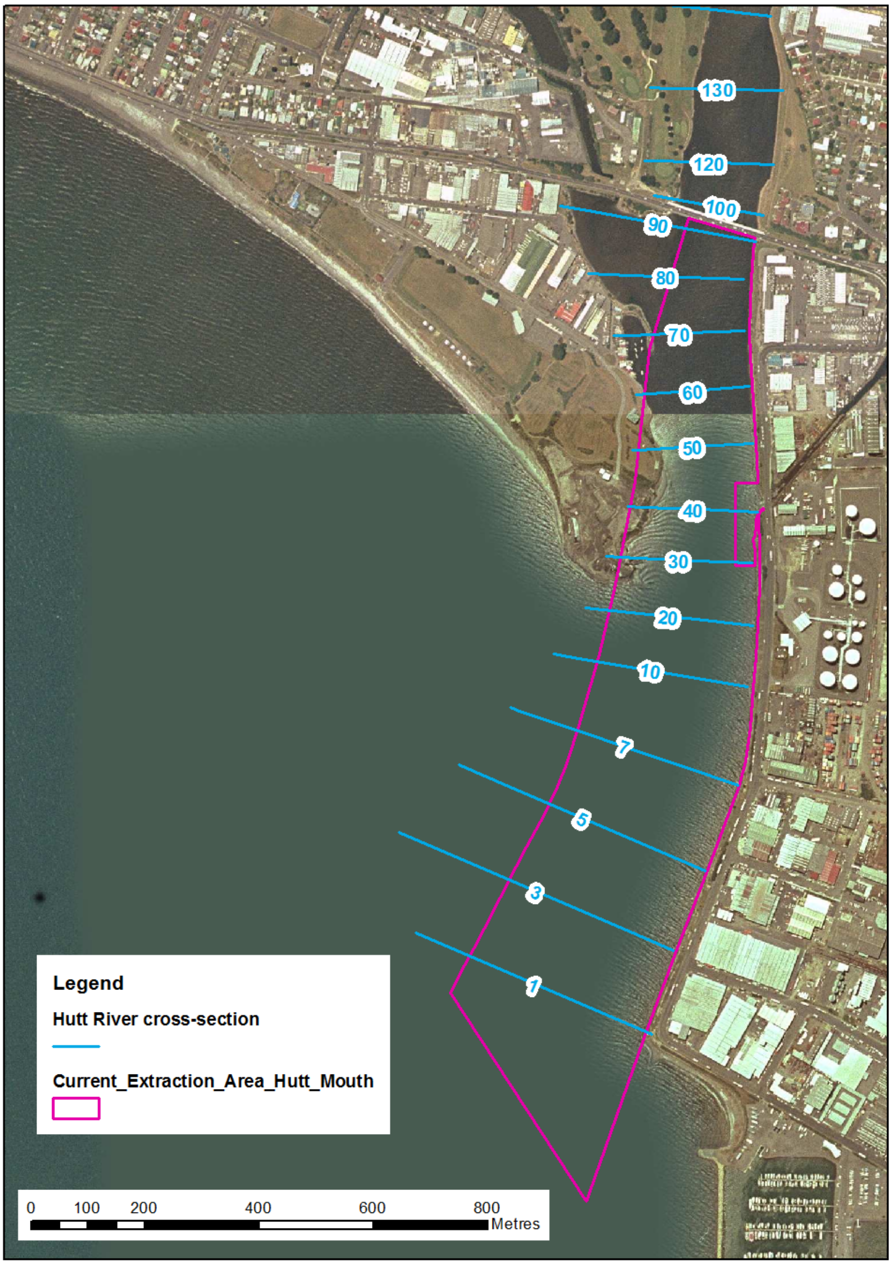


Figure 1 Hutt River mouth extraction area

A 1988 study (Clarke, 1988) assessed the impact of bed level lowering and widening below the Estuary Bridge. For this current study, the "Hydraulic Line", defining the width of the flood channel below the bridge (following the right extent of the extraction area in Figure 1) is assumed. Otherwise, the hydraulic model results and conclusions of the 1998 study are updated in this report. The discussion of sediment transport in the 1998 report is updated by two reports from Opus (2010a, b).

2. Model

An existing MIKE 11 model has been used for this exercise. The model was originally developed in the early 1990s (Barnett Consultants, 1993) and has been refined and updated over the years since. The model was recalibrated in 2002.

For this study, the model has been truncated upstream of Melling Bridge and some of the Hutt floodplain branches have been removed to reduce the model size. Those changes have no impact in the area of interest.

Note that the downstream end of the model is at cross-section 3, i.e. model chainage 50459m. The 1988 Mouth Study modelling extended the model further out into the harbour. However, results from that modelling showed very little fall from cross-section 3, and this model boundary is considered reasonable.

2.1.1 Bridge Representation

The Estuary Bridge has been remodelled as with a bridge structure now available within the software, replacing the previous representation of the bridge as a culvert and weir.

An attempt has also been made to model Ava Bridge with a bridge structure. Although model results appeared stable, unlike those of a previous attempt at using a bridge structure in 2002, results gave what seemed unrealistically high water levels upstream of the bridge. For final model runs, the bridge was not modelled (either with a bridge structure or with the culvert representation of the previous model). Results will therefore be conservative, as without any structure modelled at the bridge site, the backwater effect of bed level changes near the mouth will extend further upstream than would otherwise be the case (if anything, a structure would have the effect of drowning out any effect upstream).

3. Mouth Bed Conditions

The prime aim of the modelling is to determine the sensitivity of results to mouth bed levels. Four scenarios have been modelled:

- 2009 bed levels
- 1998 bed levels,
- -2.5m RL bed levels
- -2.0m RL bed levels

The 2009 surveyed cross-sections were used for the 2009 bed level model. Above Estuary Bridge, the survey did not cover the berms, so the berms were based either on 1998 sections or design sections (accounting for recent works in the Ava to Ewen reach and at the Black Creek outlet) as appropriate.

The 1998 bed model was based on the 1998 survey, modified to include design sections for the Ava to Ewen reach and Black Creek outlet works.

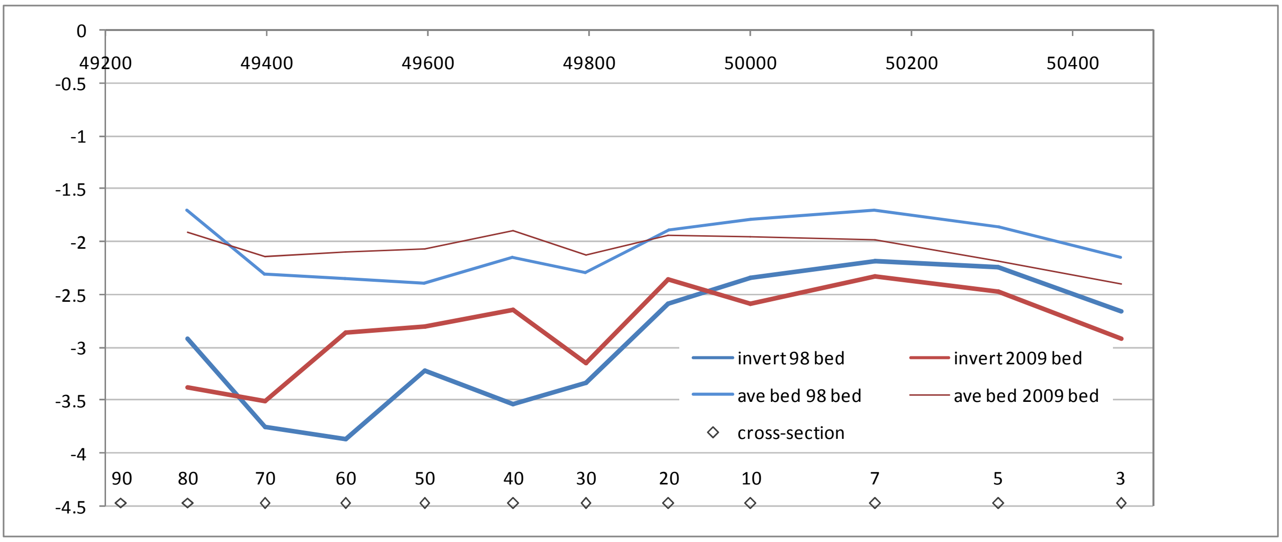


Figure 2 Bed levels for 1998 and 2009 surveys

Figure 2 shows the invert of the bed recorded in the 1998 and 2009 surveys. (The "hydraulic line" has been taken as the right, i.e. western, extent of the bed.) The mean bed level (calculated below the RL = 0 datum) is also plotted in Figure 2. This shows that the bed is higher downstream of section 20.

After consideration of Figure 2, it was decided to model the two additional bed scenarios of -2.5m RL and 2.0m RL. The 2009 bed model was modified by changing the cross-sections to have a typically flat bed of -2.5m RL and -2.0m RL over the approximate width of the extraction zone, representing greater and lesser extraction scenarios. Figure 3 shows the average bed levels (again, calculated below 0m RL) for the four scenarios.

The cross-sections for each of the four scenarios are presented in Appendix II.

Relative to the 2009 bed, the volume changes between cross-section 90 and cross-section 3 of the other three scenarios are

- 1998 bed: -21700 m^3 aggradation
- -2.5m bed: 56870 m^3 degradation
- -2.0m bed: -65530 m^3 aggradation

For comparison, the extraction in over the last ten years has been between 35000 m^3 and 50000 m^3 per annum (Opus, 2010b).

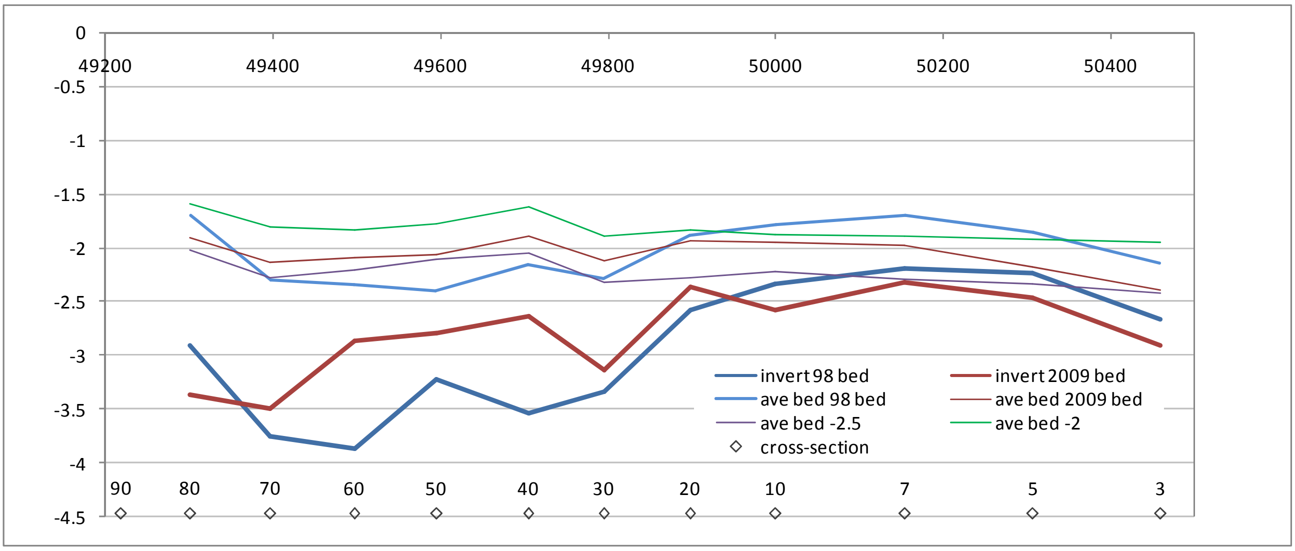


Figure 3 Average bed levels

4. Design Scenarios

4.1 Flow scenarios

The bed level scenarios were modelled with the following Hutt River flow and tide scenarios:

- 2800 m^3/s peak flow hydrograph (the design standard adopted for new works upstream of Ava Bridge). Tide held constant at 1.5m RL at time of flow peak.
- 2800 m^3/s peak flow hydrograph, constant tide of 2.2m RL (a more extreme tide of 2m RL plus 0.2m allowance for sea level rise to c2040).
- 2300 m^3/s peak flow (approximately 440 year return period), tide held constant at 1.5m RL at time of flow peak.
- 2300 m^3/s peak flow, constant tide of 2.2m RL
- 1900 m^3/s peak flow(approximately 100 year return period), tide held constant at 1.5m RL
- 15 m^3/s constant flow (median Hutt River flow), approximate spring tide cycle (0.7m RL high tide, -0.7m RL low tide).
- 15 m^3/s constant flow (median Hutt River flow), approximate spring tide cycle with 0.2m sea level rise (i.e. 0.9m RL high tide, -0.5m RL low tide).
- 777 m^3/s peak flow (approximately 2 year return period), spring tide cycle timed so that peak flow occurs at high tide

Table 1 summarises the combinations of bed level, flow and tide conditions modelled.

Bed scenario	Tide condition	Peak Flow (m^3/s)				
		2800	2300 (440 year)	1900 (100 year)	15 (median) (constant)	777 (2 year)
2009 bed	1.5m (rise to constant)	1	3	5		
	2.2m constant	2	4			
	spring tide cycle				6	29
	spring tide + 0.2m SLR				7	
1998 bed	1.5m (rise to constant)	8	10	12		
	2.2m constant	9	11			
	spring tide cycle				13	30
	spring tide + 0.2m SLR				14	
-2.5m RL	1.5m (rise to constant)	15	17	19		
	2.2m constant	16	18			
	spring tide cycle				20	31
	spring tide + 0.2m SLR				21	
-2m RL	1.5m (rise to constant)	22	24	26		
	2.2m constant	23	25			
	spring tide cycle				27	32
	spring tide + 0.2m SLR				28	

Table 1 Bed level and flow/tide combinations modelled (numbers refer to simulation number and results in Appendix III)

4.2 Results

Selected results are presented and discussed below. Results for all simulations are summarised in Appendix III.

4.2.1 2800 cumecs and 1.5m tide

Results of the 2800 m^3/s + 1.5m tide scenario showed that the bed extraction effects reduced to less than 100 mm upstream of the Ava Bridge (Figure 4). As noted above, if the Ava Bridge structure was modelled, the impact of bridge would be expected to drown out any impacts of extraction upstream of the bridge.

(Results for the 2800 cumec flood + 2.2m tide scenario show a similar relativity of the bed level cases, albeit with slightly higher levels. The impact of the higher tide diminishes further upstream.)

Note that it is not possible to pass 2800 m^3/s through the Ava Bridge, and so the results for this scenario are somewhat academic. Indeed, earlier detailed modelling of the Ava Bridge indicated that the bridge capacity was only around 2200 m^3/s (Wallace, 2006).

It is interesting to note that, peak flood levels for the -2m RL bed case are the highest of the four bed scenarios immediately downstream of Estuary Bridge, as expected, but drop below the 2009 bed case upstream of the bridge. More detailed testing of the model representation of the bridge could be warranted, although without better calibration information around the bridge it may be difficult to conclude much.

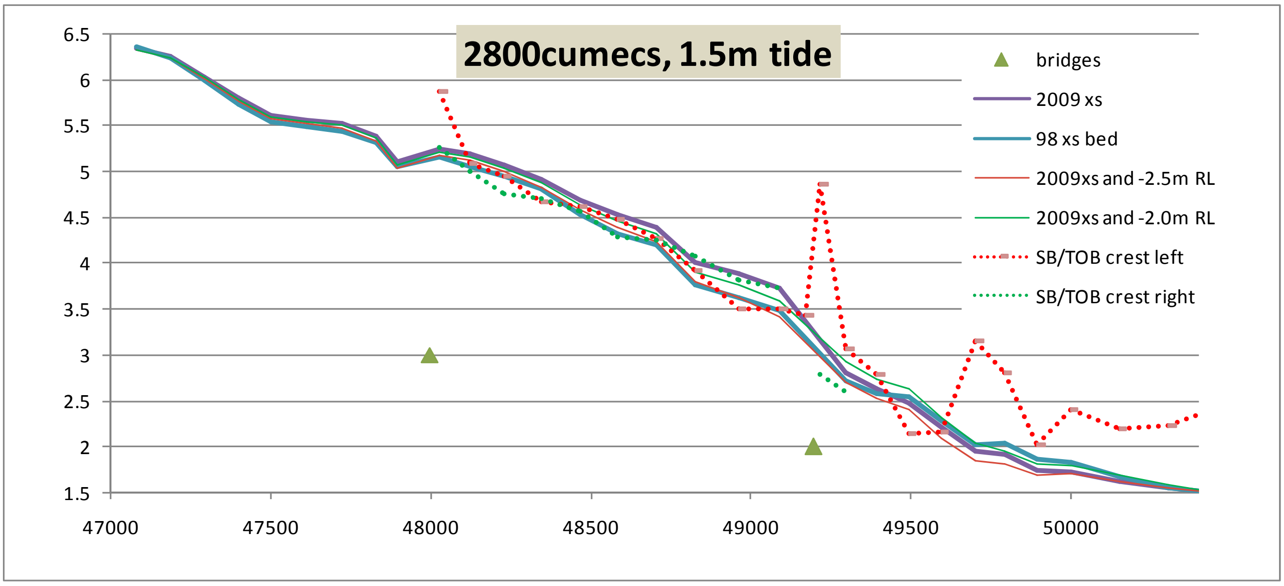


Figure 4 Peak flood levels: 2800 m^3/s flow and 1.5m tide.

4.2.2 2300 cumecs and 1.5m tide

Greater Wellington has adopted a freeboard of 900 mm (in general) for design purposes. Upstream of the Estuary Bridge, freeboard is less than 900 mm, regardless of the bed level scenario. The -2m RL bed level aggradation case is predicted to raise peak flood levels by between 25 mm and 80 mm between Estuary Bridge and Ava Bridge, compared to the 2009 surveyed bed case. The -2.5m RL degradation case would lower levels by between 80 mm and 280 mm over the same reach. (Figure 5)

Downstream of the Estuary Bridge, there are no formed stopbanks. However, generally the Seaview industrial area on the left bank is above the 2300 m^3/s flood level, the exception being at around section 50-60 where aggradation would lead to some bank overtopping.

Peak channel-average velocities are plotted in Figure 6. Central channel velocities would be higher, but the same patterns are expected. Upstream of Estuary Bridge, there is very little difference between the bed level cases. Downstream, the -2m RL bed level case gives slightly higher velocities, as expected. At the velocities indicated however, some scour can be expected.

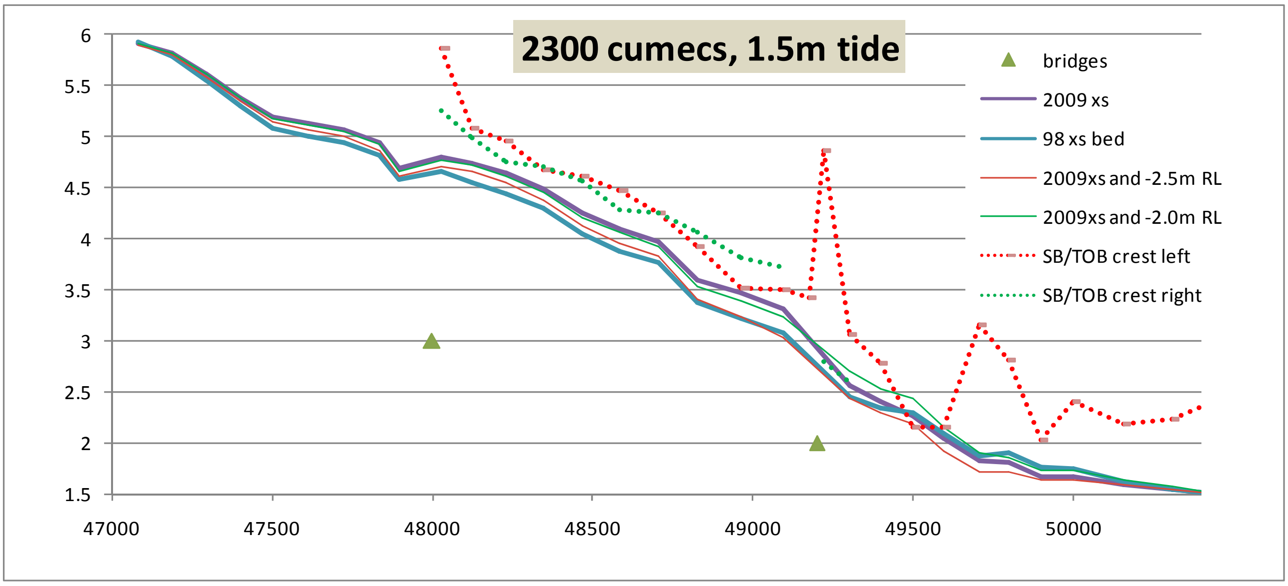


Figure 5 Peak flood levels: 2300 m3/s flow and 1.5m tide.

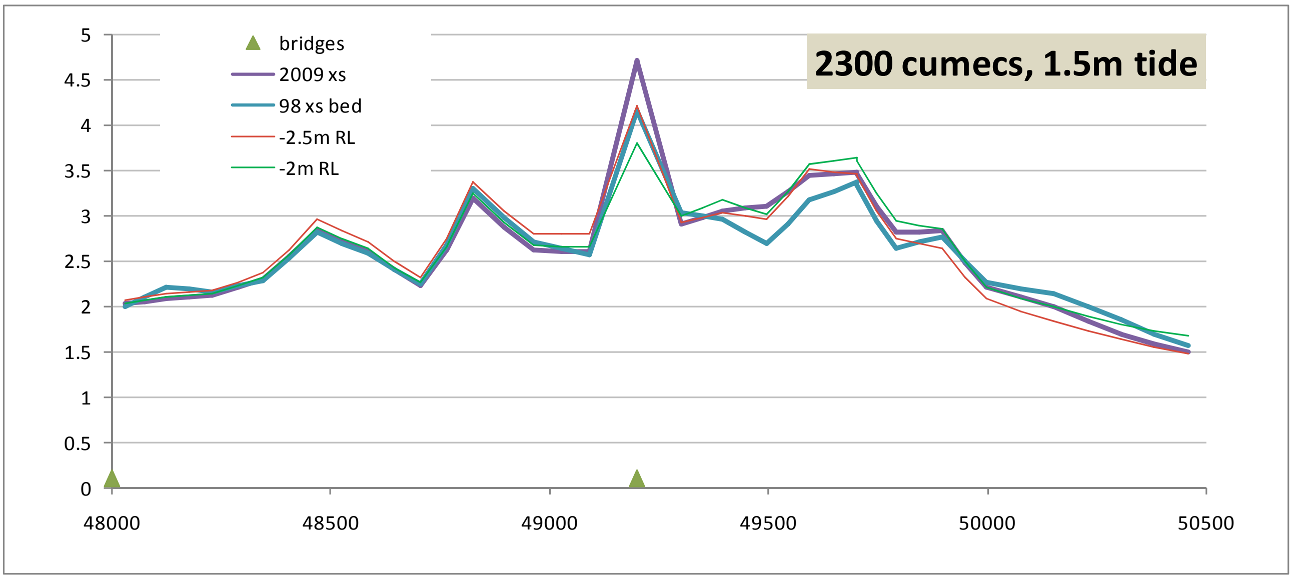


Figure 6 Peak channel-average velocities: 2300 m3/s flow and 1.5m tide.

4.2.3 1900 cumecs and 1.5m tide

The -2m RL case leads to a rise in flood levels of around 200 mm immediately downstream of Estuary Bridge, but makes no significant difference to water levels upstream, compared to the 2009 bed case. Degradation to -2.5m RL lowers levels upstream by up to 200 mm. (Figure 7).

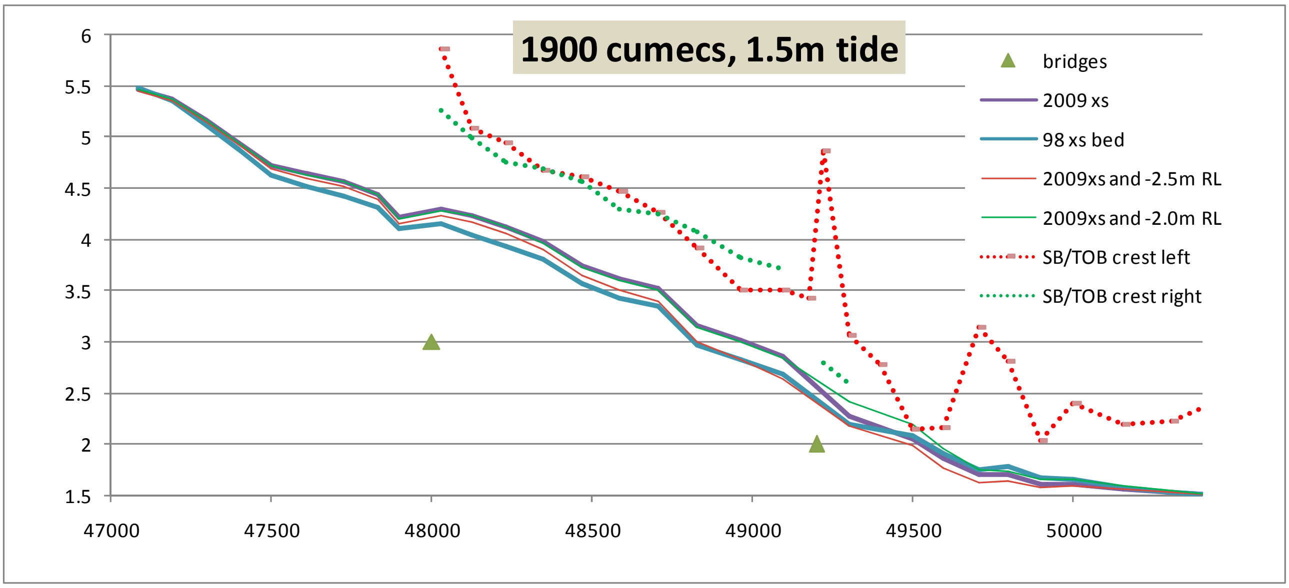


Figure 7 Peak channel-average velocities: 1900 m3/s flow and 1.5m tide.

4.2.4 777 cumecs and spring tide

A smaller and more frequent flood has been modelled together with a spring tide scenario, to assess possible impact upon local drainage. If river levels in such event are raised due to bed aggradation, gravity outlets may not function as well.

Hydrographs for river levels at cross-sections 40 and 80 are presented in Figures 8 and 9. These show possible impacts in the lower Waiwhetu Stream (in the case of no flood flow in the Waiwhetu Stream) and in Te Mome Stream (??), respectively.

Figure 8 shows that the -2m RL case could impact on the drainage in Te Mome Stream, depending on the head in Stream. There is little difference between the other bed level scenarios.

The impact on drainage in lower Waiwhetu Stream outfalls is lessed marked, although there might be some minor improvements with the -2.5m RL case (Figure 9).

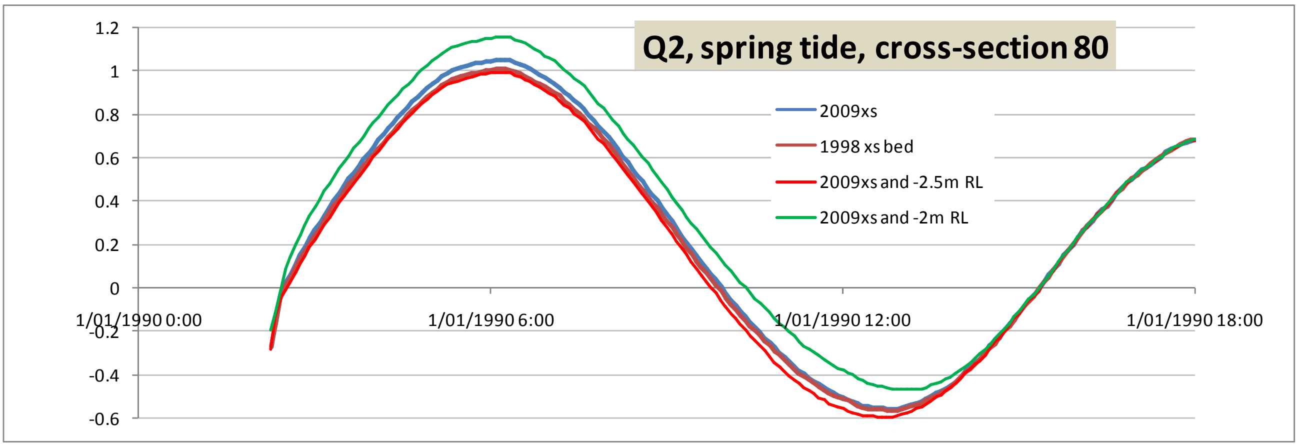


Figure 8 Flood hydrograph at cross-section 80

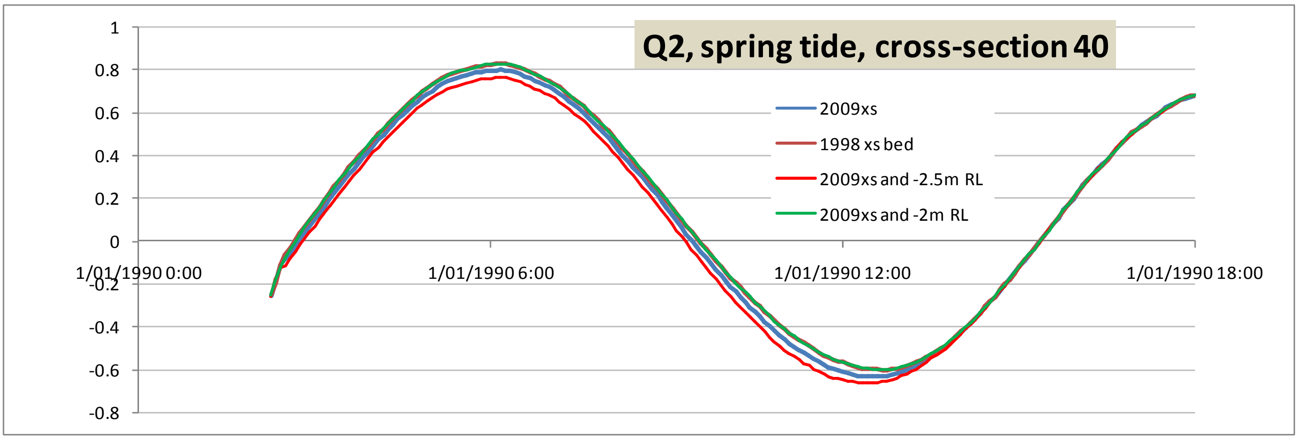


Figure 9 Flood hydrograph at cross-section 40

4.2.5 Median flow and spring tide

The impact of bed level changes upon river levels in median flow is negligible (Figure 10).

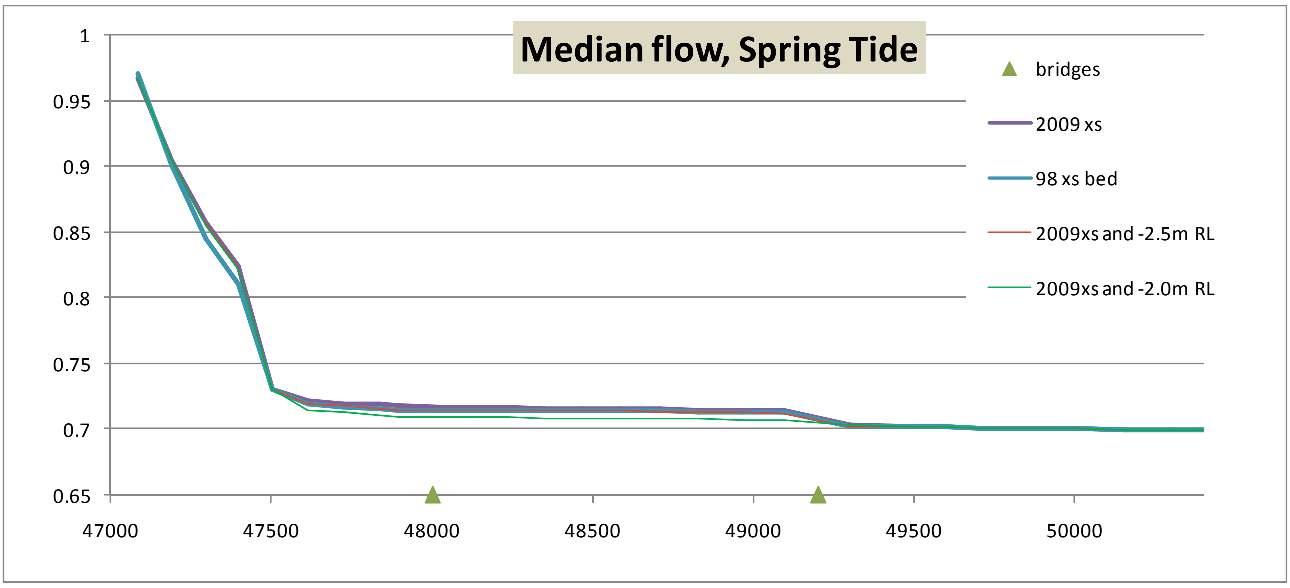


Figure 10 River levels for median flow and spring tide conditions

5. Conclusions

There has been slight aggradation below the Estuary Bridge in recent years (Opus, 2010b), and model results confirm that this has lead to a rise in design flood levels between 1998 and 2009. Continued aggradation is predicted to lead to further rises in design levels downstream of the Estuary Bridge, although upstream the effect is not so clear. If extraction was to cease, the aggradation would be accelerated. On the other hand, greater extraction would lead to a lowering of design flood levels at least as far upstream as the Ava Bridge. Nonetheless, freeboard is less than desired in design flood events regardless of the bed level scenarios tested.

Drainage in lower floodplain areas might also be affected by aggradation or degradation of the river bed in small river flood events.

6. References

Barnett Consultants (1993); Hutt River Flood Control Scheme Review: Floodplain Hydraulic Modelling.

Clarke, G.D. (1988); Hutt River Flood Control Scheme Review: Interim Report – Hutt River Mouth Sedimentation Study. Wellington Regional Council.

Opus (2010a); Hutt River Mouth: Fluvial Sediment Transport.

Opus (2010b); Hutt River Mouth: Coastal sediment transport processes and beach dynamics.

Wallace, P. (2006); Hydraulic Modelling of Hutt River at Ava Rail Bridge. Greater Wellington. Powerdocs #359926.

Appendix I – Files Used

All files are held on the Greater Wellington (Flood Protection) computer system *yet to transfer*

MIKE11 files

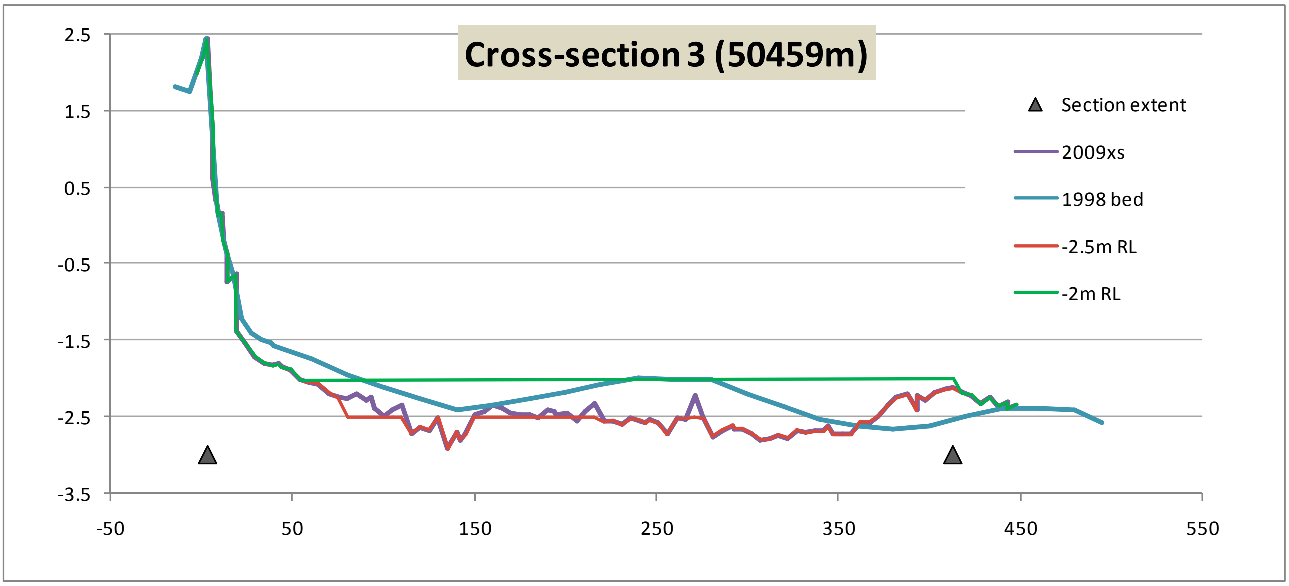
All files can be tracked via the batch file *Mouth.bs11*

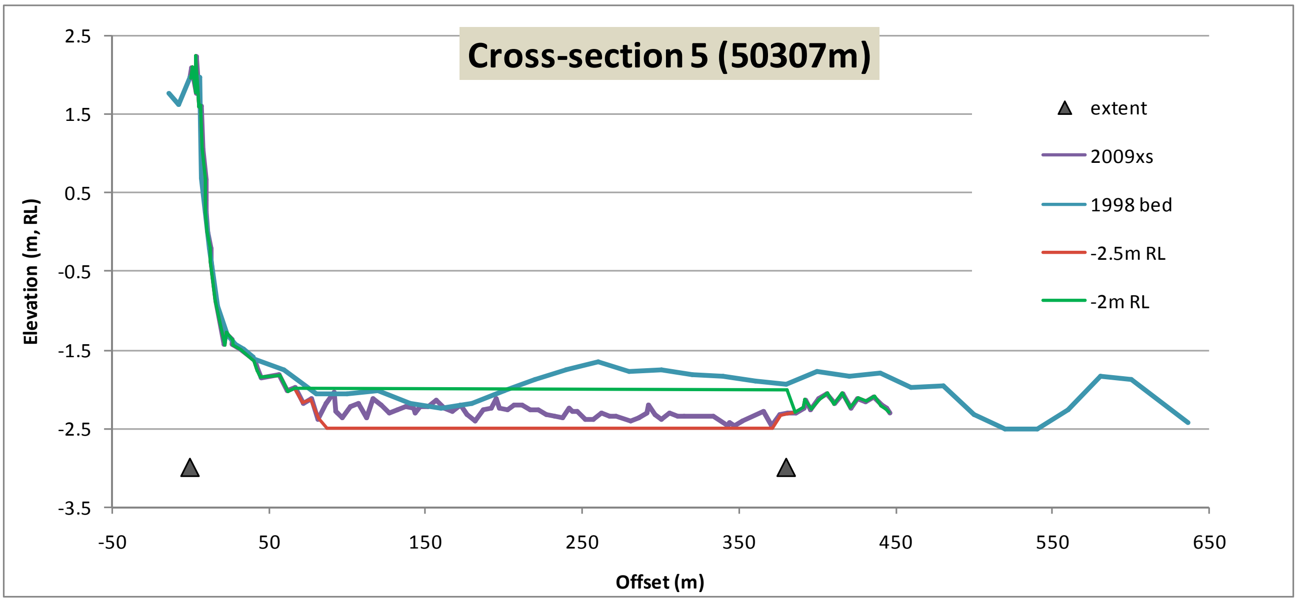
Spreadsheets

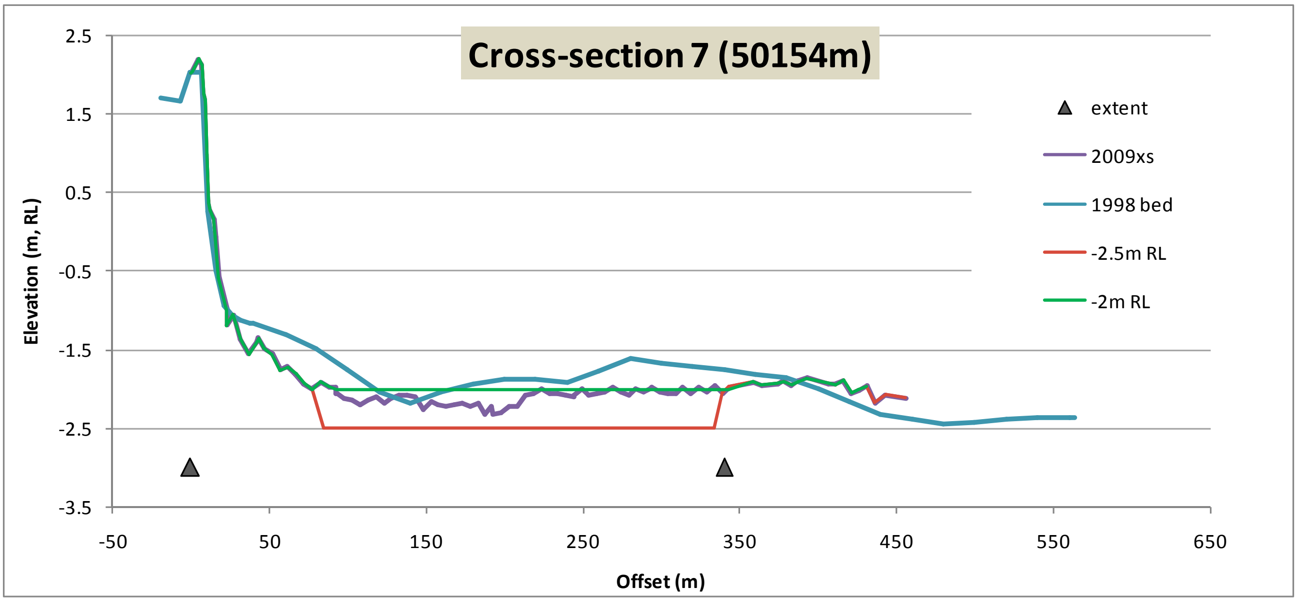
Mouth results (Autosaved).xlsx
2009_Cross_sections.xlsx

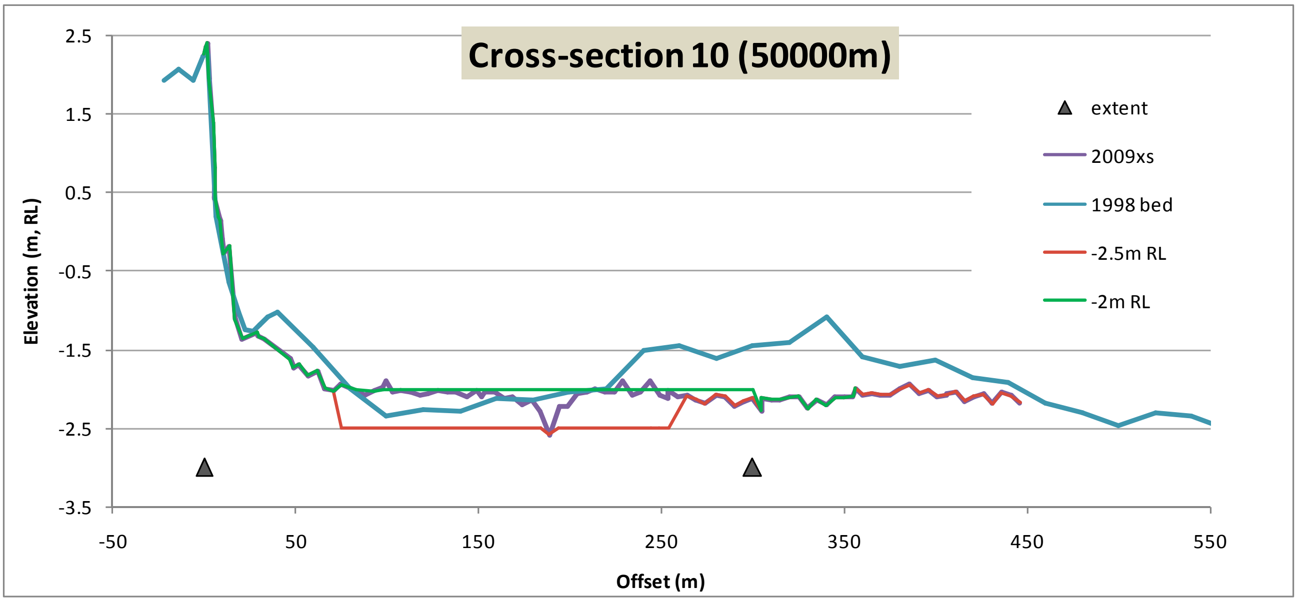
Appendix II – River Cross-sections

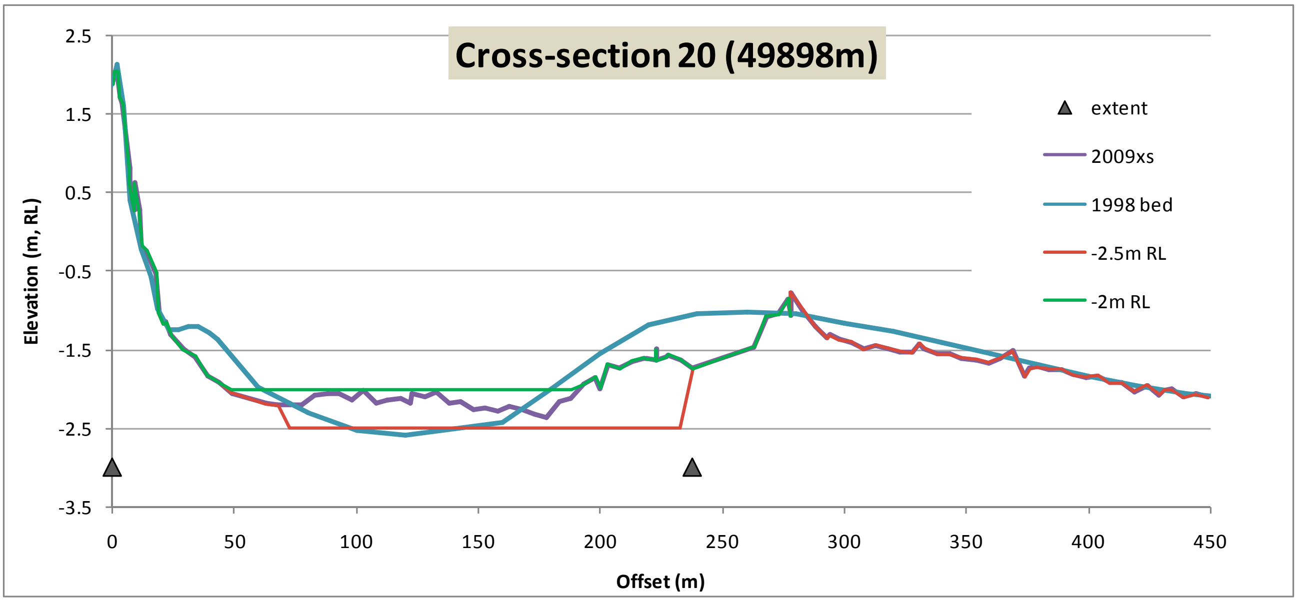
Following are plots of cross-sections. After 1987, the river berms were not surveyed again until 2009. Hence the 1998 cross-sections have been supplemented with the 1987 berm data (and hence modelling prior to 2009 assumed those 1987 berms in the modelling – see for example cross-sections 520 and 530).

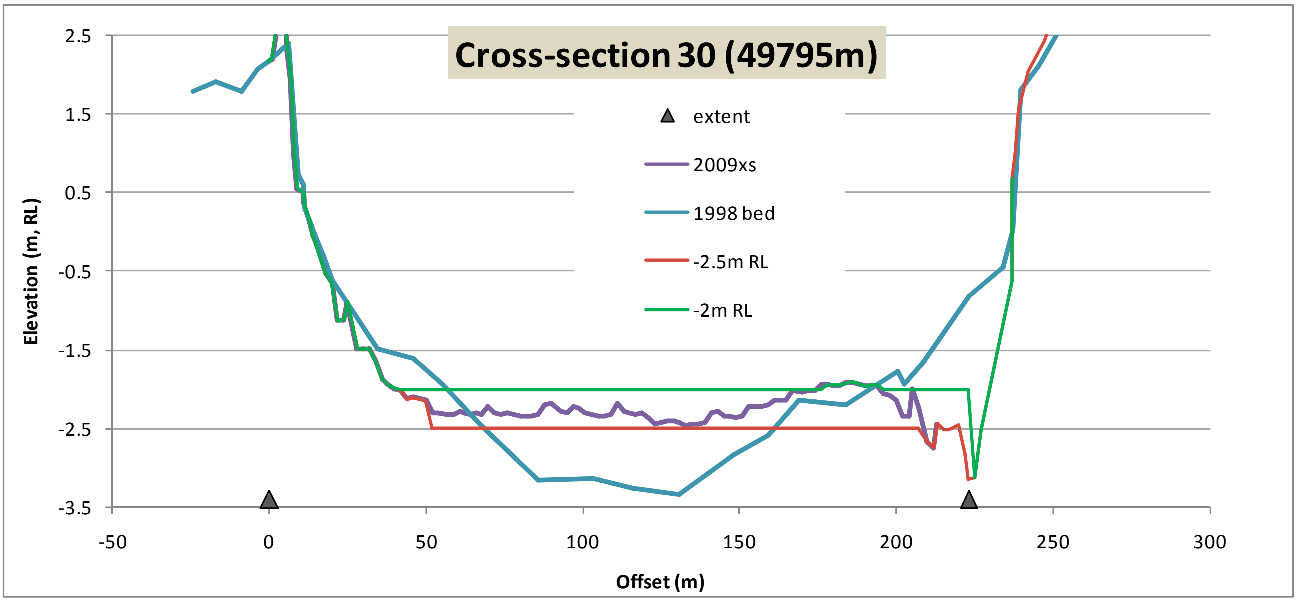


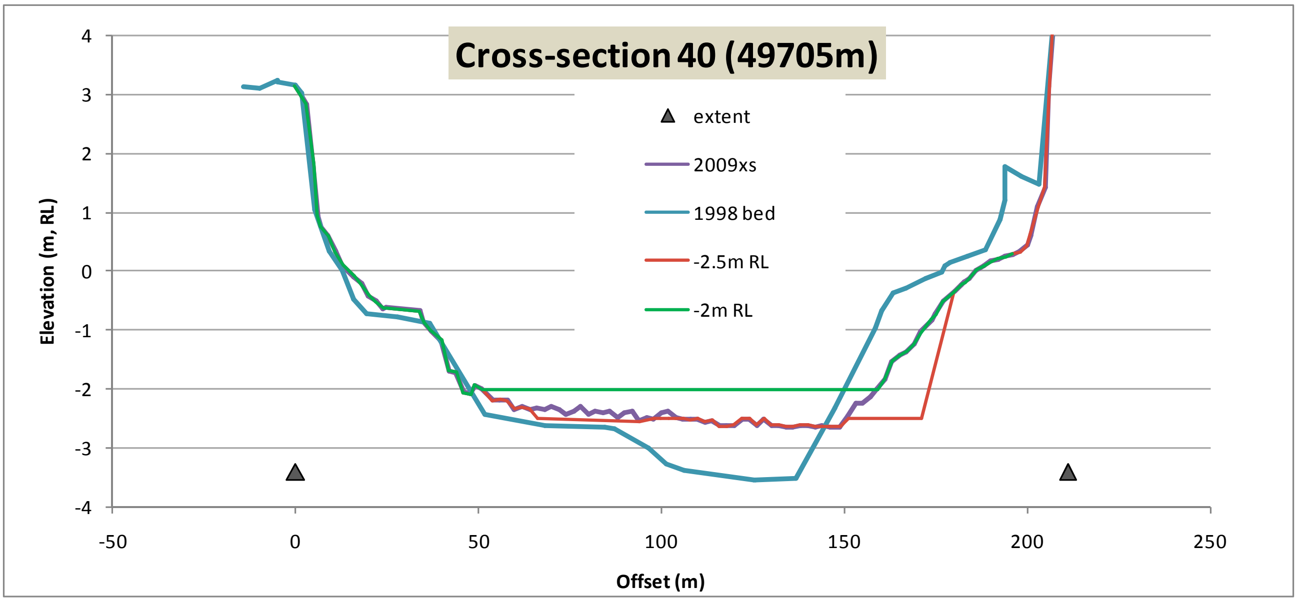


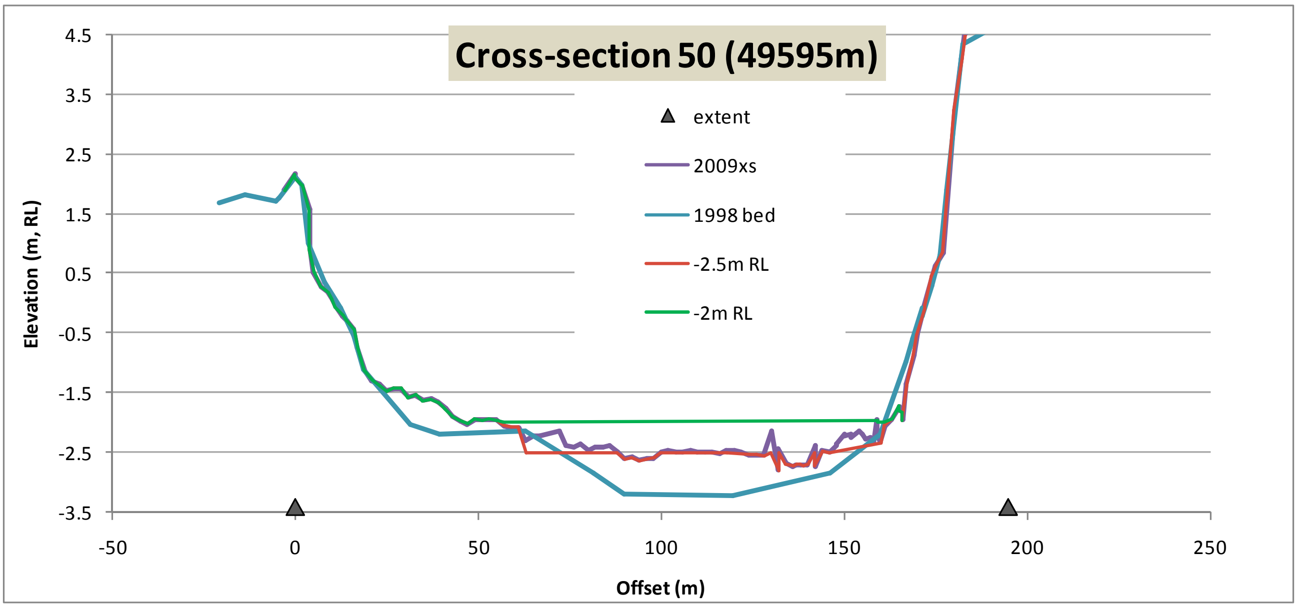

Cross-section 7 (50154m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL
Elevation (m, RL)
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-50
50
150
250
350
450
550
650
Offset (m)

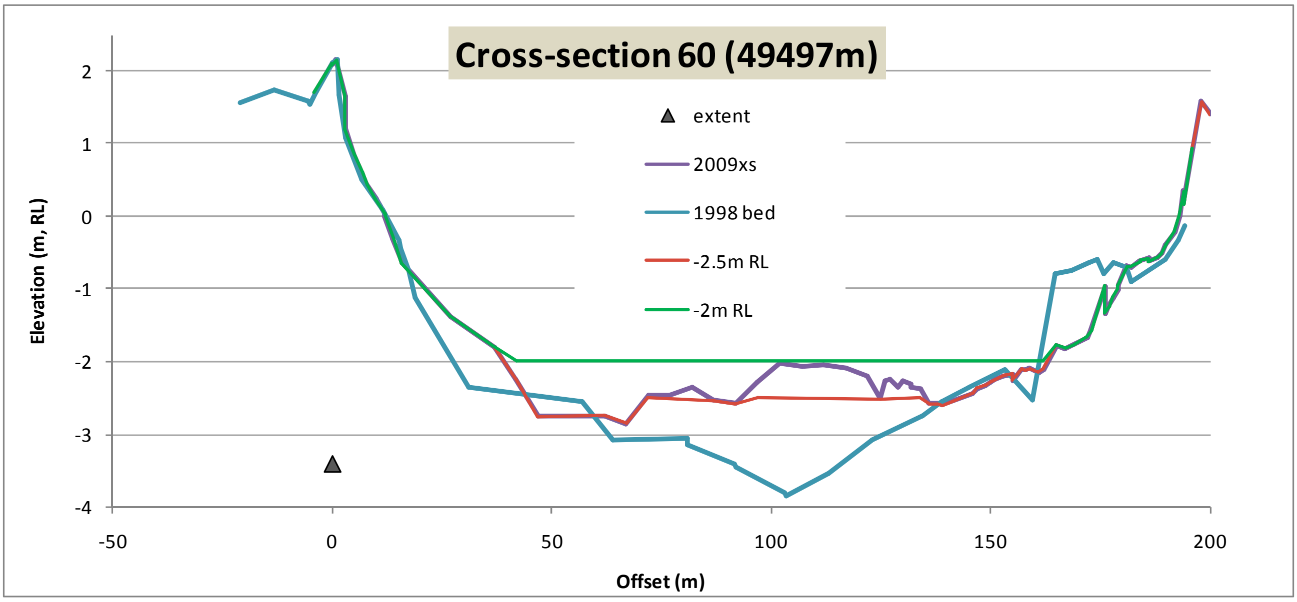

Cross-section 10 (50000m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL
Elevation (m, RL)
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-50
50
150
250
350
450
550
Offset (m)

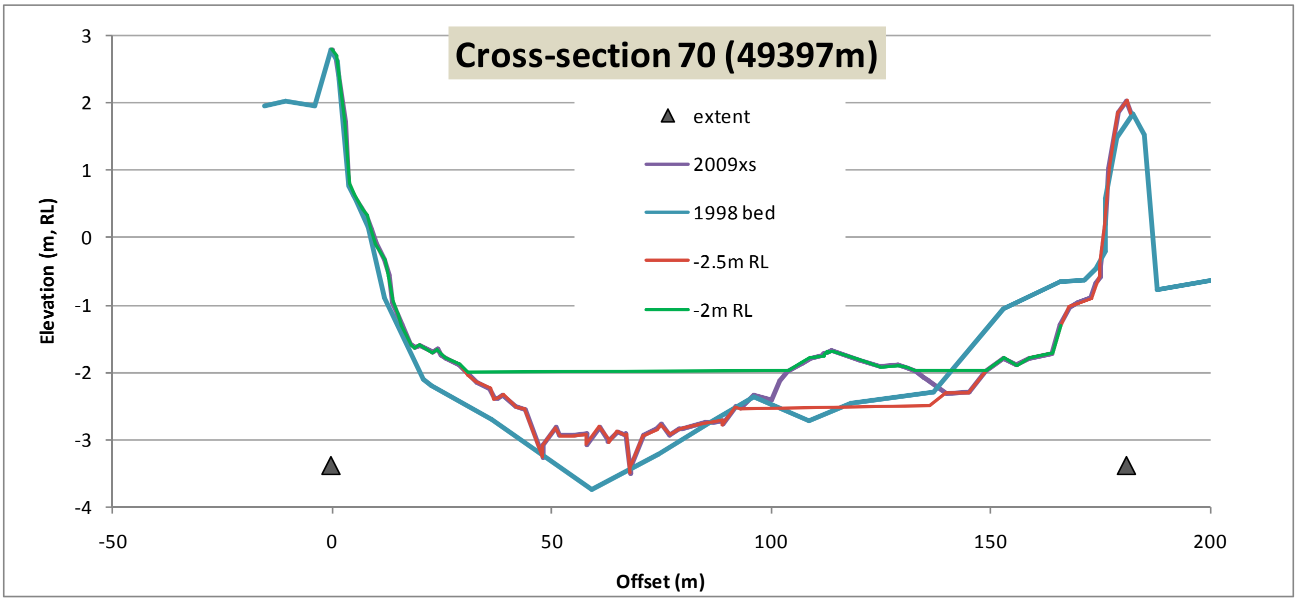

Cross-section 20 (49898m)
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
Elevation (m, RL)
0
50
100
150
200
250
300
350
400
450
Offset (m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL

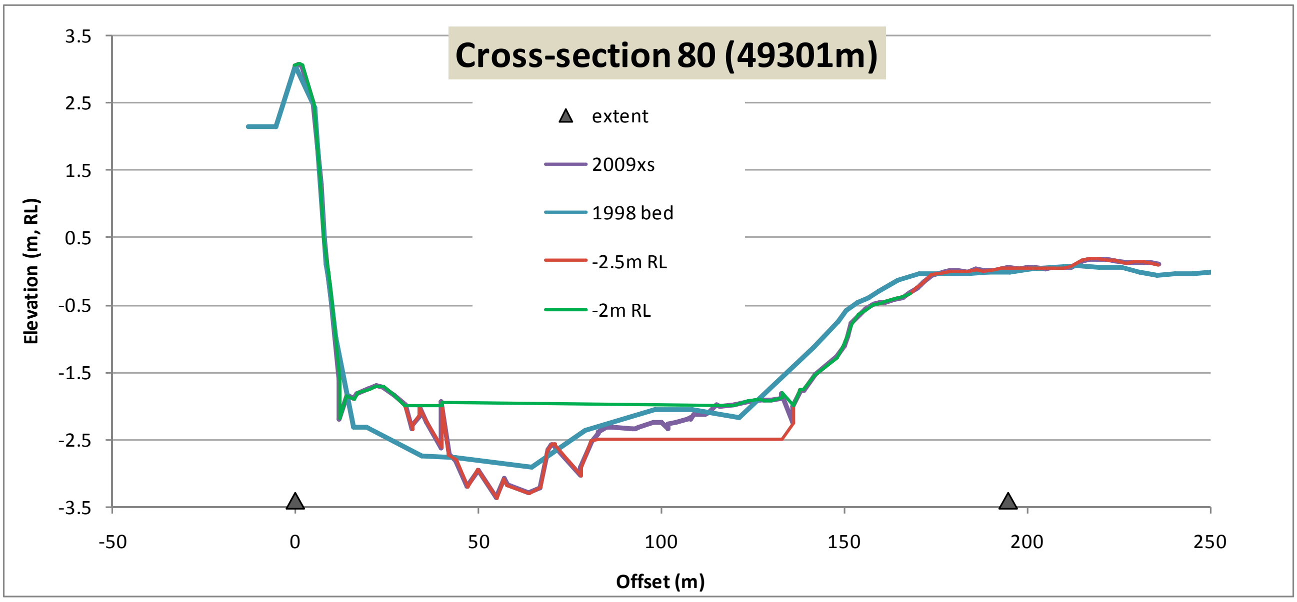

Cross-section 30 (49795m)
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
Elevation (m, RL)
-50
0
50
100
150
200
250
300
Offset (m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL


Cross-section 40 (49705m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL
Elevation (m, RL)
Offset (m)
4
3
2
1
0
-1
-2
-3
-4
-50
0
50
100
150
200
250


Cross-section 50 (49595m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL
Elevation (m, RL)
Offset (m)
4.5
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-50
0
50
100
150
200
250


Cross-section 60 (49497m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL
Elevation (m, RL)
Offset (m)
2
1
0
-1
-2
-3
-4
-50
0
50
100
150
200


Cross-section 70 (49397m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL
Elevation (m, RL)
Offset (m)
3
2
1
0
-1
-2
-3
-4
-50
0
50
100
150
200



Cross-section 80 (49301m)
extent
2009xs
1998 bed
-2.5m RL
-2m RL
Elevation (m, RL)
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-50
0
50
100
150
200
250
Offset (m)

Appendix III – Model Result Tables

Cross-section	MIKE 11 Branch & Chainage		Simulation													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
320	HUTT	46835	6.924	6.926	6.454	6.460	5.961	1.120	1.120	6.924	6.929	6.448	6.457	5.961	1.123	1.123
300	HUTT	46981	6.468	6.471	6.049	6.058	5.604	1.023	1.023	6.469	6.476	6.041	6.053	5.604	1.028	1.028
290	HUTT	47085	6.338	6.341	5.918	5.928	5.472	0.967	0.967	6.363	6.371	5.929	5.944	5.490	0.971	0.971
280	HUTT	47191	6.251	6.254	5.826	5.837	5.375	0.904	0.933	6.228	6.237	5.790	5.807	5.350	0.901	0.930
270	HUTT	47295	6.031	6.035	5.616	5.630	5.173	0.857	0.930	5.984	5.995	5.553	5.573	5.120	0.845	0.926
260	HUTT	47399	5.792	5.797	5.386	5.402	4.947	0.824	0.927	5.735	5.748	5.307	5.332	4.880	0.810	0.924
250	HUTT	47501	5.610	5.616	5.188	5.209	4.725	0.730	0.923	5.537	5.554	5.083	5.117	4.632	0.730	0.919
240	HUTT	47612	5.563	5.570	5.124	5.149	4.638	0.722	0.920	5.480	5.499	5.001	5.041	4.522	0.719	0.917
230	HUTT	47726	5.528	5.536	5.073	5.100	4.564	0.720	0.919	5.437	5.459	4.936	4.981	4.431	0.717	0.915
220	HUTT	47834	5.384	5.392	4.940	4.969	4.438	0.719	0.918	5.306	5.329	4.812	4.861	4.316	0.716	0.915
210	HUTT	47899	5.105	5.114	4.688	4.721	4.211	0.718	0.917	5.052	5.077	4.582	4.635	4.112	0.715	0.914
200	HUTT	48030	5.235	5.245	4.795	4.829	4.291	0.717	0.917	5.152	5.178	4.656	4.713	4.162	0.715	0.914
190	HUTT	48124	5.186	5.196	4.745	4.780	4.236	0.717	0.917	5.046	5.074	4.543	4.606	4.041	0.714	0.913
180	HUTT	48229	5.075	5.086	4.637	4.676	4.126	0.717	0.916	4.947	4.977	4.442	4.510	3.938	0.714	0.913
170	HUTT	48348	4.912	4.924	4.483	4.526	3.978	0.716	0.916	4.802	4.836	4.304	4.378	3.806	0.714	0.913
160	HUTT	48468	4.683	4.698	4.248	4.300	3.745	0.716	0.916	4.529	4.569	4.043	4.128	3.566	0.714	0.913
150	HUTT	48586	4.532	4.551	4.096	4.156	3.616	0.716	0.915	4.326	4.370	3.881	3.970	3.434	0.714	0.913
140	HUTT	48706	4.393	4.416	3.970	4.035	3.519	0.716	0.915	4.190	4.238	3.775	3.868	3.343	0.714	0.913
130	HUTT	48827	4.002	4.032	3.591	3.672	3.156	0.715	0.915	3.766	3.828	3.370	3.489	2.962	0.713	0.913
120	HUTT	48964	3.886	3.923	3.466	3.561	3.020	0.715	0.914	3.626	3.703	3.223	3.369	2.821	0.713	0.913
110	HUTT	49094	3.731	3.773	3.307	3.417	2.864	0.715	0.914	3.477	3.565	3.078	3.244	2.687	0.713	0.912
80	HUTT	49301	2.801	2.980	2.555	2.809	2.276	0.703	0.903	2.710	2.909	2.446	2.740	2.190	0.702	0.902
70	HUTT	49497	2.467	2.707	2.267	2.584	2.046	0.702	0.902	2.539	2.781	2.303	2.639	2.078	0.702	0.902
60	HUTT	49497	2.467	2.707	2.267	2.584	2.046	0.702	0.902	2.539	2.781	2.303	2.639	2.078	0.702	0.902
50	HUTT	49595	2.209	2.513	2.042	2.492	1.867	0.702	0.902	2.277	2.567	2.085	2.489	1.908	0.702	0.902
40	HUTT	49705	1.952	2.468	1.824	2.443	1.702	0.701	0.901	2.024	2.472	1.873	2.448	1.746	0.701	0.901
30	HUTT	49795	1.913	2.436	1.807	2.407	1.704	0.701	0.901	2.040	2.440	1.900	2.418	1.777	0.701	0.901
20	HUTT	49898	1.743	2.400	1.672	2.368	1.609	0.701	0.901	1.864	2.398	1.760	2.381	1.673	0.701	0.901
10	HUTT	50000	1.733	2.368	1.673	2.337	1.616	0.701	0.901	1.835	2.363	1.742	2.348	1.664	0.701	0.901
7	HUTT	50154	1.620	2.322	1.588	2.293	1.558	0.700	0.900	1.671	2.317	1.620	2.305	1.579	0.700	0.900
5	HUTT	50307	1.552	2.259	1.538	2.242	1.525	0.700	0.900	1.561	2.249	1.542	2.242	1.527	0.700	0.900
3	HUTT	50459	1.500	2.200	1.500	2.200	1.500	0.700	0.900	1.500	2.200	1.500	2.200	1.500	0.700	0.900

Peak river levels

Cross-section	MIKE 11 Branch & Chainage		Simulation																	
			15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
320	HUTT	46835	6.911	6.915	6.440	6.448	5.953	1.120	1.120	6.918	6.922	6.450	6.457	5.960	1.120	1.120	4.202	4.232	4.199	4.202
300	HUTT	46981	6.450	6.455	6.030	6.041	5.593	1.023	1.023	6.460	6.465	6.044	6.053	5.603	1.023	1.023	4.009	4.045	4.005	4.009
290	HUTT	47085	6.316	6.323	5.896	5.909	5.459	0.967	0.967	6.328	6.334	5.911	5.923	5.470	0.967	0.967	3.901	3.949	3.896	3.901
280	HUTT	47191	6.227	6.234	5.801	5.815	5.360	0.904	0.931	6.240	6.247	5.818	5.831	5.373	0.904	0.925	3.812	3.82	3.807	3.812
270	HUTT	47295	6.002	6.011	5.587	5.604	5.155	0.856	0.927	6.018	6.026	5.608	5.623	5.171	0.855	0.922	3.652	3.62	3.646	3.652
260	HUTT	47399	5.757	5.768	5.349	5.371	4.925	0.823	0.925	5.776	5.786	5.375	5.393	4.945	0.822	0.919	3.455	3.409	3.446	3.455
250	HUTT	47501	5.566	5.579	5.140	5.168	4.695	0.730	0.920	5.590	5.602	5.173	5.197	4.722	0.730	0.915	3.133	3.055	3.118	3.133
240	HUTT	47612	5.513	5.528	5.068	5.101	4.600	0.720	0.918	5.540	5.554	5.108	5.136	4.634	0.714	0.912	2.901	2.77	2.877	2.901
230	HUTT	47726	5.474	5.490	5.011	5.047	4.521	0.718	0.916	5.503	5.519	5.055	5.085	4.560	0.713	0.911	2.783	2.618	2.754	2.783
220	HUTT	47834	5.325	5.343	4.871	4.912	4.391	0.716	0.915	5.357	5.374	4.920	4.953	4.434	0.711	0.910	2.68	2.524	2.646	2.68
210	HUTT	47899	5.039	5.059	4.612	4.657	4.158	0.715	0.915	5.075	5.094	4.666	4.703	4.206	0.710	0.909	2.534	2.403	2.494	2.534
200	HUTT	48030	5.165	5.187	4.714	4.762	4.234	0.715	0.914	5.204	5.223	4.771	4.810	4.285	0.709	0.909	2.537	2.391	2.493	2.537
190	HUTT	48124	5.114	5.136	4.660	4.710	4.176	0.715	0.914	5.153	5.174	4.720	4.761	4.230	0.709	0.908	2.445	2.191	2.395	2.445
180	HUTT	48229	4.996	5.020	4.544	4.599	4.059	0.714	0.914	5.039	5.061	4.610	4.654	4.119	0.709	0.908	2.303	2.023	2.24	2.303
170	HUTT	48348	4.823	4.850	4.379	4.440	3.902	0.714	0.914	4.871	4.896	4.453	4.502	3.970	0.708	0.908	2.207	1.957	2.14	2.207
160	HUTT	48468	4.572	4.605	4.123	4.196	3.655	0.714	0.913	4.632	4.663	4.212	4.271	3.736	0.708	0.908	2.017	1.779	1.929	2.017
150	HUTT	48586	4.396	4.434	3.961	4.040	3.512	0.714	0.913	4.466	4.506	4.057	4.122	3.605	0.708	0.908	1.904	1.673	1.799	1.904
140	HUTT	48706	4.234	4.277	3.827	3.911	3.401	0.713	0.913	4.313	4.362	3.928	3.998	3.507	0.708	0.907	1.784	1.595	1.675	1.784
130	HUTT	48827	3.795	3.852	3.405	3.514	3.002	0.713	0.912	3.899	3.962	3.536	3.625	3.140	0.708	0.907	1.52	1.341	1.39	1.52
120	HUTT	48964	3.628	3.701	3.232	3.370	2.832	0.713	0.912	3.759	3.838	3.399	3.506	3.001	0.707	0.907	1.439	1.28	1.292	1.439
110	HUTT	49094	3.422	3.510	3.027	3.194	2.639	0.712	0.911	3.580	3.675	3.228	3.353	2.841	0.707	0.906	1.344	1.218	1.181	1.344
80	HUTT	49301	2.697	2.903	2.437	2.735	2.179	0.702	0.902	2.934	3.112	2.703	2.897	2.415	0.703	0.903	1.156	1.009	0.995	1.156
70	HUTT	49497	2.408	2.678	2.191	2.555	1.984	0.702	0.902	2.631	2.859	2.435	2.690	2.192	0.702	0.902	1.039	0.957	0.907	1.039
60	HUTT	49497	2.408	2.678	2.191	2.555	1.984	0.702	0.902	2.631	2.859	2.435	2.690	2.192	0.702	0.902	1.039	0.957	0.907	1.039
50	HUTT	49595	2.094	2.500	1.923	2.500	1.773	0.702	0.902	2.323	2.595	2.157	2.483	1.963	0.702	0.902	0.937	0.896	0.826	0.937
40	HUTT	49705	1.842	2.445	1.721	2.433	1.628	0.701	0.901	2.032	2.469	1.899	2.447	1.758	0.701	0.901	0.827	0.827	0.761	0.827
30	HUTT	49795	1.809	2.416	1.716	2.405	1.641	0.701	0.901	1.960	2.441	1.854	2.418	1.741	0.701	0.901	0.82	0.838	0.767	0.82
20	HUTT	49898	1.693	2.379	1.631	2.369	1.583	0.701	0.901	1.805	2.409	1.729	2.386	1.651	0.701	0.901	0.779	0.793	0.743	0.779
10	HUTT	50000	1.701	2.344	1.644	2.334	1.596	0.701	0.900	1.800	2.382	1.731	2.359	1.659	0.701	0.901	0.774	0.78	0.742	0.774
7	HUTT	50154	1.623	2.286	1.588	2.282	1.559	0.700	0.900	1.689	2.336	1.644	2.313	1.598	0.700	0.900	0.745	0.739	0.724	0.745
5	HUTT	50307	1.558	2.240	1.541	2.240	1.527	0.700	0.900	1.593	2.267	1.570	2.253	1.547	0.700	0.900	0.721	0.713	0.711	0.721
3	HUTT	50459	1.500	2.200	1.500	2.200	1.500	0.700	0.900	1.500	2.200	1.500	2.200	1.500	0.700	0.900	0.7	0.7	0.7	0.7

Peak river levels

MIKE 11 Branch & Chainage		Simulation													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
HUTT	48229	2.24	2.24	2.12	2.10	2.10	0.82	0.81	2.24	2.23	2.16	2.12	2.06	0.87	0.85
HUTT	48229	2.23	2.22	2.12	2.10	2.10	0.82	0.81	2.24	2.22	2.16	2.12	2.06	0.87	0.85
HUTT	48288.5	2.33	2.32	2.21	2.18	2.18	0.73	0.73	2.32	2.30	2.22	2.18	2.11	0.75	0.73
HUTT	48348	2.44	2.43	2.30	2.28	2.28	0.67	0.66	2.40	2.38	2.29	2.25	2.16	0.67	0.65
HUTT	48408	2.66	2.65	2.54	2.51	2.51	0.79	0.78	2.62	2.60	2.53	2.47	2.39	0.75	0.73
HUTT	48468	2.93	2.91	2.84	2.80	2.80	0.91	0.90	2.90	2.86	2.82	2.75	2.68	0.84	0.81
HUTT	48527	2.79	2.77	2.71	2.67	2.67	0.94	0.92	2.78	2.75	2.70	2.63	2.55	0.85	0.82
HUTT	48586	2.66	2.64	2.60	2.55	2.55	0.96	0.94	2.68	2.64	2.58	2.52	2.43	0.85	0.82
HUTT	48586	2.64	2.62	2.60	2.55	2.55	0.96	0.94	2.68	2.64	2.58	2.52	2.43	0.86	0.82
HUTT	48646	2.49	2.47	2.40	2.36	2.36	0.92	0.89	2.53	2.49	2.40	2.35	2.25	0.84	0.79
HUTT	48706	2.35	2.33	2.23	2.19	2.19	0.89	0.84	2.39	2.36	2.25	2.20	2.09	0.83	0.77
HUTT	48766.5	2.75	2.73	2.62	2.58	2.58	0.94	0.88	2.84	2.80	2.67	2.60	2.49	0.93	0.84
HUTT	48827	3.33	3.30	3.19	3.12	3.12	0.98	0.91	3.48	3.42	3.30	3.19	3.09	1.04	0.94
HUTT	48895.5	3.00	2.97	2.88	2.81	2.81	0.92	0.83	3.15	3.09	2.97	2.86	2.78	0.93	0.83
HUTT	48964	2.74	2.71	2.62	2.55	2.55	0.87	0.76	2.87	2.81	2.71	2.60	2.52	0.85	0.75
HUTT	49029	2.73	2.70	2.61	2.54	2.54	0.85	0.72	2.81	2.75	2.64	2.53	2.44	0.78	0.68
HUTT	49094	2.72	2.69	2.60	2.53	2.53	0.82	0.69	2.75	2.69	2.57	2.47	2.37	0.72	0.62
HUTT	49200	5.30	4.97	4.71	4.35	4.35	1.11	0.94	4.63	4.37	4.15	3.81	3.63	1.07	0.89
HUTT	49301	3.20	3.07	2.90	2.74	2.74	0.87	0.82	3.36	3.20	3.03	2.83	2.67	0.89	0.85
HUTT	49349	3.25	3.05	2.97	2.76	2.76	1.00	0.96	3.33	3.11	3.00	2.78	2.63	1.01	0.97
HUTT	49397	3.35	3.13	3.05	2.83	2.83	1.05	1.01	3.31	3.09	2.97	2.75	2.59	1.00	0.97
HUTT	49447	3.38	3.15	3.08	2.84	2.84	1.14	1.10	3.15	2.93	2.82	2.61	2.46	1.02	0.98
HUTT	49497	3.42	3.17	3.11	2.85	2.85	1.20	1.15	3.00	2.79	2.69	2.48	2.35	1.01	0.97
HUTT	49546	3.60	3.29	3.27	2.96	2.96	1.33	1.26	3.25	2.98	2.91	2.66	2.53	1.12	1.06
HUTT	49595	3.80	3.45	3.44	3.09	3.09	1.44	1.35	3.56	3.24	3.17	2.88	2.74	1.22	1.15
HUTT	49650	3.83	3.41	3.46	3.04	3.04	1.56	1.43	3.67	3.29	3.26	2.91	2.81	1.32	1.24
HUTT	49705	3.86	3.38	3.48	3.00	3.00	1.65	1.45	3.78	3.34	3.36	2.94	2.88	1.42	1.29
HUTT	49750	3.46	3.03	3.10	2.69	2.69	1.40	1.18	3.33	2.96	2.95	2.60	2.52	1.22	1.08
HUTT	49795	3.16	2.76	2.82	2.45	2.45	1.18	0.97	3.00	2.67	2.64	2.34	2.26	1.04	0.91
HUTT	49846.5	3.18	2.74	2.83	2.42	2.42	1.18	0.93	3.07	2.70	2.70	2.36	2.30	1.10	0.92
HUTT	49898	3.20	2.72	2.83	2.40	2.40	1.19	0.92	3.15	2.72	2.77	2.38	2.35	1.16	0.95
HUTT	49949	2.81	2.38	2.49	2.10	2.10	1.03	0.79	2.84	2.44	2.49	2.13	2.11	1.05	0.85
HUTT	50000	2.51	2.11	2.21	1.86	1.86	0.91	0.69	2.58	2.20	2.26	1.93	1.92	0.97	0.77
HUTT	50077	2.38	1.99	2.10	1.75	1.75	0.83	0.62	2.53	2.12	2.20	1.85	1.85	0.94	0.73
HUTT	50154	2.27	1.88	1.99	1.65	1.65	0.76	0.55	2.47	2.04	2.14	1.78	1.79	0.92	0.69
HUTT	50230.5	2.10	1.73	1.83	1.52	1.52	0.64	0.45	2.31	1.89	1.99	1.64	1.66	0.81	0.59
HUTT	50307	1.95	1.61	1.70	1.41	1.41	0.58	0.41	2.16	1.76	1.85	1.53	1.54	0.73	0.54
HUTT	50383	1.82	1.50	1.59	1.32	1.32	0.52	0.38	1.98	1.62	1.69	1.40	1.41	0.63	0.47
HUTT	50459	1.72	1.42	1.49	1.24	1.24	0.47	0.34	1.83	1.49	1.56	1.29	1.29	0.55	0.41

Peak channel-average velocity

MIKE 11 Branch & Chainage		Simulation																	
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
HUTT	48229	2.29		2.17					2.26		2.13					1.86	1.96	1.89	1.84
HUTT	48288.5	2.38		2.27					2.35		2.22					1.74	1.76	1.78	1.72
HUTT	48348	2.50		2.37					2.47		2.32					1.67	1.62	1.69	1.65
HUTT	48408	2.74		2.63					2.70		2.57					1.93	1.83	1.97	1.91
HUTT	48468	3.04		2.96					2.98		2.88					2.30	2.10	2.36	2.27
HUTT	48527	2.91		2.83					2.85		2.75					2.20	2.03	2.25	2.16
HUTT	48586	2.79		2.71					2.72		2.63					2.10	1.96	2.16	2.07
HUTT	48646	2.61		2.50					2.55		2.43					1.88	1.78	1.94	1.85
HUTT	48706	2.46		2.32					2.40		2.26					1.71	1.64	1.76	1.68
HUTT	48766.5	2.90		2.74					2.83		2.66					1.95	1.91	2.01	1.92
HUTT	48827	3.55		3.36					3.44		3.24					2.29	2.30	2.36	2.25
HUTT	48895.5	3.22		3.06					3.11		2.93					2.00	1.97	2.07	1.96
HUTT	48964	2.95		2.80					2.84		2.67					1.78	1.73	1.84	1.75
HUTT	49029	2.96		2.80					2.84		2.66					1.73	1.62	1.79	1.70
HUTT	49094	2.97		2.80					2.84		2.65					1.68	1.53	1.75	1.65
HUTT	49200	4.70		4.21					4.24		3.79					2.34	2.10	2.12	1.97
HUTT	49301	3.23		2.92					3.33		3.00					1.51	1.57	1.48	1.61
HUTT	49349	3.30		2.98					3.34		3.08					1.51	1.50	1.48	1.63
HUTT	49397	3.38		3.04					3.45		3.17					1.51	1.44	1.47	1.64
HUTT	49447	3.34		3.00					3.36		3.09					1.52	1.37	1.47	1.60
HUTT	49497	3.30		2.96					3.28		3.01					1.52	1.31	1.46	1.57
HUTT	49497	3.30		2.96					3.26		3.01					1.52	1.31	1.46	1.57
HUTT	49546	3.59		3.21					3.54		3.26					1.59	1.39	1.55	1.67
HUTT	49595	3.94		3.51					3.88		3.56					1.65	1.49	1.66	1.79
HUTT	49650	3.92		3.48					3.93		3.60					1.67	1.54	1.71	1.81
HUTT	49705	3.91		3.45					3.97		3.64					1.68	1.59	1.73	1.84
HUTT	49750	3.48		3.06					3.56		3.24					1.47	1.38	1.41	1.59
HUTT	49795	3.15		2.75					3.24		2.93					1.30	1.21	1.23	1.39
HUTT	49846.5	3.09		2.69					3.21		2.89					1.30	1.25	1.20	1.37
HUTT	49898	3.04		2.63					3.18		2.86					1.30	1.29	1.17	1.34
HUTT	49949	2.68		2.32					2.77		2.49					1.14	1.17	1.03	1.17
HUTT	50000	2.40		2.08					2.46		2.20					1.02	1.06	0.93	1.03
HUTT	50077	2.26		1.95					2.35		2.09					0.96	1.03	0.86	0.97
HUTT	50154	2.13		1.84					2.24		1.99					0.90	1.00	0.81	0.92
HUTT	50230.5	2.01		1.73					2.13		1.89					0.82	0.91	0.76	0.87
HUTT	50307	1.90		1.63					2.03		1.80					0.75	0.84	0.71	0.82
HUTT	50383	1.82		1.55					1.96		1.73					0.69	0.76	0.67	0.78
HUTT	50459	1.74		1.48					1.90		1.67					0.65	0.69	0.64	0.75

Peak channel-average velocity