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17 May 2005

Goulburn Broken Catchment Management Authority
PO Box 1752
Shepparton, VIC 3632

Att Wayne Tennant

Dear Wayne,

Mokoan Inlet Channel Closure
Impacts on Broken River and Holland Creek Hydraulics

We are pleased to provide the results of our investigations into hydraulic impacts on the Broken River and Holland Creek arising from the possible closure of the Mokoan Inlet Channel.

1. Approach

The investigations have been carried out using the available survey information in the form of surveyed cross sections obtained by the then State Rivers and Water Supply Commission (SR&WSC) in 1977. Cross section data from the 1977 survey consisted of the following:

- Broken River – total of nine surveyed cross sections upstream of the Holland Creek confluence, with the most upstream cross section located approximately 1 km downstream of the Mokoan Inlet Channel offtake.
- Holland Creek – total of six surveyed cross sections upstream of the Broken River confluence with the most upstream cross section located approximately 1.7 km downstream of the Mokoan Inlet Channel offtake.

The above cross sections (refer attached Figure 1) and additional cross sections within and downstream of Benalla were utilised for the 1984 Benalla Floodplain Management Study undertaken by the SR&WSC.

Hydraulic model (HEC-2) data files from the 1984 study were provided by the Goulburn Broken CMA for the current investigation. The model data sets were imported into the HEC-RAS hydraulic model.

The HEC-RAS models were then used to identify the following:

- Approximate in-channel capacity of the Broken River and Holland Creek.
- The increase in water surface elevation and water surface top width in both the Broken River and Holland Creek for a range of flows arising from the possible closure of the Mokoan Inlet Channel.

The combined offtake capacity of the Mokoan Inlet Channel is 28 m^3/s, consisting of 21 m^3/s offtake capacity from the Broken River and 7 m^3/s from Holland Creek. The combined capacity of 28 m^3/s represents approximately 2% of the peak October 1993 recorded flow rate at Benalla of 1,300 m^3/s. The 1993 flood is recognised as being equivalent to approximately a 100 year average recurrence interval (ARI) event.

2. Hydraulic Modelling Results

The modelling results are summarised in the attached Tables 1 and 2 for the Broken River and Holland Creek respectively. Graphical output at sample cross sections is shown on the attached Figures 2 and 3.

The models identify in-channel discharge capacities of 100 m^3/s for the Broken River and 50 m^3/s for Holland Creek. These capacities are indicative only given that the threshold for out of channel flooding changes from cross section to cross section and that the point at which out of channel flooding first occurs is open to some interpretation.

The Broken River modelling is complicated by the presence of multiple anabranch channels on the floodplain, which for the purpose of the modelling were assumed to be active when the river water levels exceed the anabranch bed levels.

Modelling results for the Broken River are summarised as follows:

- Water surface elevation and water surface top width results in Table 1 are documented for flows of 50, 75, 100, 200 and 300 m^3/s. The equivalent ARI of these flows is likely to range from less than 1 year ARI to around 10 year ARI based on design flow rates documented in the 1995 Benalla Flood Study Report.

- Modelling results for the post Mokoan closure scenario are based on the capacity of the Mokoan inlet channel offtake at the Broken River (21 m^3/s) added to the above flow rates (i.e. increased flows of 71, 96, 121, 221, 321 m^3/s used for post Mokoan closure conditions).

- The modelled increase in water surface elevation varies from an average increase of 0.34 metre for the lowest flow modelled (50/71 m^3/s) to an average increase of 0.07 metre for the highest flow modelled (300/321 m^3/s). The predicted water surface elevation increase diminishes with increasing flow modelled due to both the Mokoan flow component reducing as a proportion of the total flow modelled and the higher flows coinciding with out of channel flow.

- The modelled increase in flow width varies significantly depending on the flow modelled and from cross section to cross section. The largest average increase in top water surface width of 28 metres coincides with the flows of 100 and 200 m^3/s when out of channel flow is first initiated.

Modelling results for Holland Creek are summarised as follows:

- Water surface elevation and water surface top width results in Table 2 are documented for flows of 20, 35, 50, 100 and 200 m^3/s. The equivalent ARI of these flows is likely to range from less than 1 year ARI to around 5 year ARI based on design flow rates documented in the 1995 Benalla Flood Study Report.

- Modelling results for the post Mokoan closure scenario are based on the additional capacity of the Mokoan inlet channel offtake at Holland Creek (7 m^3/s) added to the above flow rates (i.e. increased flows of 27, 42, 57, 107, 207 m^3/s used for post Mokoan closure conditions).

- The modelled increase in water surface elevation varies from an average increase of 0.34 metre for the lowest flow modelled (10/17 m^3/s) to an average increase of 0.03 metre for the highest flow modelled (200/207 m^3/s). The predicted water surface elevation increase diminishes with increasing flow modelled due to both the Mokoan flow component reducing as a proportion of the total flow modelled and the higher flows coinciding with out of channel flow.

- The modelled increase in flow width varies significantly depending on the flow modelled and from cross section to cross section. The largest average increase in top water surface width of 83 metres coincides with a flow of 50 m^3/s when out of channel flow is first initiated.

The results for both the Broken River and Holland Creek indicate that increases in water surface elevation and water surface widths diminish rapidly with increasing flow above the out of channel flow threshold. Impacts in moderate and major flood events are therefore expected to be negligible.

3. Summary and Conclusions

Hydraulic modelling using a steady state HEC-RAS model assembled from cross sections of the Broken River and Holland Creek floodplains obtained in 1977 has enabled predictions to be made of changes in water surface elevations and water surface top widths for a range of varying flow rates in the event of the Mokoan inlet channel being closed.

Hydraulic modelling found that the threshold flows to initiate out of channel flow for the Broken River and Holland Creek are approximately 100 and 50 m^3/s respectively. Both these flows may coincide with around a 1 to 2 year ARI frequency event, however detailed analysis has not been undertaken to verify this.

Modelling results are detailed in the attached Tables 1 and 2. Water surface elevation increases are greatest for in-channel flow where average increases of up to 0.34 metre can occur. These higher range water level increases occur only when the flow remains within the river channel (i.e. non flood flow conditions).

Water surface top width increases are greatest when out of channel flow is first initiated with average increases of up 83 metres predicted.

Impacts on both water surface levels and water surface flow widths diminish rapidly with increasing flow above the out of channel flow threshold. Impacts during moderate and major flood events are therefore expected to be negligible.

We trust the documented results are in accordance with your expectations. Should you require any further information in this respect, please contact the undersigned.

Yours faithfully
Earth Tech Engineering Pty Ltd

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Table 1 – Hydraulic Modelling Results – Broken River

Cross section number (HEC-RAS / SR&WSC) see Note 1	Flow (m^3/s) see Note 2	Modelled Water Surface Elevation			Modelled Water Surface Width		
		Existing (m AHD)	No Mokoan channel (m AHD)	Increase in water level (m)	Existing (m)	No Mokoan channel (m)	Increase in width (m)
16 / 96.15	50 / 71	168.17	168.57	0.40	85	104	19
	75 / 96	168.69	168.98	0.29	114	133	19
	100 / 121	169.07	169.32	0.25	139	169	30
	200 / 221	170.06	170.18	0.12	289	333	44
	300 / 321	170.64	170.73	0.09	398	399	1
17 / 96.56	50 / 71	168.60	168.96	0.36	52	57	5
	75 / 96	169.05	169.34	0.29	61	77	16
	100 / 121	169.40	169.63	0.23	79	90	11
	200 / 221	170.28	170.40	0.12	195	210	15
	300 / 321	170.82	170.91	0.09	236	240	4
18 / 97.01	50 / 71	169.05	169.42	0.37	78	136	58
	75 / 96	169.50	169.76	0.26	155	203	48
	100 / 121	169.81	170.00	0.19	211	249	38
	200 / 221	170.57	170.68	0.09	381	422	41
	300 / 321	171.08	171.16	0.08	440	458	18
19 / 98.65	50 / 71	170.26	170.58	0.32	75	124	49
	75 / 96	170.64	170.85	0.21	132	151	19
	100 / 121	170.88	171.04	0.16	154	203	49
	200 / 221	171.43	171.51	0.08	322	330	8
	300 / 321	171.80	171.88	0.08	369	372	3
19.5 / 99.60	50 / 71	170.83	171.16	0.33	77	96	19
	75 / 96	171.22	171.47	0.25	99	116	17
	100 / 121	171.51	171.78	0.27	122	193	71
	200 / 221	172.16	172.24	0.08	601	669	68
	300 / 321	172.46	172.51	0.05	976	1020	44
20 / 100.44	50 / 71	171.67	172.00	0.33	84	101	17
	75 / 96	172.05	172.31	0.26	104	121	17
	100 / 121	172.36	172.67	0.31	125	169	44
	200 / 221	173.11	173.20	0.09	280	301	21
	300 / 321	173.42	173.46	0.04	365	386	21
20.5 / 101.20	50 / 71	172.52	172.81	0.29	56	61	5
	75 / 96	172.86	173.11	0.25	63	74	11
	100 / 121	173.15	173.39	0.24	75	84	9
	200 / 221	173.95	174.07	0.12	134	181	47
	300 / 321	174.36	174.42	0.06	563	597	34

Cross section number (HEC-RAS / SR&WSC)	Flow (m^3/s) see Note 2	Modelled Water Surface Elevation			Modelled Water Surface Width		
		Existing (m AHD)	No Mokoan channel (m AHD)	Increase in water level (m)	Existing (m)	No Mokoan channel (m)	Increase in width (m)
21 / 102.14	50 / 71	172.66	172.99	0.33	42	43	1
	75 / 96	173.04	173.33	0.29	44	45	1
	100 / 121	173.38	173.64	0.26	45	46	1
	200 / 221	174.40	174.43	0.03	52	62	10
	300 / 321	174.81	174.88	0.07	110	117	7
22 / 103.24	50 / 71	172.67	173.01	0.34	521	523	2
	75 / 96	173.07	173.37	0.30	523	526	3
	100 / 121	173.42	173.68	0.26	526	528	2
	200 / 221	174.37	174.52	0.15	532	533	1
	300 / 321	174.93	175.02	0.09	535	536	1

Notes:

1. Cross section locations are shown on Figure 1.
2. There are two flow figures given in this column. The first flow (i.e. 50, 75, 100, 200 & 300 m^3/s) listed is a nominal flow selected to assess the impacts of the possible Mokoan Inlet Channel closure. The second flow listed is the corresponding nominal flow plus the offtake capacity of 21 m^3/s into the Mokoan Inlet Channel (i.e. 71, 96, 121, 221 & 321 m^3/s).

Table 2 – Hydraulic Modelling Results – Holland Creek

Cross section number (HEC-RAS / SR&WSC)	Flow (m^3/s) see Note 2	Modelled Water Surface Elevation			Modelled Water Surface Width		
		Existing (m AHD)	No Mokoan channel (m AHD)	Increase in water level (m)	Existing (m)	No Mokoan channel (m)	Increase in width (m)
23.2 / 0.40	20 / 27	167.87	168.18	0.31	83	100	17
	35 / 42	168.46	168.67	0.21	115	139	24
	50 / 57	168.90	169.14	0.24	188	365	177
	100 / 107	169.62	169.67	0.05	537	558	21
	200 / 207	170.22	170.25	0.03	750	751	1
24 / 0.70	20 / 27	168.07	168.38	0.31	40	53	13
	35 / 42	168.65	168.86	0.21	62	72	10
	50 / 57	169.08	169.31	0.23	84	98	14
	100 / 107	169.80	169.85	0.05	481	541	60
	200 / 207	170.36	170.39	0.03	782	784	2
25 / 0.92	20 / 27	168.46	168.78	0.32	16	19	3
	35 / 42	169.07	169.28	0.21	22	24	2
	50 / 57	169.53	169.70	0.17	58	86	28
	100 / 107	170.22	170.29	0.07	157	195	38
	200 / 207	170.66	170.69	0.03	255	256	1
26 / 1.75	20 / 27	169.31	169.71	0.40	25	27	2
	35 / 42	170.09	170.39	0.30	39	69	30
	50 / 57	170.86	170.94	0.08	123	187	64
	100 / 107	171.40	171.46	0.06	217	219	2
	200 / 207	172.10	172.13	0.03	420	423	3
27 / 2.71	20 / 27	170.34	170.71	0.37	30	34	4
	35 / 42	171.10	171.41	0.31	65	111	46
	50 / 57	171.80	171.89	0.09	401	521	120
	100 / 107	172.14	172.19	0.05	601	603	2
	200 / 207	172.72	172.75	0.03	617	618	1
28 / 3.61	20 / 27	171.59	171.93	0.34	28	31	3
	35 / 42	172.27	172.53	0.26	61	76	15
	50 / 57	172.77	172.95	0.18	130	227	97
	100 / 107	173.21	173.30	0.09	394	450	56
	200 / 207	173.52	173.54	0.02	548	549	1

Notes:

1. Cross section locations are shown on Figure 1.
2. There are two flow figures given in this column. The first flow (i.e. 20, 35, 50, 100 & 200 m^3/s) listed is a nominal flow selected to assess the impacts of the possible Mokoan Inlet Channel closure. The second flow listed is the corresponding nominal flow plus the offtake capacity of 7 m^3/s into the Mokoan Inlet Channel (i.e. 27, 42, 57, 107 & 207 m^3/s).

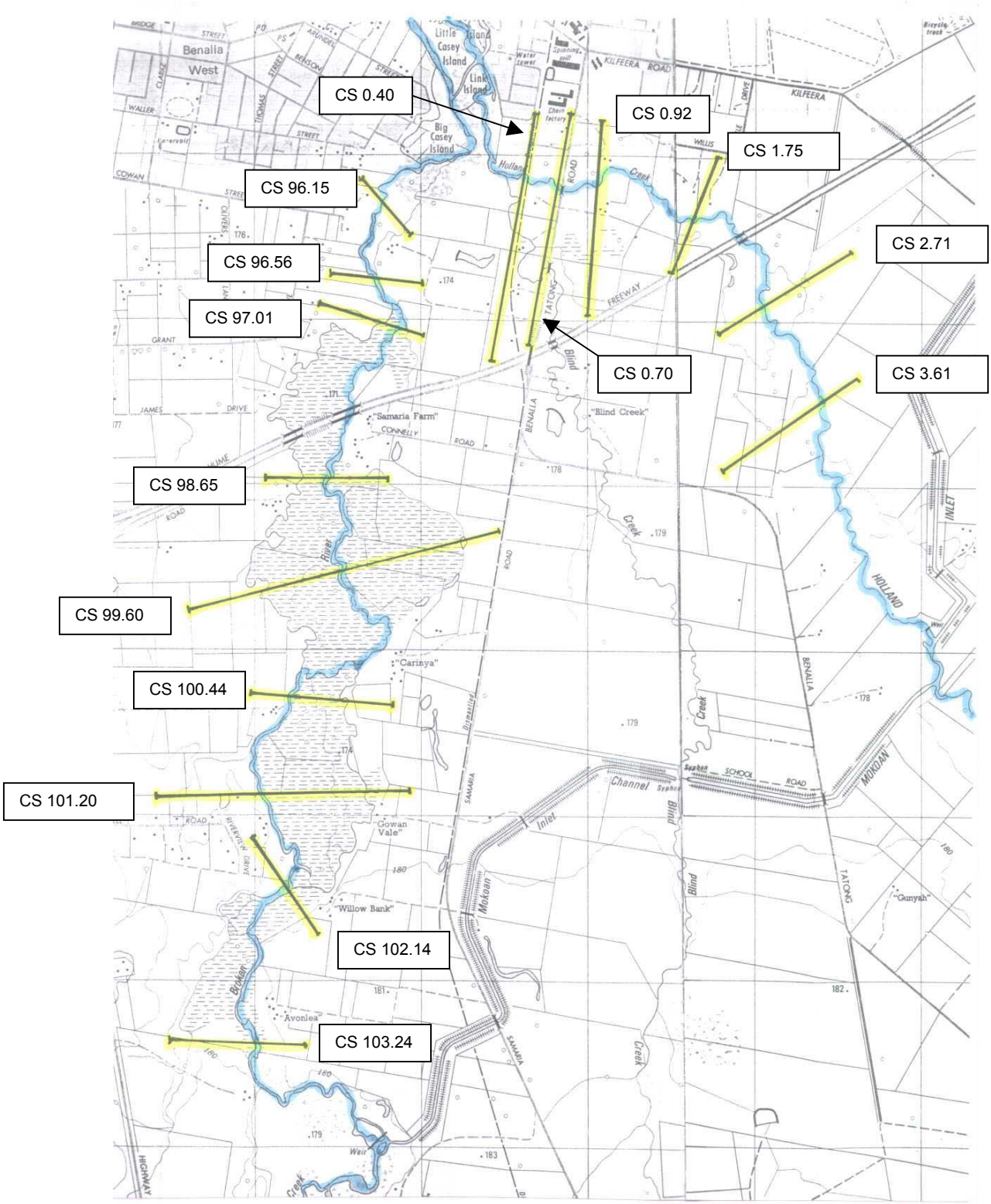
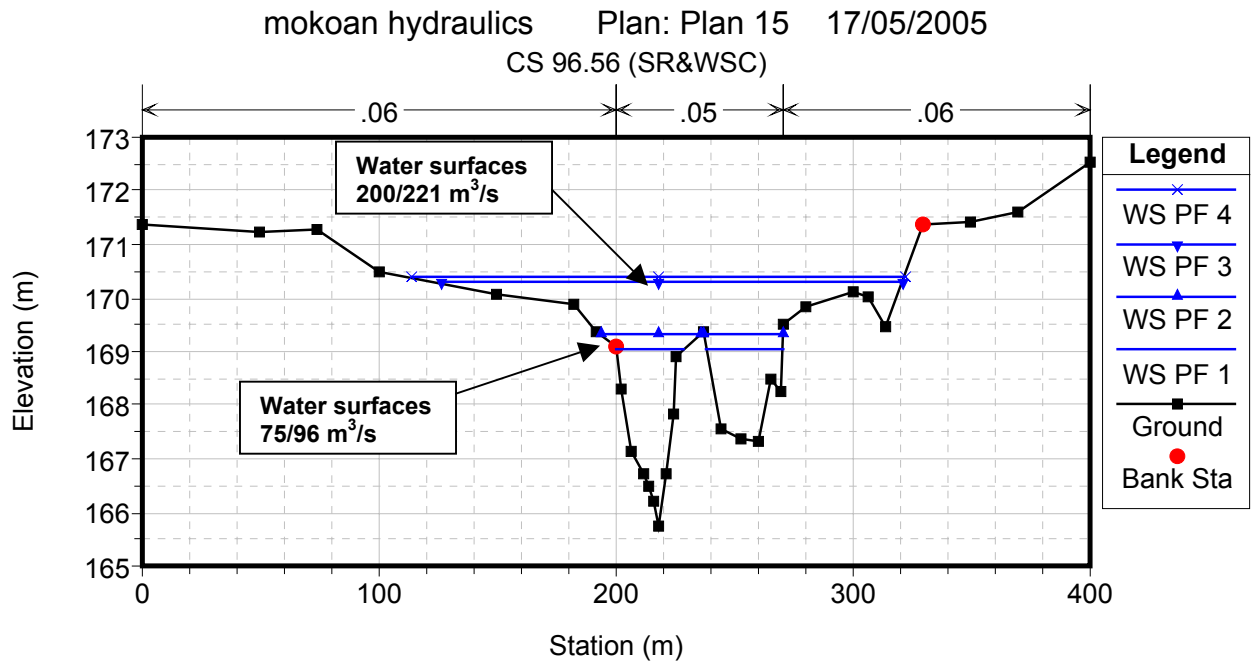


Figure 1 – Hydraulic Model Cross Section Locations



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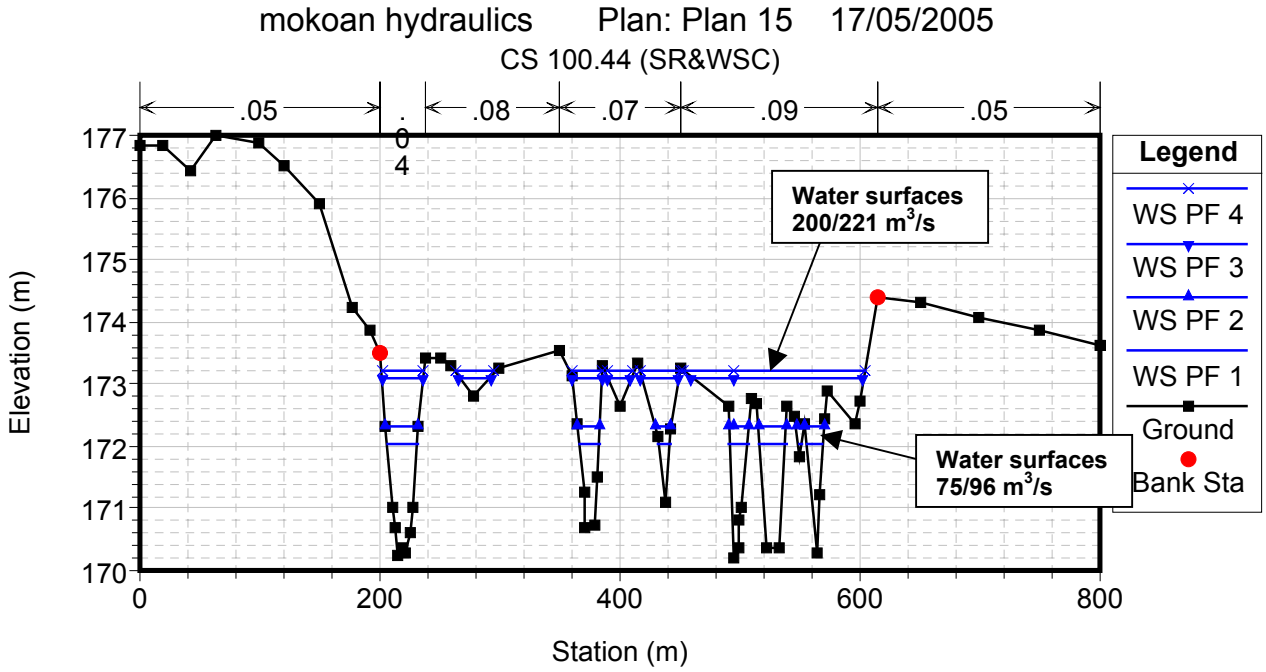
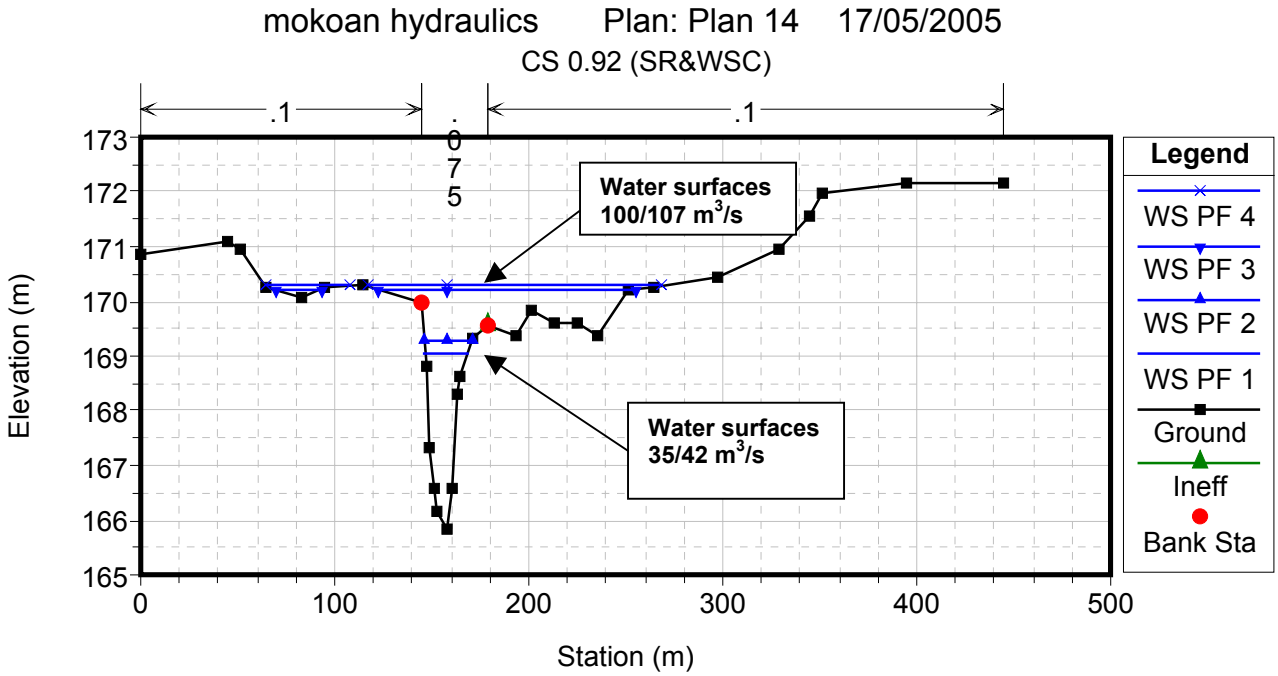


Cross Section 100.44

Figure 2 – Broken River Cross Section Plots



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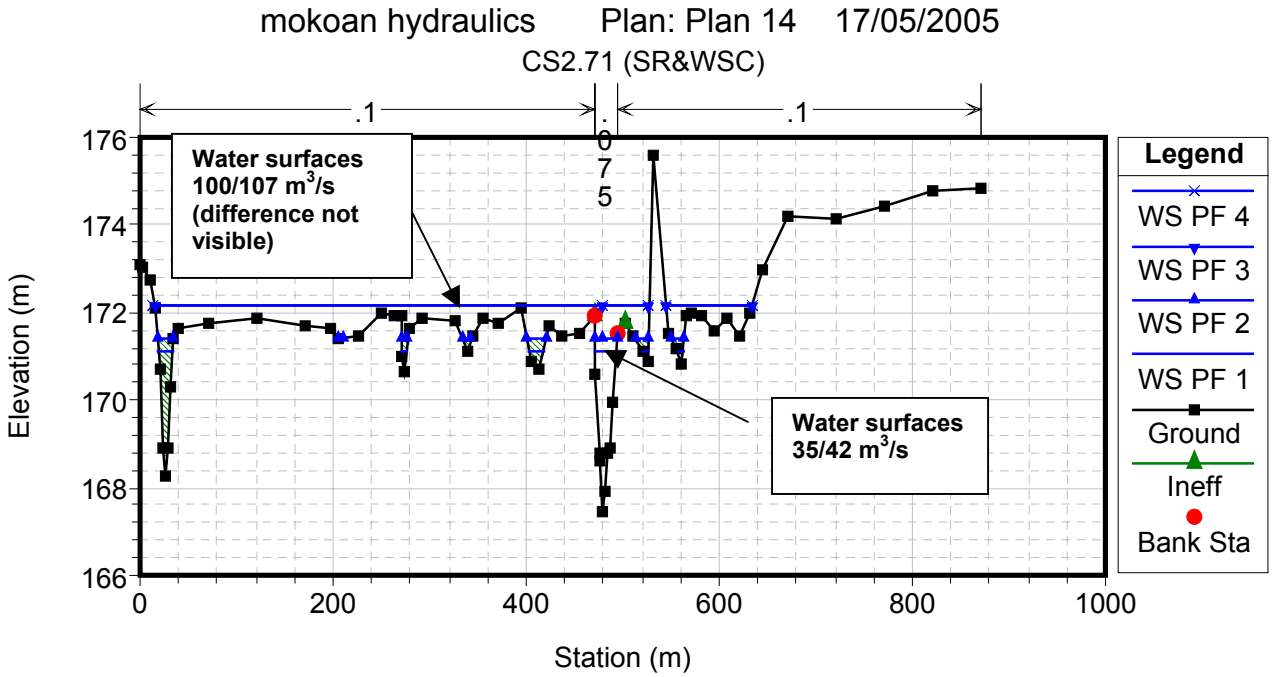

Cross Section 2.71

Figure 3 Holland Creek Cross Section Plots