Margaret Dowling Creek Hydraulic Modelling

DEWNR Technical note 2014/21

Government of South Australia
Department of Environment, Water and Natural Resources

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Mahdi Montazeri
Department of Environment, Water and Natural Resources

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GPO Box 1047, Adelaide SA 5001

Telephone	National (08) 8463 6946
	International +61 8 8463 6946
Fax	National (08) 8463 6999
	International +61 8 8463 6999
Website	www.environment.sa.gov.au

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Summary

The Science, Monitoring and Knowledge (SMK) branch of the Department of Environment, Water and Natural Resources (DEWNR) was requested to examine the hydraulic characteristics along Margaret Dowling Creek by updating the current hydraulic model using new survey data to ensure that the proposed functional requirements of the structures can be met under a range of weir pool level scenarios for the River Murray.

The hydraulic modelling results indicate that:

- With existing structures the model based on updated survey data accurately simulates the expected current flow of 184 ML/d through the creek which is consistent with previous modelled flows of 170 ML/d (McCullough, 2013) and 181 ML/d (Water Technology, 2010c).
- With preliminary conceptual structures in place for the normal pool level scenario (16.3 m AHD), a flow of 400 ML/d can be passed through the creek within the current banks however a risk of erosion (represented by a bed shear stress threshold of 11 N/m^2) occurs in some cross sections.
- With preliminary conceptual structures fully open for the normal pool level scenario (16.3 m AHD), a flow of 498 ML/d can be conveyed through the creek, however bed shear stress values exceeded 11 N/m^2 in some places. For the scenario where Lock 5 is raised to 16.8 m AHD, flows remained within the banks of the creek and a flow of 713 ML/d could be passed, however high risk of erosion is expected in many cross sections.
- Without structures in place for the normal pool level scenario (16.3 m AHD), a flow of 641 ML/d is modelled and the banks are expected to contain the flow.

As such, it is expected that at flows of approximately 400 ML/d and greater some erosion protection may be required within the creek, but the banks are expected to be able to contain this flow. Further investigation of soil type and channel characteristics is required to confirm the bed shear stress threshold of 11 N/m^2 adopted to indicate erosion risk. Appropriate freeboard requirements should also be considered as part of the design phase.

A range in Manning's n values was also considered to assess the impact on the capacity of the creek. An increase in n from n=0.06 to n=0.08 reduced the flow conveyed through the channel from 641 ML/d to 484 ML/d for the scenario without structures in place at pool level. With a lower Manning's value of n=0.03 the flow through the channel increased substantially to 1,267 ML/d. However, the currently adopted value of n=0.06 represents a calibrated value, and the current best knowledge of the representative roughness for the creek.

It is recommended that the channel capacity be re-evaluated after detailed design of the structures for Margaret Dowling Creek, and to include the designed tail water levels.

1 Introduction

1.1 Background

The Pike floodplain is an anabranch of the River Murray located in the vicinity of Renmark, South Australia. It allows flows to bypass Lock 5 through two regulated creeks flowing from the River Murray upstream of Lock 5 into the Pike River anabranch system which eventually discharges back into the River Murray upstream of Berri in the Lock 4 weir pool. The Pike floodplain is currently experiencing a significant decline in health and the South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP) has been initiated to improve the ecological health of the floodplain by upgrading infrastructure and proposing better operation solutions.

The inlets of Margaret Dowling Creek and Deep Creek are the two main flow inlets to the Pike floodplain and as such play a key role in managing the flow and water levels throughout the floodplain. Figure 1.1 shows the two main inlets of the Pike floodplain.

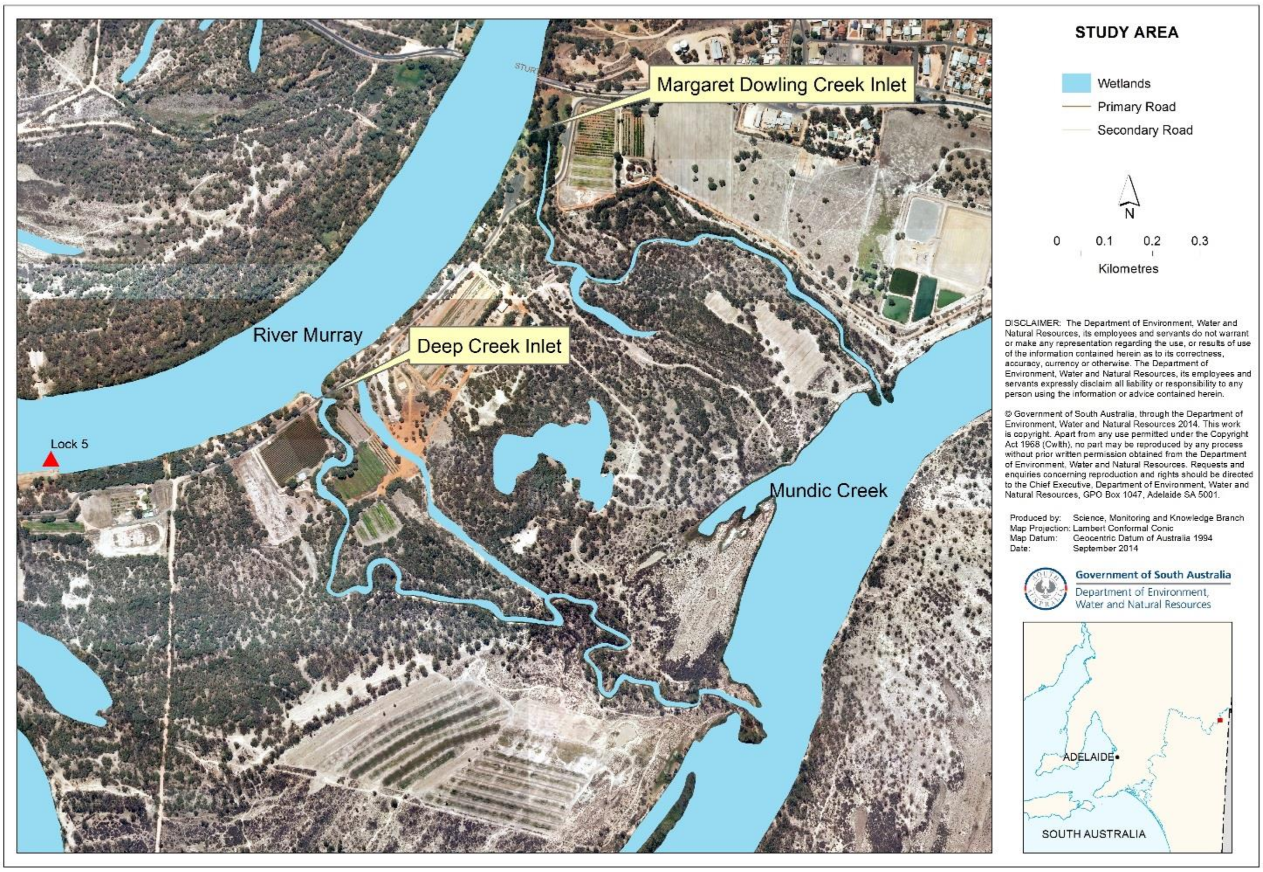

Figure 1.1 Margaret Dowling Creek and Deep Creek Inlets

Margaret Dowling Creek and Deep Creek currently have a limited capacity due to the existing structures at the inlets of the two creeks which require to be upgraded to enable the viability of proposed water management actions. SKM (2010) developed a concept design for increasing the capacity of these creeks by removing the existing structures and replacing them with higher flow capacity structures. A range of structures was proposed by SKM (2010) and design flows of 600 ML/d for Deep Creek and 400 ML/d for Margaret Dowling Creek were determined by considering the functional requirements for the preliminary conceptual structures and the practical constraints at the sites including (but not limited to) the flow needed from the combined structures to fill the Pike Floodplain, the hydraulic capacity of the creek, erosion control limitations and the operation of Lock 4 and Lock 5.

However, it was recommended by SKM (2010) that more defined hydraulic modelling be undertaken when more detailed survey data was available to confirm the design flows.

1.2 Scope

The River Murray Operations and the Major Projects branch of the DEWNR received the recent survey data for Margaret Dowling Creek and Deep Creek as part of the detailed design process in September 2014. The Science, Monitoring and Knowledge (SMK) branch was requested to examine the hydraulic characteristics along Margaret Dowling Creek by updating the current hydraulic model to ensure that the proposed functional requirements of the structures can be met under a range of weir pool level scenarios.

This work investigated the functional requirements of the structures at Margaret Dowling Creek. This involved determining the maximum feasible flows at the following specified water levels in the River Murray:

- Normal Lock 5 Weir Pool Level (16.3 m AHD)
- Raised Lock 5 Weir Pool Level (16.8 m AHD)
- Lowered Lock 5 Weir Pool Level (15.7 m AHD)

The maximum feasible flows were determined based on the hydraulic characteristics of the creek including bed shear stress imitations to reduce the risk of erosion. Therefore, the aim of this investigation was:

- to update the current hydraulic model using the latest survey data and the preliminary conceptual structures for Margaret Dowling Creek
- run the updated model under different weir pool level and structure scenarios
- report hydraulic characteristics along Margaret Dowling Creek including: flow, water level, velocity and bed shear stress

The raised weir pool level is not currently planned as an operating regime, but this is required for robustness of design as it has been identified as a possible future flow scenario.

2 Model Specifications

The numerical hydrodynamic models were originally produced and calibrated by Water Technology using the MIKE FLOOD modelling platform that combines the dynamic coupling of the one-dimensional MIKE 11 river model and MIKE 21 two-dimensional model system. The details of the original MIKE FLOOD model are described in Water Technology (2009). The original MIKE FLOOD model was further refined and re-calibrated in 2013 within the SMK branch to improve model run time and also to address the updates implemented by the DEWNR. The details of the current MIKE FLOOD model are presented in McCullough (2013). Given that the requested outputs of this investigation do not involve extensive floodplain inundation, they are best represented by the one-dimensional river model. Hence only the one-dimensional part of the current MIKE FLOOD model (MIKE 11) was used for this investigation.

2.1 Survey data

New detailed survey data for Margaret Dowling Creek was supplied by Adelaide Complete Surveys Pty Ltd in AutoCAD format with multiple 3-dimensional points. Approximately 42 cross sections in 20-40 m intervals along Margaret Dowling Creek were extracted from survey data and incorporated into the MIKE 11 model. The anabranch in the middle of Margaret Dowling Creek and the stone weir that was built locally to divert water into the anabranch were included in the updated model as they were not considered in the model previously. Figure 2.1 shows a schematic of the hydraulic model for Margaret Dowling Creek.

Figure 2.1 MIKE 11 model of Margaret Dowling Creek

2.2 Structures

The simulations were run for three different scenarios for the structures at the inlet of Margaret Dowling Creek. The maximum hydraulic capacity of the creek was determined without infrastructure in place and the existing hydraulic capacity of the creek was determined with existing structures. From the latest survey data the existing structures are understood to be as follows:

- 1 × 1050 mm pipe culverts (invert level 14.84 m AHD) at Inlet
- 3 × 1100 mm pipe culverts (invert level 15.00 m AHD) at Road Crossing

For the preliminary conceptual structures at Margaret Dowling Creek, it was agreed that the following structures from the concept design phase (SKM, 2010) should be included in the model:

- 2 × 1350 mm pipe culverts (invert level 14.3 m AHD) at Inlet
- Single span bridge (11 m span) at Road Crossing

The results from this study will allow the detailed design of these structures to be undertaken.

2.3 Boundary Conditions

The model requires the boundary conditions to be defined, including upstream flow into the model and the water level at the outlet of the model. The upstream boundary condition downstream from Lock 6 representing the combined flow from the River Murray and Chowilla Creek was set at 10,000 ML/d. The downstream boundary condition at Lock 4 was set at 13.2 m AHD (Lock 4 weir pool level).

It should be noted that the water level in Mundic Creek downstream of Margaret Dowling Creek is impacted by flow through both Margaret Dowling Creek and Deep Creek and also the operation of the Col Col regulator. Therefore, the operation of the Deep Creek and Col Col bank may influence the backwaters within Margaret Dowling Creek. For this reason, in this investigation it is assumed that the proposed structures by SKM (2010) for Deep Creek are in place and remain fully open to be able to pass flow of around 600 ML/d and Col Col regulator is being operated at 14.4 m AHD (McCullough, 2013).

2.4 Roughness

Manning's 'n' hydraulic roughness values were used from the previously re-calibrated model discussed in McCullough (2013). Modelled water levels using these roughness values were found to be in good agreement with observed water levels (McCullough, 2013). Roughness value of n = 0.06 was assigned to Margaret Dowling Creek in previous modelling which is believed to be a relatively high value for Margaret Dowling Creek based on the density of the vegetation that can be seen through available photos. To assess the impact of this parameter on the results, a sensitivity analysis on roughness value for Margaret Dowling Creek was performed. A Manning's value of n = 0.03 from the lower range of typical values for an earth channel and also a Manning's value of n = 0.08 from the upper range of typical values for a densely vegetated creek were applied.

3 Results

The following scenarios were defined to provide in-depth information for the design of infrastructure for Margaret Dowling Creek and this section presents the outputs of the hydraulic modelling exercise for each scenario:

1. Existing Structures
    - **Scenario A**: Existing Structures (fully open) - Normal Lock 5 Weir Pool Level (16.3 m AHD)
2. Preliminary Conceptual Structures – the following is based on concept design and will be revisited on completion of the detailed design phase.

    Normal Pool Level
    - **Scenario B**: Preliminary Conceptual Structures (set at 150 ML/d) - Normal Lock 5 Weir Pool Level (16.3 m AHD)
    - **Scenario C**: Preliminary Conceptual Structures (set at 400 ML/d) - Normal Lock 5 Weir Pool Level (16.3 m AHD)
    - **Scenario D**: Preliminary Conceptual Structures (fully open) - Normal Lock 5 Weir Pool Level (16.3 m AHD)

    Weir Pool Manipulation
    - **Scenario E**: Preliminary Conceptual Structures (fully open) - Raised Lock 5 Weir Pool Level (16.8 m AHD)
    - **Scenario F**: Preliminary Conceptual Structures (fully open) - Lowered Lock 5 Weir Pool Level (15.7 m AHD)
3. No Structures
    - **Scenario G**: No Structure - Normal Lock 5 Weir Pool Level (16.3 m AHD)
    - **Scenario H**: No Structure - Raised Lock 5 Weir Pool Level (16.8 m AHD)
    - **Scenario I**: No Structure - Lowered Lock 5 Weir Pool Level (15.7 m AHD)
4. Manning's n Sensitivity Test
    - **Scenario J**: No Structure - Normal Lock 5 Weir Pool Level (16.3 m AHD) – Manning's n (0.03)
    - **Scenario K**: No Structure - Normal Lock 5 Weir Pool Level (16.3 m AHD) – Manning's n (0.08)

Outputs of the hydraulic modelling including water level, flow, velocity and bed shear stress at several locations along the main channel for Margaret Dowling Creek (refer to Figure 3.1 for indication of reporting locations) are presented in Table 3.1 to Table 3.11 and water level profiles are shown in Figure 3.2 to Figure 3.12. The average water level and velocity within the publicly accessible Bert Dix Park for the different scenarios are shown in Table 3.12 separately.

It is stated in Gippel et al. (2008) that no significant risk of bank erosion exists for clay soils at bed shear stress values of less than 11 N/m^2. Given that clay is the major component of soils within the main channels of the Pike system (McCullough, 2013) bed shear stress values of greater than 11 N/m^2 are considered as not suitable and highlighted in grey. However, further investigation of actual soil type and channel characteristics is recommended to confirm this threshold.

It is indicated in Wallace (2014) that a velocity greater than 0.18 m/s is considered the minimum threshold for the protection of core fish habitat. In addition, the upper limit of 1.4 m/s is suggested as too fast for fish to swim against (Water Technology, 2012). Therefore, velocities between 0.18 and 1.4 m/s are highlighted in green as they represent desirable habitat for large bodied fish.

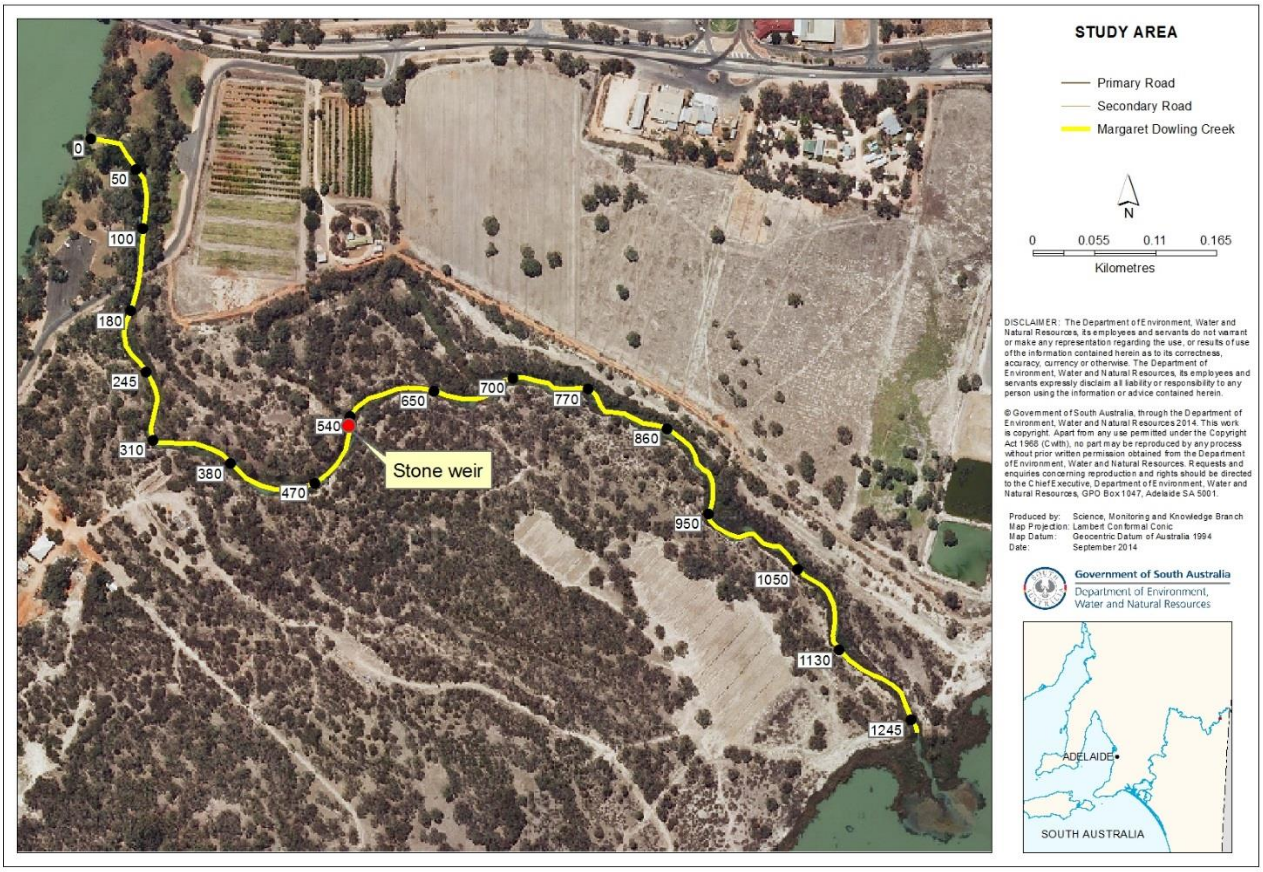

Figure 3.1 Distances along Margaret Dowling Creek

3.1 Existing Structures

With updated survey data and structure information, a flow of 184 ML/d was simulated to occur through the existing structures. This is consistent with previous analyses (Water Technology, 2010c simulated a flow of 181 ML/d and McCullough, 2013 a flow of 170 ML/d). Gauged flows within the creek average 155 ML/d and range between 140 and 170 ML/d, however the gaugings represent the flow in the current condition with the gate on the inlet structures partially closed, which has not been represented in the modelling. As such, it would be expected that the modelled flow is slightly higher than the range of gauged flows.
Note that the flow is lower between chainage 530 and 690, where some flow is conveyed through the anabranch. This is the case for all scenarios. The impact of the stone weir and road crossing on the water level under existing conditions can be seen in Figure 3.2.

With existing structures, most of the cross sections considered for Margaret Dowling Creek can be seen to represent desirable fish habitat, with velocities within the range of 0.2–0.5 m/s (Table 3.1).

3.2 Preliminary Conceptual Structures

3.2.1 Pool Level

With the flow through the preliminary conceptual structures limited to 150 ML/d (Scenario B) the results can be seen to be similar to the existing structures scenario, however with upgraded structures the road crossing no longer controls the water level (Figure 3.3).

With the flow set at 400 ML/d there was a 0.3–0.4 m increase in water level, but there was still substantial freeboard between the modelled water level and the banks. It is recommended that the necessary freeboard requirements are determined at the design stage. The bed shear stress was simulated to exceed 11 N/m2 in some places (Table 3.3). At flows of 400 ML/d and above, it can be seen that all cross sections considered were simulated to have velocities representing desirable fish habitat.

With the structures fully open and Lock 5 at pool level, the flow through Margaret Dowling Creek was modelled to increase to 498 ML/d, with a further increase in water level of 0.1–0.2 m and two additional cross sections with shear stress greater than 11 N/m^2 (Table 3.4).

3.2.2 Weir Pool Manipulation

For the weir pool manipulation scenarios, an increase in water level of 0.5 m from 16.3 m to 16.8 m at Lock 5 resulted in an increase in flow through the creek from 498 ML/d to 713 ML/d. The flow in this scenario remained within the channel banks with a minimum freeboard of 0.5 m, however the bed shear stress was higher than 11 N/m^2 in many cross sections (Table 3.5).

With the weir pool lowered to 15.7 m AHD the water level difference across the creek reduced from 1.1 m to 0.8 m. Given this reduction in water level difference, the flow conveyed through the creek reduced to 203 ML/d in this scenario compared to the fully open pool level scenario of 498 ML/d.

3.3 No Structures

The no structures scenarios were considered to test the capacity of Margaret Dowling Creek, without the preliminary conceptual structures in place that were simulated to be controlling the flow rate. For the normal pool level scenario (16.3 m AHD), the banks were still expected to contain the flow, modelled to be 641 ML/d. The impact of the stone weir was also assessed by removing the stone weir and running the model with no structure for the normal pool level scenario. In this case, the flow through the creek was modelled to slightly increase to 647 ML/d, and the change in water level profile was minimal. As such the influence of the stone weir under these conditions is expected to be negligible.

For the weir pool lowering (15.7 m AHD), the flow through the channel remained 200 ML/d, indicating that the structures have a limited influence on conveyance of flow when the weir pool is lowered.

For the weir pool raising scenario (16.8 m AHD) with no structures, at chainage 300 there was minimal freeboard of 0.15 m modelled between the top of the bank and the water level. Given this small difference, some reinforcement may be required for almost 50 m of left bank (around chainage 300) if this scenario was to be considered operationally. In this case, the flow through the creek was modelled to be 1,248 ML/d, with high bed shear stress values in the majority of the cross sections.

3.4 Mannings n Sensitivity Test

A range in Manning's n values were considered to assess the impact on the results presented. An increase in n from n=0.06 to n=0.08 reduced the flow conveyed through the channel from 641 ML/d to 484 ML/d for the fully open structures at pool level scenario. This represents a densely vegetated channel and is expected to be very conservative, and indicates that without the structures in place the targeted flow of 400 ML/d can be delivered.

With a lower Manning's value of n=0.03 the flow through the channel increased substantially to 1,267 ML/d. Velocities were simulated to start to exceed the upper threshold representing desirable fish habitat (1.4 m/s) for this case. However, the currently adopted value of n=0.06 represents a calibrated value, and the current best knowledge of the representative roughness for the creek.

Table 3.1 Modelling Results for Scenario A

Existing Structures (fully open) - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m^2
2	17.7	17.3	14.8	16.3	184	0.2	1.5
10	17.5	17.7	14.8	15.8	184	0.3	2.6
30	17.5	17.3	14.7	15.8	184	0.2	1.5
50	18.4	17.2	14.6	15.8	184	0.4	5.0
75	18.5	17.5	14.3	15.8	184	0.3	3.4
110	18.4	17.7	14.7	15.8	184	0.3	3.0
140	18.6	17.5	14.8	15.8	184	0.3	2.8
160	18.9	17.3	14.7	15.8	184	0.3	2.8
200	18.1	17.2	14.6	15.5	184	0.3	4.4
230	17.8	17.4	14.4	15.5	184	0.3	2.9
260	17.8	17.0	14.3	15.5	184	0.3	4.0
300	16.6	17.3	14.0	15.5	184	0.3	3.8
330	16.9	18.4	14.6	15.5	184	0.5	11.7
370	16.8	18.2	14.5	15.4	184	0.4	5.6
420	17.4	17.4	14.0	15.4	184	0.4	4.9
460	17.8	18.0	13.5	15.4	184	0.2	1.4
500	17.8	18.1	14.4	15.4	184	0.3	4.5
530	17.2	18.1	13.6	15.4	181	0.2	0.9
545	16.8	17.6	13.8	15.1	181	0.3	2.9
570	18.0	18.2	14.0	15.1	181	0.4	4.7
600	18.1	18.0	14.2	15.1	181	0.5	10.5
630	17.7	17.7	13.1	15.1	181	0.1	0.6
690	17.4	17.2	13.7	15.1	181	0.2	2.0
745	18.1	17.9	13.1	15.0	184	0.2	1.0
800	17.8	17.5	13.8	15.0	184	0.3	2.9
855	17.9	17.4	13.6	15.0	184	0.2	1.8
910	17.9	17.1	13.9	15.0	184	0.3	3.5
965	18.0	16.9	14.4	15.0	184	0.5	11.8
1020	17.7	17.7	13.6	14.9	184	0.3	2.4
1075	17.6	17.7	13.5	14.9	184	0.2	2.1
1130	17.3	17.6	13.7	14.9	184	0.3	2.7
1185	17.5	17.4	13.8	14.8	184	0.4	5.9
1245	17.4	17.3	13.5	14.8	184	0.3	4.3

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

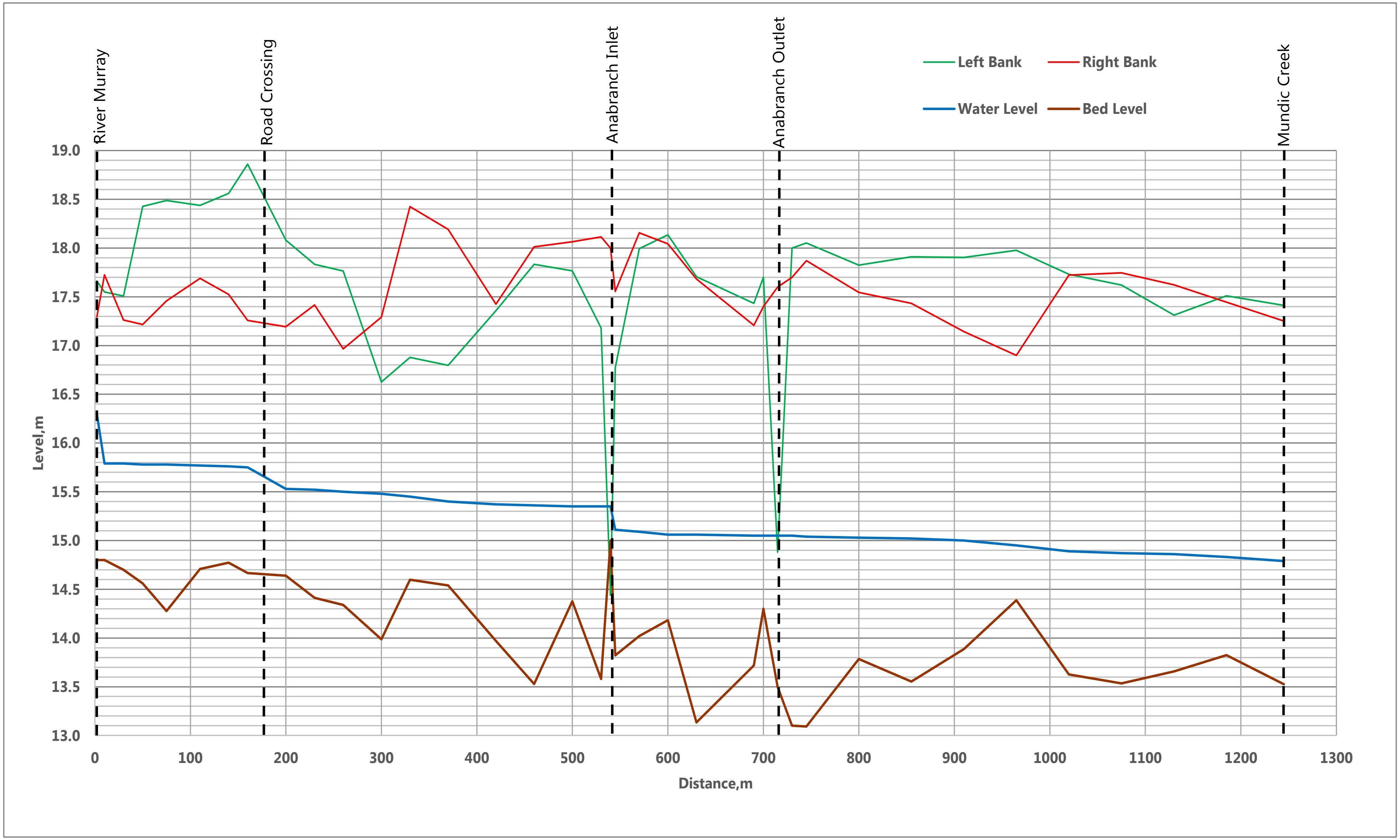

Figure 3.2 Water level profile for Scenario A
Existing Structures (fully open) - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Table 3.2 Modelling Results for Scenario B

Preliminary Conceptual Structures (set at 150 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m^2
2	17.7	17.3	14.8	15.6	149	0.3	3.1
10	17.5	17.7	14.8	15.6	149	0.3	2.7
30	17.5	17.3	14.7	15.6	149	0.2	1.7
50	18.4	17.2	14.6	15.6	149	0.4	7.7
75	18.5	17.5	14.3	15.5	149	0.4	4.6
110	18.4	17.7	14.7	15.5	149	0.3	4.6
140	18.6	17.5	14.8	15.5	149	0.3	
160	18.9	17.3	14.7	15.5	149	0.4	5.7
200	18.1	17.2	14.6	15.5	149	0.3	3.9
230	17.8	17.4	14.4	15.5	149	0.3	2.5
260	17.8	17.0	14.3	15.4	149	0.3	3.4
300	16.6	17.3	14.0	15.4	149	0.3	3.0
330	16.9	18.4	14.6	15.4	149	0.5	10.3
370	16.8	18.2	14.5	15.4	149	0.3	4.7
420	17.4	17.4	14.0	15.3	149	0.3	3.8
460	17.8	18.0	13.5	15.3	149	0.2	1.0
500	17.8	18.1	14.4	15.3	149	0.3	3.6
530	17.2	18.1	13.6	15.3	137	0.1	0.6
545	16.8	17.6	13.8	15.1	137	0.2	1.9
570	18.0	18.2	14.0	15.1	137	0.3	3.0
600	18.1	18.0	14.2	15.1	137	0.4	6.1
630	17.7	17.7	13.1	15.1	137	0.1	0.4
690	17.4	17.2	13.7	15.1	137	0.2	1.2
745	18.1	17.9	13.1	15.1	149	0.1	0.6
800	17.8	17.5	13.8	15.1	149	0.2	1.6
855	17.9	17.4	13.6	15.1	149	0.2	1.0
910	17.9	17.1	13.9	15.1	149	0.2	2.0
965	18.0	16.9	14.4	15.0	149	0.3	4.6
1020	17.7	17.7	13.6	15.0	149	0.2	0.9
1075	17.6	17.7	13.5	15.0	149	0.2	1.0
1130	17.3	17.6	13.7	15.0	149	0.2	1.2
1185	17.5	17.4	13.8	15.0	149	0.2	1.9
1245	17.4	17.3	13.5	15.0	149	0.2	1.6

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

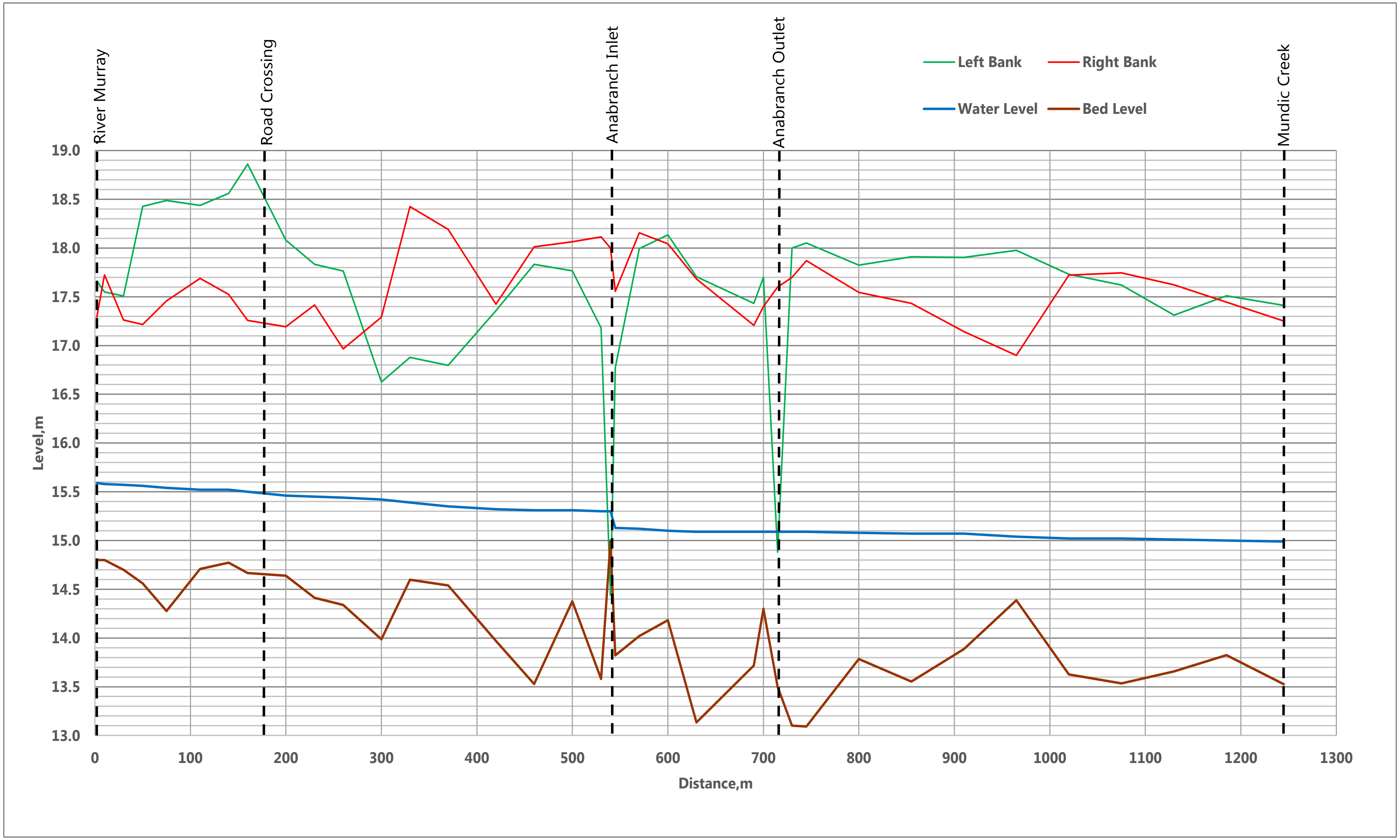

Figure 3.3 Water level profile for Scenario B
Preliminary Conceptual Structures (set at 150 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Table 3.3 Modelling Results for Scenario C

Preliminary Conceptual Structures (set at 400 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	16.1	400	0.5	8.8
10	17.5	17.7	14.8	16.0	400	0.5	8.1
30	17.5	17.3	14.7	16.0	400	0.4	4.9
50	18.4	17.2	14.6	16.0	400	0.6	14.2
75	18.5	17.5	14.3	16.0	400	0.6	11.7
110	18.4	17.7	14.7	15.9	400	0.5	9.8
140	18.6	17.5	14.8	15.9	400	0.5	
160	18.9	17.3	14.7	15.9	400	0.5	8.5
200	18.1	17.2	14.6	15.9	400	0.5	7.3
230	17.8	17.4	14.4	15.8	400	0.4	5.5
260	17.8	17.0	14.3	15.8	400	0.4	6.9
300	16.6	17.3	14.0	15.8	400	0.5	8.7
330	16.9	18.4	14.6	15.7	400	0.7	19.4
370	16.8	18.2	14.5	15.7	400	0.6	11.0
420	17.4	17.4	14.0	15.6	400	0.6	12.1
460	17.8	18.0	13.5	15.6	400	0.4	4.3
500	17.8	18.1	14.4	15.6	400	0.5	10.3
530	17.2	18.1	13.6	15.6	365	0.3	2.8
545	16.8	17.6	13.8	15.5	365	0.4	5.5
570	18.0	18.2	14.0	15.5	365	0.5	8.0
600	18.1	18.0	14.2	15.4	365	0.7	14.4
630	17.7	17.7	13.1	15.4	365	0.2	1.7
690	17.4	17.2	13.7	15.4	365	0.3	3.7
745	18.1	17.9	13.1	15.4	400	0.3	2.4
800	17.8	17.5	13.8	15.4	400	0.4	4.7
855	17.9	17.4	13.6	15.4	400	0.3	3.8
910	17.9	17.1	13.9	15.3	400	0.5	7.2
965	18.0	16.9	14.4	15.3	400	0.5	11.1
1020	17.7	17.7	13.6	15.2	400	0.3	2.6
1075	17.6	17.7	13.5	15.2	400	0.4	4.2
1130	17.3	17.6	13.7	15.2	400	0.4	5.4
1185	17.5	17.4	13.8	15.2	400	0.5	7.8
1245	17.4	17.3	13.5	15.1	400	0.5	8.1

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

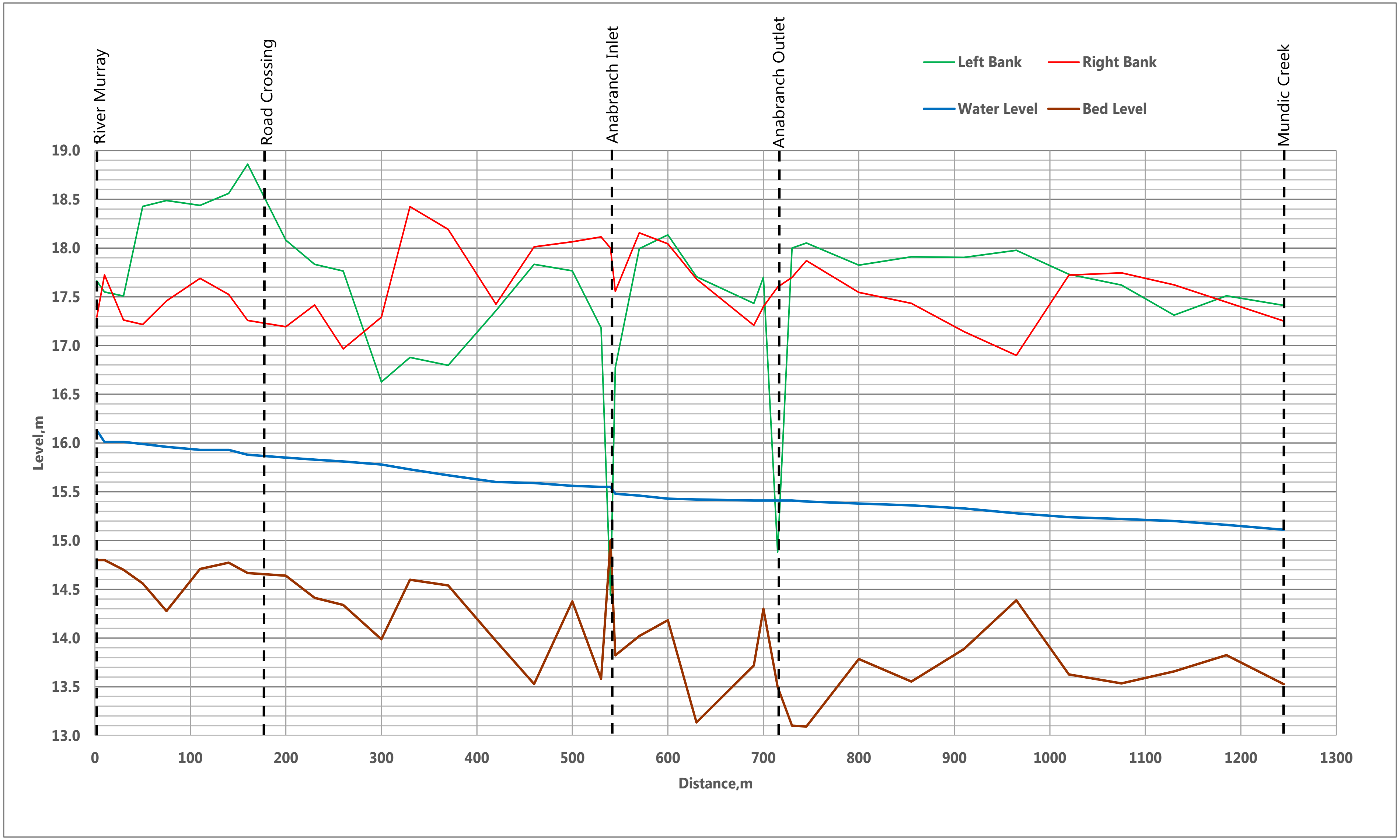

Figure 3.4 Water level profile for Scenario C

Preliminary Conceptual Structures (set at 400 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Table 3.4 Modelling Results for Scenario D

Preliminary Conceptual Structures (fully open) - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	16.3	498	0.6	10.7
10	17.5	17.7	14.8	16.3	498	0.6	10.6
30	17.5	17.3	14.7	16.2	498	0.5	6.6
50	18.4	17.2	14.6	16.1	498	0.7	18.2
75	18.5	17.5	14.3	16.1	498	0.7	14.6
110	18.4	17.7	14.7	16.0	498	0.7	11.9
140	18.6	17.5	14.8	16.0	498	0.5	
160	18.9	17.3	14.7	16.0	498	0.5	9.3
200	18.1	17.2	14.6	16.0	498	0.5	8.2
230	17.8	17.4	14.4	16.0	498	0.4	6.3
260	17.8	17.0	14.3	15.9	498	0.5	7.9
300	16.6	17.3	14.0	15.9	498	0.6	10.6
330	16.9	18.4	14.6	15.8	498	0.8	21.5
370	16.8	18.2	14.5	15.8	498	0.7	12.5
420	17.4	17.4	14.0	15.7	498	0.7	14.6
460	17.8	18.0	13.5	15.7	498	0.4	5.4
500	17.8	18.1	14.4	15.7	498	0.6	12.0
530	17.2	18.1	13.6	15.7	453	0.4	3.7
545	16.8	17.6	13.8	15.6	453	0.5	6.7
570	18.0	18.2	14.0	15.6	453	0.5	9.5
600	18.1	18.0	14.2	15.5	453	0.7	16.4
630	17.7	17.7	13.1	15.5	453	0.3	2.2
690	17.4	17.2	13.7	15.5	453	0.4	4.4
745	18.1	17.9	13.1	15.5	498	0.3	3.0
800	17.8	17.5	13.8	15.5	498	0.4	5.5
855	17.9	17.4	13.6	15.5	498	0.4	4.8
910	17.9	17.1	13.9	15.4	498	0.5	9.1
965	18.0	16.9	14.4	15.4	498	0.7	12.5
1020	17.7	17.7	13.6	15.3	498	0.3	3.1
1075	17.6	17.7	13.5	15.3	498	0.4	5.5
1130	17.3	17.6	13.7	15.3	498	0.5	7.0
1185	17.5	17.4	13.8	15.2	498	0.5	9.8
1245	17.4	17.3	13.5	15.2	498	0.6	10.9

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

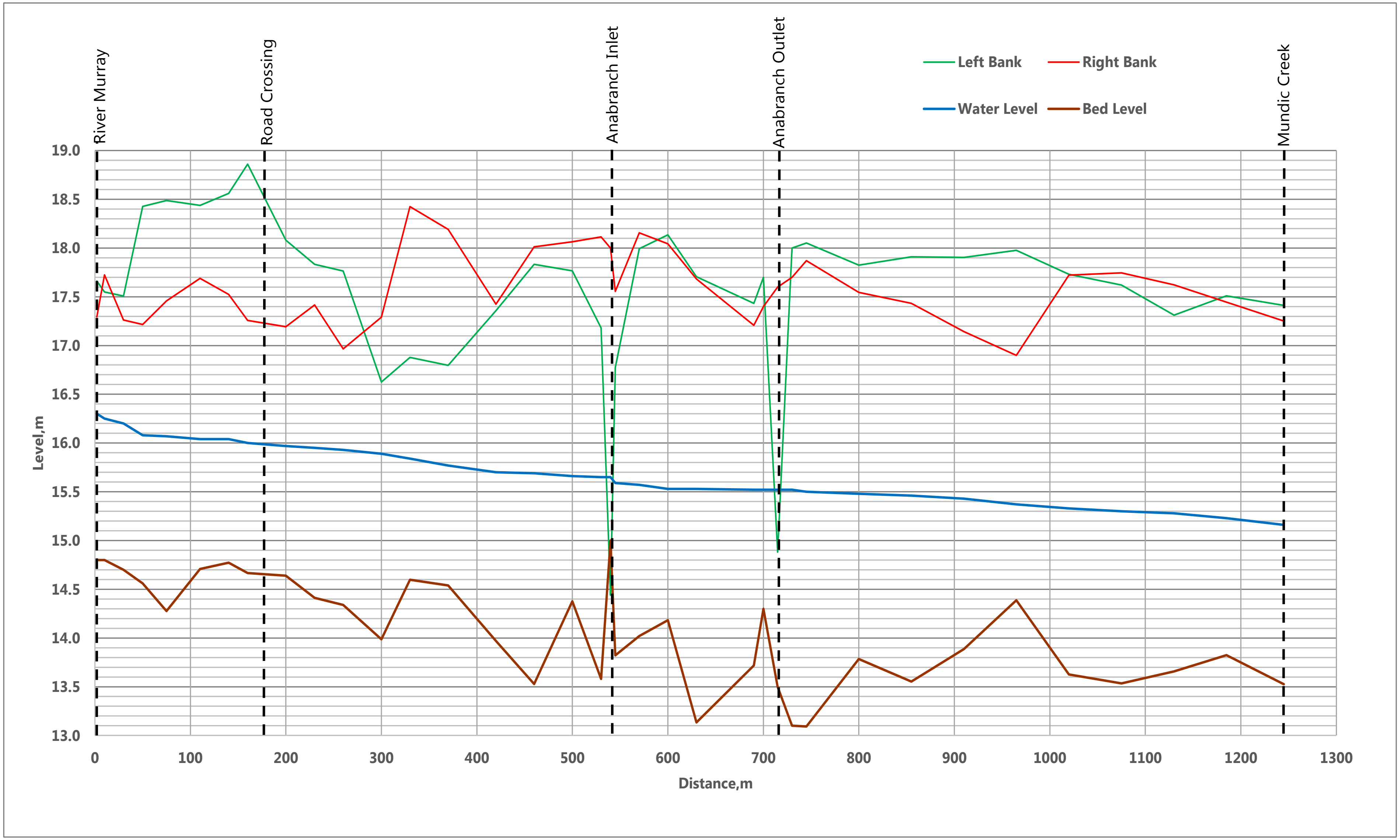

Figure 3.5 Water level profile for Scenario D
Preliminary Conceptual Structures (fully open) - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Table 3.5 Modelling Results for Scenario E

Preliminary Conceptual Structures (fully open) - Raised Lock 5 Weir Pool Level = 16.8 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	16.8	713	0.7	11.4
10	17.5	17.7	14.8	16.3	713	0.7	14.5
30	17.5	17.3	14.7	16.3	713	0.6	9.0
50	18.4	17.2	14.6	16.3	713	0.8	20.5
75	18.5	17.5	14.3	16.3	713	0.7	16.6
110	18.4	17.7	14.7	16.3	713	0.7	14.6
140	18.6	17.5	14.8	16.2	713	0.7	
160	18.9	17.3	14.7	16.2	713	0.6	10.4
200	18.1	17.2	14.6	16.2	713	0.6	10.0
230	17.8	17.4	14.4	16.2	713	0.5	7.9
260	17.8	17.0	14.3	16.2	713	0.5	9.7
300	16.6	17.3	14.0	16.1	713	0.7	12.4
330	16.9	18.4	14.6	16.1	713	0.9	24.8
370	16.8	18.2	14.5	16.0	713	0.7	14.2
420	17.4	17.4	14.0	15.9	713	0.8	18.2
460	17.8	18.0	13.5	15.9	713	0.5	7.2
500	17.8	18.1	14.4	15.9	713	0.7	14.5
530	17.2	18.1	13.6	15.9	644	0.4	5.5
545	16.8	17.6	13.8	15.8	644	0.5	9.2
570	18.0	18.2	14.0	15.8	644	0.6	12.2
600	18.1	18.0	14.2	15.7	644	0.8	19.9
630	17.7	17.7	13.1	15.7	644	0.4	3.4
690	17.4	17.2	13.7	15.7	644	0.4	5.9
745	18.1	17.9	13.1	15.7	713	0.4	4.2
800	17.8	17.5	13.8	15.7	713	0.5	7.0
855	17.9	17.4	13.6	15.7	713	0.5	6.8
910	17.9	17.1	13.9	15.6	713	0.7	12.9
965	18.0	16.9	14.4	15.5	713	0.7	14.7
1020	17.7	17.7	13.6	15.5	713	0.3	3.7
1075	17.6	17.7	13.5	15.5	713	0.5	8.0
1130	17.3	17.6	13.7	15.4	713	0.6	10.4
1185	17.5	17.4	13.8	15.4	713	0.7	13.3
1245	17.4	17.3	13.5	15.3	713	0.7	16.8

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

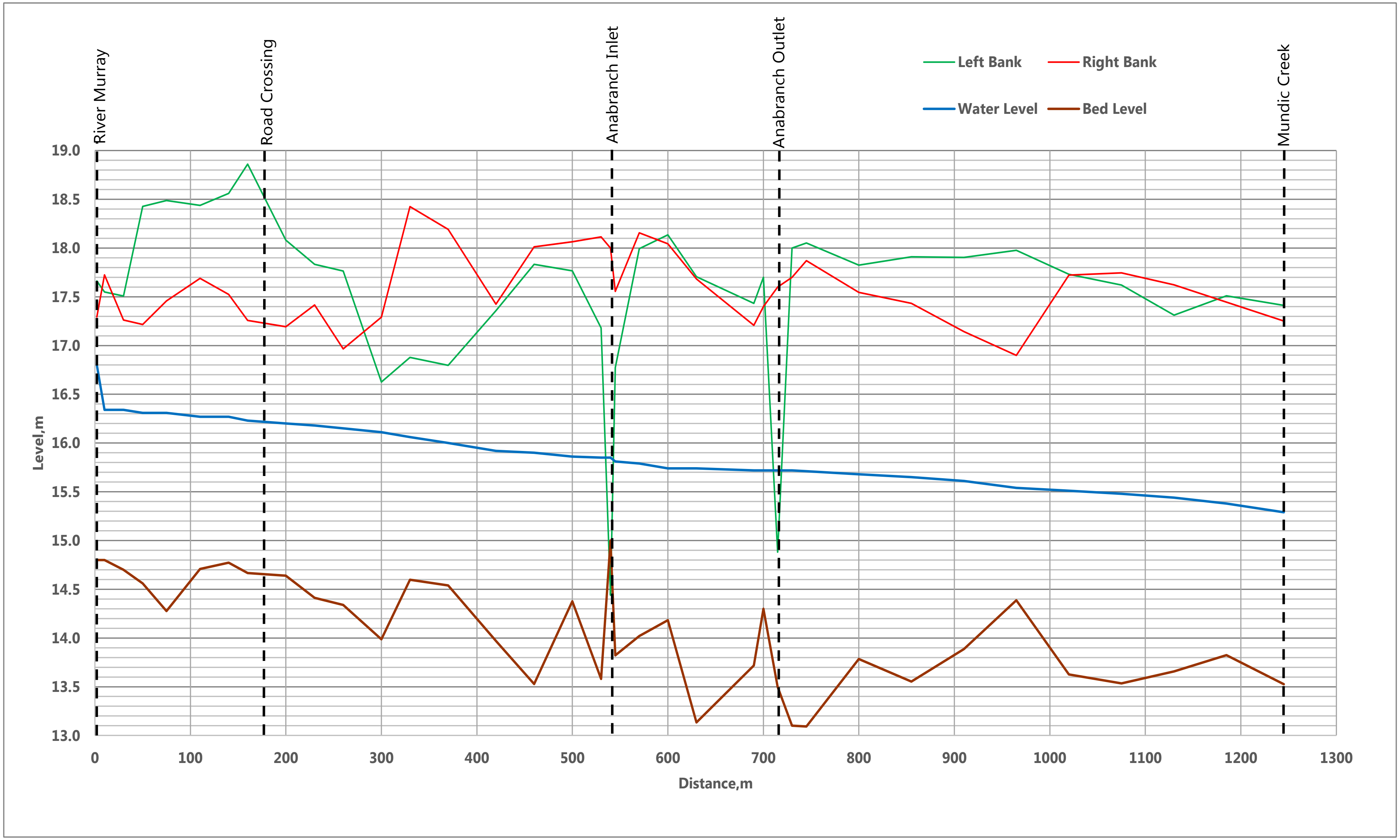

Figure 3.6 Water level profile for Scenario E
Preliminary Conceptual Structures (fully open) - Raised Lock 5 Weir Pool Level = 16.8 m AHD

Table 3.6 Modelling Results for Scenario F

Preliminary Conceptual Structures (fully open) - Lowered Lock 5 Weir Pool Level = 15.7 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	15.7	203	0.4	4.7
10	17.5	17.7	14.8	15.7	203	0.4	4.1
30	17.5	17.3	14.7	15.7	203	0.3	2.5
50	18.4	17.2	14.6	15.7	203	0.5	10.7
75	18.5	17.5	14.3	15.7	203	0.4	6.9
110	18.4	17.7	14.7	15.6	203	0.4	6.1
140	18.6	17.5	14.8	15.6	203	0.3	
160	18.9	17.3	14.7	15.6	203	0.4	6.4
200	18.1	17.2	14.6	15.6	203	0.3	4.7
230	17.8	17.4	14.4	15.6	203	0.3	3.2
260	17.8	17.0	14.3	15.5	203	0.3	4.3
300	16.6	17.3	14.0	15.5	203	0.4	4.3
330	16.9	18.4	14.6	15.5	203	0.6	12.5
370	16.8	18.2	14.5	15.4	203	0.4	6.2
420	17.4	17.4	14.0	15.4	203	0.4	5.6
460	17.8	18.0	13.5	15.4	203	0.2	1.6
500	17.8	18.1	14.4	15.4	203	0.4	5.0
530	17.2	18.1	13.6	15.4	186	0.2	1.0
545	16.8	17.6	13.8	15.2	186	0.3	3.0
570	18.0	18.2	14.0	15.2	186	0.4	4.7
600	18.1	18.0	14.2	15.1	186	0.5	9.9
630	17.7	17.7	13.1	15.1	186	0.2	0.7
690	17.4	17.2	13.7	15.1	186	0.2	2.0
745	18.1	17.9	13.1	15.1	203	0.2	1.1
800	17.8	17.5	13.8	15.1	203	0.3	2.9
855	17.9	17.4	13.6	15.1	203	0.2	1.8
910	17.9	17.1	13.9	15.1	203	0.3	3.6
965	18.0	16.9	14.4	15.0	203	0.5	9.3
1020	17.7	17.7	13.6	15.0	203	0.2	1.9
1075	17.6	17.7	13.5	15.0	203	0.2	2.0
1130	17.3	17.6	13.7	15.0	203	0.3	2.5
1185	17.5	17.4	13.8	14.9	203	0.3	4.6
1245	17.4	17.3	13.5	14.9	203	0.3	3.7

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

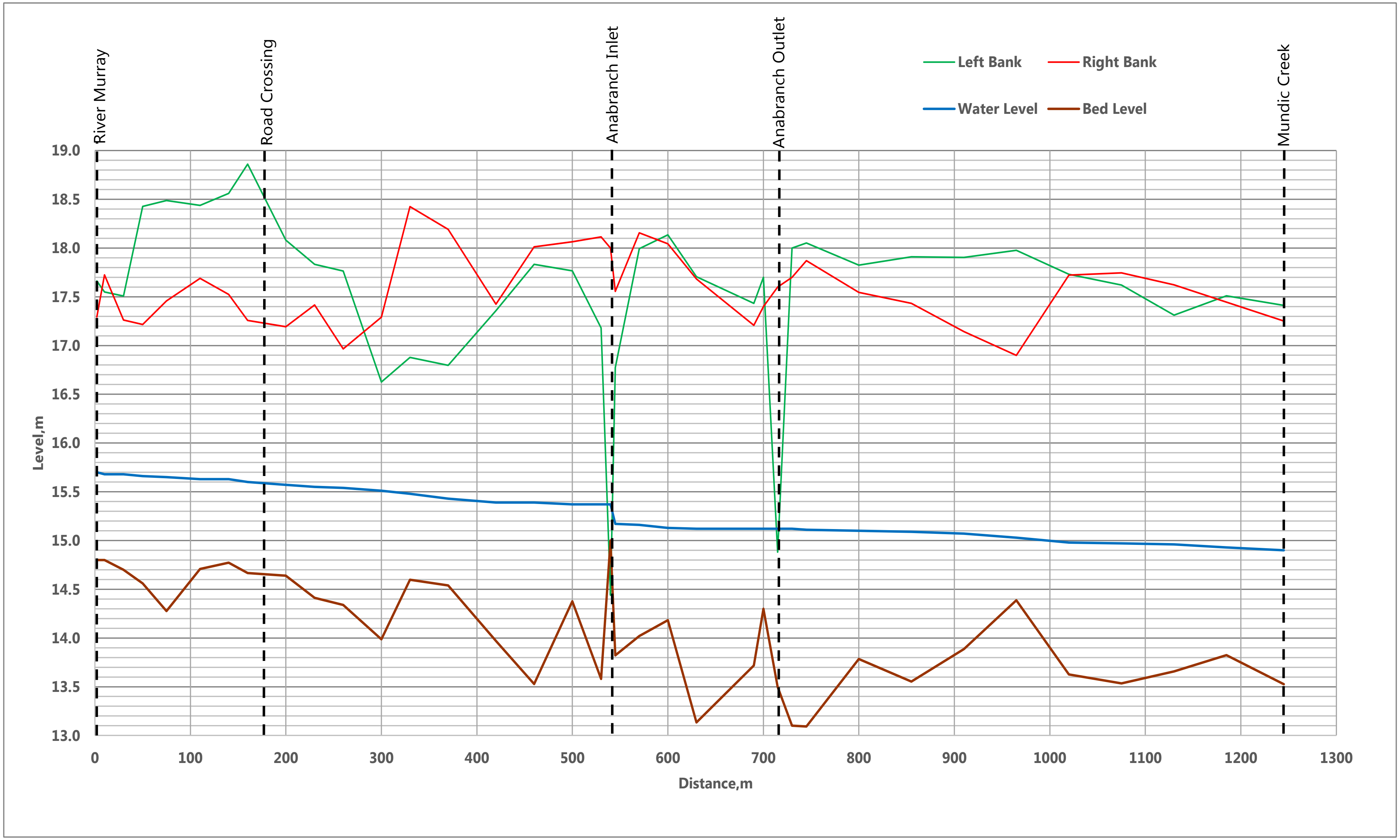

Figure 3.7 Water level profile for Scenario F
Preliminary Conceptual Structures (fully open) - Lowered Lock 5 Weir Pool Level = 15.7 m AHD

Table 3.7 Modelling Results for Scenario G

No Structure - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	16.3	641	0.8	17.5
10	17.5	17.7	14.8	16.3	641	0.7	12.6
30	17.5	17.3	14.7	16.3	641	0.5	7.9
50	18.4	17.2	14.6	16.3	641	0.8	18.9
75	18.5	17.5	14.3	16.2	641	0.7	16.3
110	18.4	17.7	14.7	16.2	641	0.7	13.7
140	18.6	17.5	14.8	16.2	641	0.5	9.9
160	18.9	17.3	14.7	16.2	641	0.5	10.1
200	18.1	17.2	14.6	16.1	641	0.5	9.4
230	17.8	17.4	14.4	16.1	641	0.5	7.4
260	17.8	17.0	14.3	16.1	641	0.5	9.2
300	16.6	17.3	14.0	16.0	641	0.7	12.4
330	16.9	18.4	14.6	16.0	641	0.8	23.9
370	16.8	18.2	14.5	15.9	641	0.7	13.9
420	17.4	17.4	14.0	15.9	641	0.7	17.4
460	17.8	18.0	13.5	15.8	641	0.5	6.7
500	17.8	18.1	14.4	15.8	641	0.6	13.9
530	17.2	18.1	13.6	15.8	572	0.4	5.0
545	16.8	17.6	13.8	15.7	572	0.5	8.1
570	18.0	18.2	14.0	15.7	572	0.6	11.0
600	18.1	18.0	14.2	15.7	572	0.7	18.2
630	17.7	17.7	13.1	15.7	572	0.3	2.9
690	17.4	17.2	13.7	15.7	572	0.4	5.2
745	18.1	17.9	13.1	15.6	641	0.4	3.8
800	17.8	17.5	13.8	15.6	641	0.4	6.6
855	17.9	17.4	13.6	15.6	641	0.4	6.2
910	17.9	17.1	13.9	15.6	641	0.6	11.7
965	18.0	16.9	14.4	15.5	641	0.6	14.1
1020	17.7	17.7	13.6	15.5	641	0.3	3.5
1075	17.6	17.7	13.5	15.4	641	0.5	7.2
1130	17.3	17.6	13.7	15.4	641	0.5	9.3
1185	17.5	17.4	13.8	15.3	641	0.6	12.3
1245	17.4	17.3	13.5	15.2	641	0.7	15.0

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

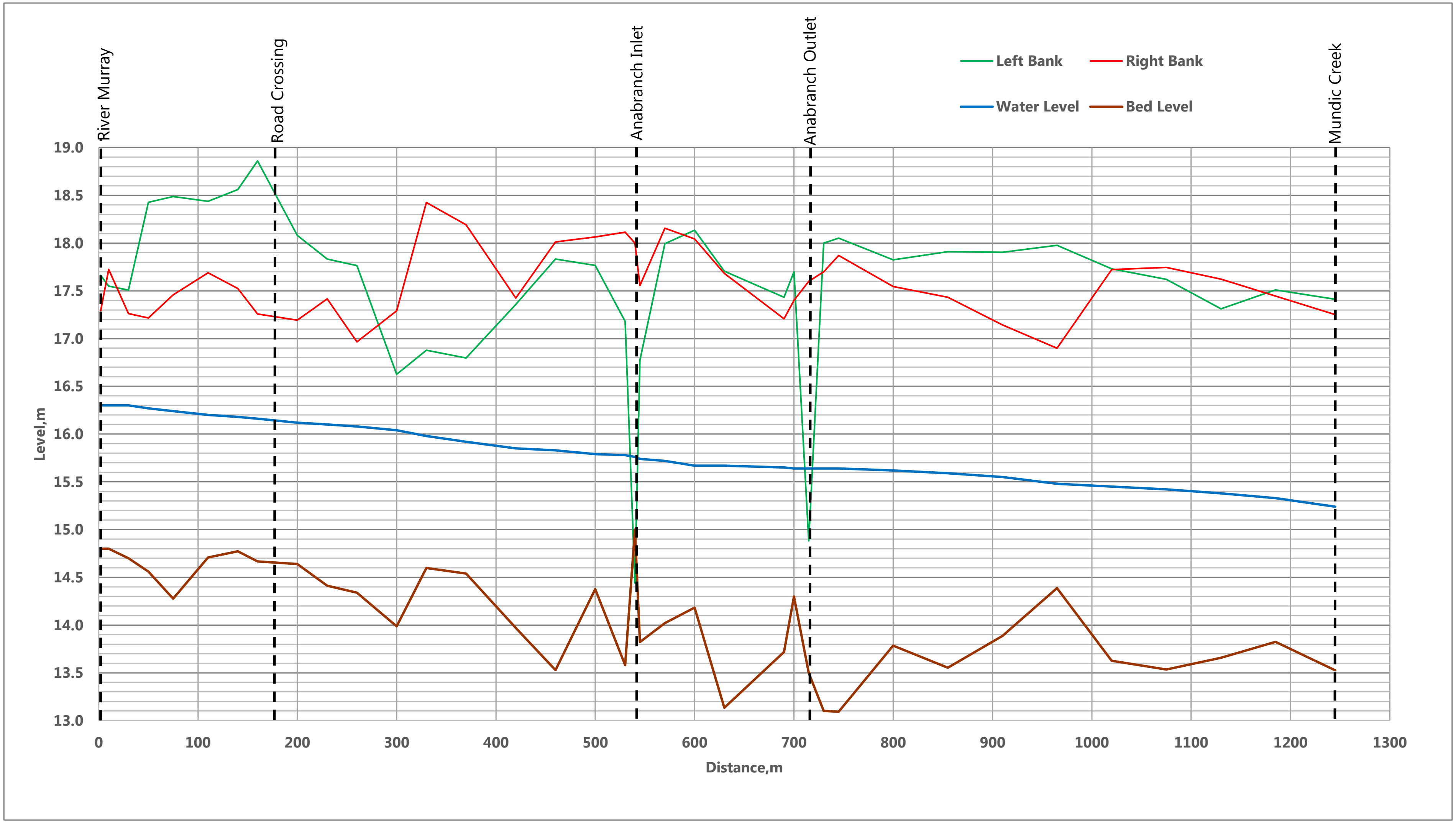

Figure 3.8 Water level Profile for Scenario G
No Structure - Normal Lock 5 Weir Pool Level = 16.3 m AHD

Table 3.8 Modelling Results for Scenario H
No Structure - Raised Lock 5 Weir Pool Level = 16.8 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m^2
2	17.7	17.3	14.8	16.8	1248	1.1	35.5
10	17.5	17.7	14.8	16.8	1248	0.9	23.0
30	17.5	17.3	14.7	16.8	1248	0.7	14.2
50	18.4	17.2	14.6	16.8	1248	1.0	29.9
75	18.5	17.5	14.3	16.7	1248	0.9	24.9
110	18.4	17.7	14.7	16.7	1248	0.9	22.3
140	18.6	17.5	14.8	16.7	1248	0.7	14.3
160	18.9	17.3	14.7	16.6	1248	0.7	13.8
200	18.1	17.2	14.6	16.6	1248	0.7	14.1
230	17.8	17.4	14.4	16.6	1248	0.6	11.3
260	17.8	17.0	14.3	16.6	1248	0.7	14.0
300	16.6	17.3	14.0	16.5	1248	0.5	8.9
330	16.9	18.4	14.6	16.5	1248	0.9	26.2
370	16.8	18.2	14.5	16.4	1248	0.6	13.7
420	17.4	17.4	14.0	16.3	1248	0.8	21.6
460	17.8	18.0	13.5	16.3	1248	0.6	10.7
500	17.8	18.1	14.4	16.3	1248	0.8	19.7
530	17.2	18.1	13.6	16.3	1064	0.6	9.8
545	16.8	17.6	13.8	16.2	1064	0.7	13.4
570	18.0	18.2	14.0	16.2	1064	0.7	16.2
600	18.1	18.0	14.2	16.1	1064	0.9	24.3
630	17.7	17.7	13.1	16.1	1064	0.5	5.8
690	17.4	17.2	13.7	16.1	1064	0.5	8.2
745	18.1	17.9	13.1	16.1	1248	0.5	7.0
800	17.8	17.5	13.8	16.1	1248	0.6	10.5
855	17.9	17.4	13.6	16.0	1248	0.6	11.5
910	17.9	17.1	13.9	16.0	1248	0.8	21.1
965	18.0	16.9	14.4	15.9	1248	0.8	19.3
1020	17.7	17.7	13.6	15.9	1248	0.4	5.1
1075	17.6	17.7	13.5	15.8	1248	0.7	13.7
1130	17.3	17.6	13.7	15.8	1248	0.8	18.1
1185	17.5	17.4	13.8	15.7	1248	0.8	20.6
1245	17.4	17.3	13.5	15.6	1248	1.0	30.7

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

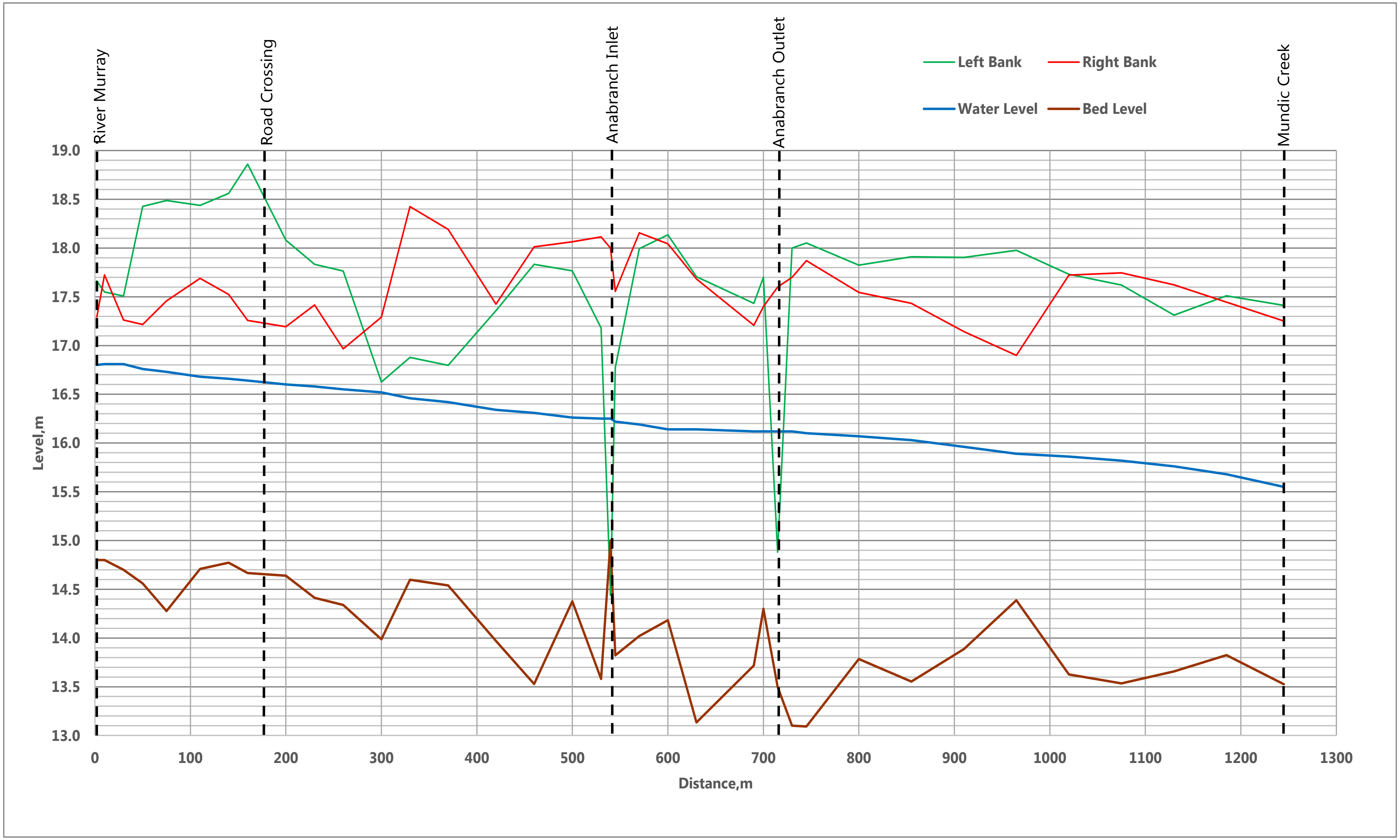

Figure 3.9 Water level profile for Scenario H
No Structure - Raised Lock 5 Weir Pool Level = 16.8 m AHD

Table 3.9 Modelling Results for Scenario I

No Structure - Lowered Lock 5 Weir Pool Level = 15.7 m AHD

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	15.7	200	0.4	4.4
10	17.5	17.7	14.8	15.7	200	0.3	3.7
30	17.5	17.3	14.7	15.7	200	0.3	2.3
50	18.4	17.2	14.6	15.7	200	0.5	8.8
75	18.5	17.5	14.3	15.7	200	0.4	6.0
110	18.4	17.7	14.7	15.6	200	0.4	5.4
140	18.6	17.5	14.8	15.6	200	0.4	6.0
160	18.9	17.3	14.7	15.6	200	0.4	6.3
200	18.1	17.2	14.6	15.6	200	0.3	4.7
230	17.8	17.4	14.4	15.6	200	0.3	3.1
260	17.8	17.0	14.3	15.5	200	0.3	4.3
300	16.6	17.3	14.0	15.5	200	0.3	4.2
330	16.9	18.4	14.6	15.5	200	0.5	12.4
370	16.8	18.2	14.5	15.4	200	0.4	6.1
420	17.4	17.4	14.0	15.4	200	0.4	5.5
460	17.8	18.0	13.5	15.4	200	0.2	1.6
500	17.8	18.1	14.4	15.4	200	0.4	5.0
530	17.2	18.1	13.6	15.4	182	0.2	1.0
545	16.8	17.6	13.8	15.2	182	0.3	2.9
570	18.0	18.2	14.0	15.2	182	0.4	4.7
600	18.1	18.0	14.2	15.1	182	0.5	9.8
630	17.7	17.7	13.1	15.1	182	0.2	0.7
690	17.4	17.2	13.7	15.1	182	0.2	2.0
745	18.1	17.9	13.1	15.1	200	0.2	1.1
800	17.8	17.5	13.8	15.1	200	0.3	2.8
855	17.9	17.4	13.6	15.1	200	0.2	1.8
910	17.9	17.1	13.9	15.1	200	0.3	3.5
965	18.0	16.9	14.4	15.0	200	0.5	9.2
1020	17.7	17.7	13.6	15.0	200	0.2	1.9
1075	17.6	17.7	13.5	15.0	200	0.2	2.0
1130	17.3	17.6	13.7	15.0	200	0.3	2.4
1185	17.5	17.4	13.8	14.9	200	0.3	4.5
1245	17.4	17.3	13.5	14.9	200	0.3	3.6

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

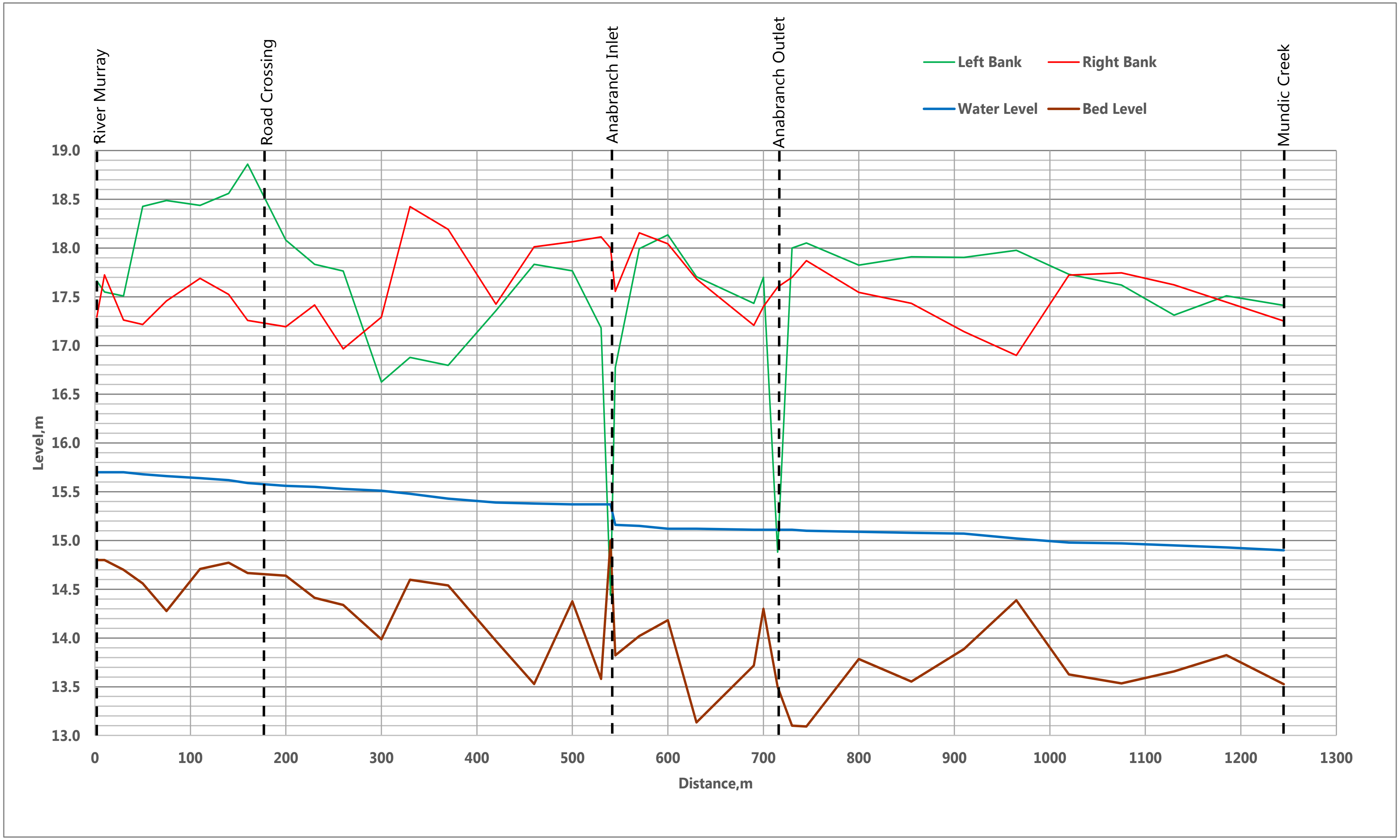

Figure 3.10 Water level profile for Scenario I
No Structure - Lowered Lock 5 Weir Pool Level = 15.7 m AHD

Table 3.10 Modelling Results for Scenario J

No Structure - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n = 0.03

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	16.3	1267	1.6	17.3
10	17.5	17.7	14.8	16.3	1267	1.3	12.0
30	17.5	17.3	14.7	16.4	1267	1.0	7.3
50	18.4	17.2	14.6	16.3	1267	1.5	18.1
75	18.5	17.5	14.3	16.3	1267	1.4	15.3
110	18.4	17.7	14.7	16.2	1267	1.2	12.4
140	18.6	17.5	14.8	16.2	1267	1.0	8.4
160	18.9	17.3	14.7	16.2	1267	1.0	8.4
200	18.1	17.2	14.6	16.2	1267	1.0	7.9
230	17.8	17.4	14.4	16.2	1267	0.9	6.1
260	17.8	17.0	14.3	16.2	1267	1.0	7.5
300	16.6	17.3	14.0	16.1	1267	1.1	9.3
330	16.9	18.4	14.6	16.1	1267	1.5	19.6
370	16.8	18.2	14.5	16.0	1267	1.1	9.8
420	17.4	17.4	14.0	16.0	1267	1.3	12.6
460	17.8	18.0	13.5	16.0	1267	0.8	4.8
500	17.8	18.1	14.4	16.0	1267	1.1	9.3
530	17.2	18.1	13.6	16.0	1001	0.7	3.7
545	16.8	17.6	13.8	15.8	1001	0.9	6.2
570	18.0	18.2	14.0	15.7	1001	1.0	8.4
600	18.1	18.0	14.2	15.7	1001	1.3	14.2
630	17.7	17.7	13.1	15.7	1001	0.6	2.2
690	17.4	17.2	13.7	15.7	1001	0.7	3.8
745	18.1	17.9	13.1	15.7	1267	0.7	3.5
800	17.8	17.5	13.8	15.7	1267	0.8	5.9
855	17.9	17.4	13.6	15.6	1267	0.9	5.6
910	17.9	17.1	13.9	15.6	1267	1.2	10.9
965	18.0	16.9	14.4	15.5	1267	1.2	12.4
1020	17.7	17.7	13.6	15.5	1267	0.6	2.9
1075	17.6	17.7	13.5	15.5	1267	0.9	6.3
1130	17.3	17.6	13.7	15.4	1267	1.0	8.2
1185	17.5	17.4	13.8	15.4	1267	1.1	10.2
1245	17.4	17.3	13.5	15.3	1267	1.2	12.7

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

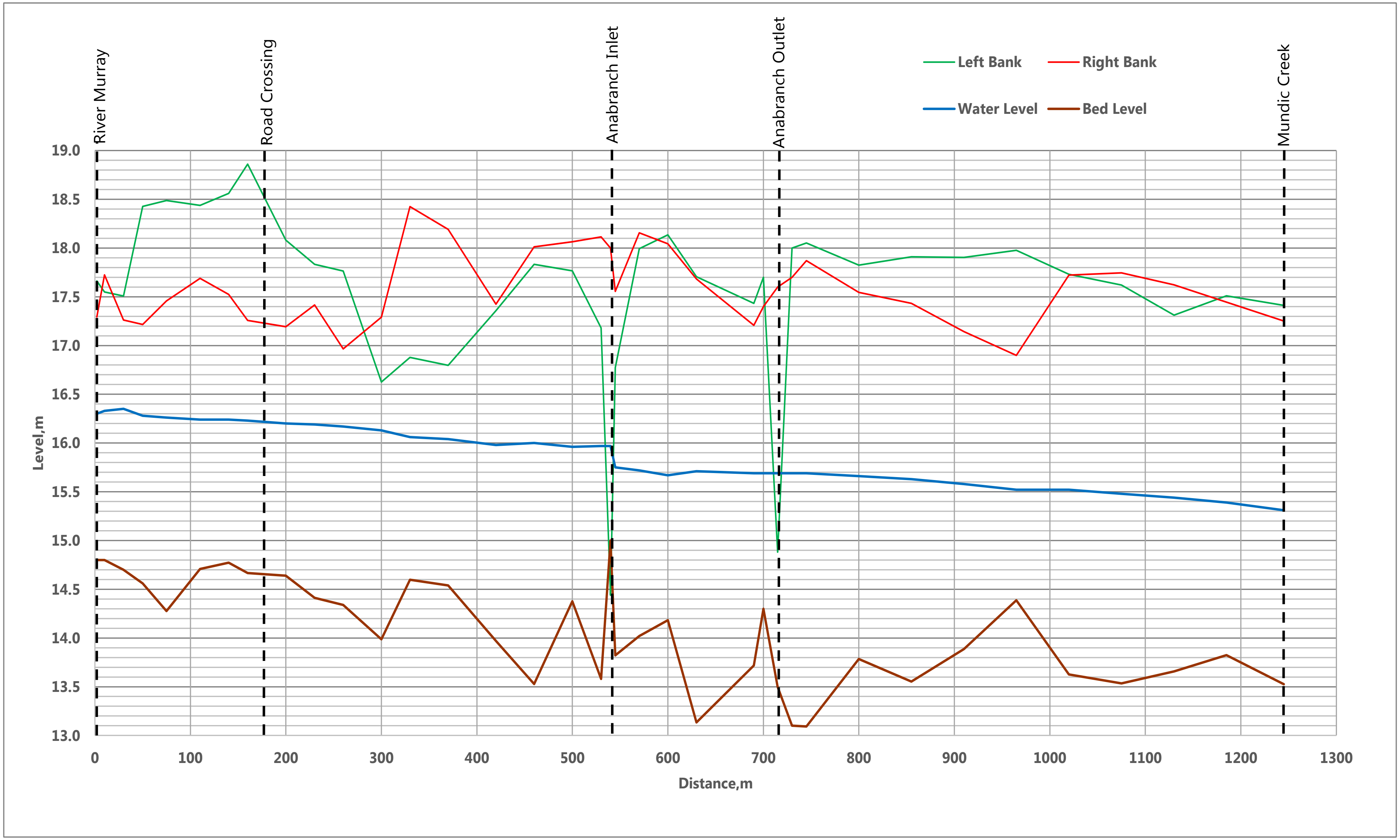

Figure 3.11 Water level profile for Scenario J

No Structure - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n = 0.03

Table 3.11 Modelling Results for Scenario K

No Structure - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n = 0.08

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	16.3	484	0.6	17.4
10	17.5	17.7	14.8	16.3	484	0.5	12.7
30	17.5	17.3	14.7	16.3	484	0.4	8.0
50	18.4	17.2	14.6	16.3	484	0.6	19.0
75	18.5	17.5	14.3	16.2	484	0.5	16.4
110	18.4	17.7	14.7	16.2	484	0.5	13.8
140	18.6	17.5	14.8	16.2	484	0.4	10.1
160	18.9	17.3	14.7	16.2	484	0.4	10.3
200	18.1	17.2	14.6	16.1	484	0.4	9.6
230	17.8	17.4	14.4	16.1	484	0.4	7.6
260	17.8	17.0	14.3	16.1	484	0.4	9.4
300	16.6	17.3	14.0	16.0	484	0.5	12.7
330	16.9	18.4	14.6	16.0	484	0.6	24.2
370	16.8	18.2	14.5	15.9	484	0.5	14.4
420	17.4	17.4	14.0	15.8	484	0.6	17.9
460	17.8	18.0	13.5	15.8	484	0.4	6.9
500	17.8	18.1	14.4	15.8	484	0.5	14.5
530	17.2	18.1	13.6	15.8	434	0.3	5.1
545	16.8	17.6	13.8	15.7	434	0.4	8.4
570	18.0	18.2	14.0	15.7	434	0.4	11.4
600	18.1	18.0	14.2	15.7	434	0.6	18.7
630	17.7	17.7	13.1	15.7	434	0.2	3.0
690	17.4	17.2	13.7	15.7	434	0.3	5.4
745	18.1	17.9	13.1	15.6	484	0.3	3.9
800	17.8	17.5	13.8	15.6	484	0.3	6.7
855	17.9	17.4	13.6	15.6	484	0.3	6.3
910	17.9	17.1	13.9	15.5	484	0.5	11.8
965	18.0	16.9	14.4	15.5	484	0.5	14.5
1020	17.7	17.7	13.6	15.4	484	0.2	3.7
1075	17.6	17.7	13.5	15.4	484	0.4	7.4
1130	17.3	17.6	13.7	15.4	484	0.4	9.6
1185	17.5	17.4	13.8	15.3	484	0.5	12.9
1245	17.4	17.3	13.5	15.2	484	0.5	15.6

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

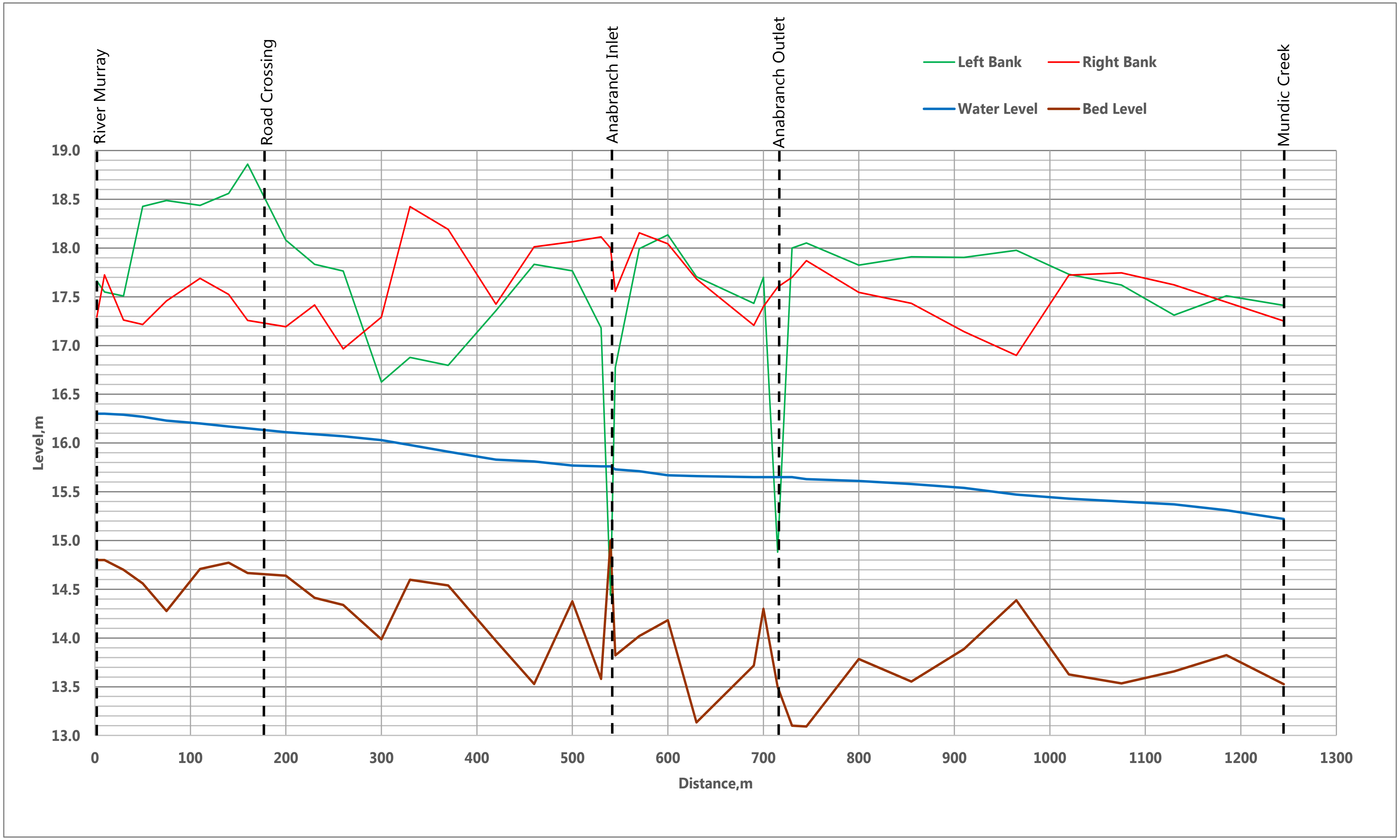

Figure 3.12 Water level profile for Scenario K

No Structure - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n = 0.08

Table 3.12 Modelling Results within Bert Dix Park

Scenarios	Flow ML/d	Average Water Level m AHD	Average Velocity m/s
Scenario A	184	15.8	0.3
Scenario B	149	15.6	0.3
Scenario C	400	16.0	0.5
Scenario D	498	16.1	0.6
Scenario E	713	16.3	0.7
Scenario F	203	15.7	0.4
Scenario G	641	16.2	0.6
Scenario H	1248	16.7	0.9
Scenario I	200	15.7	0.4
Scenario J	1267	16.3	1.2
Scenario K	484	16.2	0.5

4 Conclusions

The hydraulic modelling results indicate that:

- With existing structures the model based on updated survey data accurately simulates the expected current flow of 184 ML/d through the creek which is consistent with previous modelled flows of 170 ML/d (McCullough, 2013) and 181 ML/d (Water Technology, 2010c).
- With preliminary conceptual structures in place for the normal pool level scenario (16.3 m AHD), a flow of 400 ML/d can be passed through the creek within the current banks however a risk of erosion (represented by a bed shear stress threshold of 11 N/m^2) occurs in some cross sections.
- With preliminary conceptual structures fully open for the normal pool level scenario (16.3 m AHD), a flow of 498 ML/d can be conveyed through the creek, however bed shear stress values exceeded 11 N/m^2 in some places. For the scenario where Lock 5 is raised to 16.8 m AHD, flows remained within the banks of the creek and a flow of 713 ML/d could be passed, however high risk of erosion is expected in many cross sections.
- Without structures in place for the normal pool level scenario (16.3 m AHD), a flow of 641 ML/d is modelled and the banks are expected to contain the flow.

As such, it is expected that at flows of approximately 400 ML/d and greater some erosion protection may be required within the creek, but the banks are expected to be able to contain this flow. Further investigation of soil type and channel characteristics is required to confirm the bed shear stress threshold of 11 N/m^2 adopted to indicate erosion risk. Appropriate freeboard requirements should also be considered as part of the design phase.

A range in Manning's n values was also considered to assess the impact on the capacity of the creek. An increase in n from n=0.06 to n=0.08 reduced the flow conveyed through the channel from 641 ML/d to 484 ML/d for the scenario without structures in place at pool level. With a lower Manning's value of n=0.03 the flow through the channel increased substantially to 1,267 ML/d. However, the currently adopted value of n=0.06 represents a calibrated value, and the current best knowledge of the representative roughness for the creek.

5 References

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6 Addendum

Additional hydraulic modelling was undertaken to investigate the hydraulic characteristics along Margaret Dowling Creek by setting the flow to 600 ML/d for both the Margaret Dowling Creek and Deep Creek regulators (total inflow equals 1200 ML/d), regardless of the size of the structures. It should be noted that for this scenario, lowering or raising of the weir pool level does not impact on the water level downstream of the regulators because the flow is set to a constant value of 600 ML/d and therefore flow does not vary with changing weir pool levels. The modelling used the same methodology as described previously.

Three scenarios were defined to provide in-depth information for the design of infrastructure for Margaret Dowling Creek and this section presents the outputs of the hydraulic modelling exercise for the following additional scenarios:

- **Scenario L**: (Flow set to 600 ML/d) - Normal Lock 5 Weir Pool Level (16.3 m AHD) – Manning's n = 0.06
- **Scenario M**: (Flow set to 600 ML/d) - Normal Lock 5 Weir Pool Level (16.3 m AHD) – Manning's n = 0.03
- **Scenario N**: (Flow set to 600 ML/d) - Normal Lock 5 Weir Pool Level (16.3 m AHD) – Manning's n = 0.08

With the flow set to 600 ML/d and a Manning's n value of n=0.06 (Scenario L) the results were found to be very similar to scenario G where the model was tested without any structures in place to estimate the maximum capacity of the creek (641 ML/d). There was only a 0.02-0.04 m decrease in water level as the flow was decreased by 41 ML/d.

A range of Manning's n values was considered to assess the impact on the water levels. A decrease in n from n=0.06 to n=0.03 reduced the water level by 0.10-0.35 m and consequently the risk of erosion (represented by a bed shear stress threshold of 11 N/m^2) decreases in the majority of cross sections. The impact of the stone weir on the water level can be seen in Figure 6.2.

With a higher Manning's value of n=0.08, the water level in the channel increased by 0.10-0.20 m. The flow still remained within the banks of the creek, however a risk of erosion occurred in more channel sections.

Table 6.1 Modelling Results for Scenario L

(Flow set at 600 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n (0.06)

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	16.3	600	0.8	16.4
10	17.5	17.7	14.8	16.3	600	0.6	12.0
30	17.5	17.3	14.7	16.3	600	0.5	7.4
50	18.4	17.2	14.6	16.2	600	0.7	18.3
75	18.5	17.5	14.3	16.2	600	0.7	15.7
110	18.4	17.7	14.7	16.2	600	0.6	13.1
140	18.6	17.5	14.8	16.1	600	0.5	9.7
160	18.9	17.3	14.7	16.1	600	0.5	9.9
200	18.1	17.2	14.6	16.1	600	0.5	9.1
230	17.8	17.4	14.4	16.1	600	0.5	7.2
260	17.8	17.0	14.3	16.0	600	0.5	8.9
300	16.6	17.3	14.0	16.0	600	0.6	12.1
330	16.9	18.4	14.6	15.9	600	0.8	23.4
370	16.8	18.2	14.5	15.9	600	0.6	13.7
420	17.4	17.4	14.0	15.8	600	0.7	16.8
460	17.8	18.0	13.5	15.8	600	0.5	6.4
500	17.8	18.1	14.4	15.8	600	0.6	13.5
530	17.2	18.1	13.6	15.7	536	0.4	4.7
545	16.8	17.6	13.8	15.7	536	0.5	7.8
570	18.0	18.2	14.0	15.7	536	0.6	10.7
600	18.1	18.0	14.2	15.6	536	0.7	17.9
630	17.7	17.7	13.1	15.6	536	0.3	2.7
690	17.4	17.2	13.7	15.6	536	0.4	5.0
745	18.1	17.9	13.1	15.6	600	0.4	3.7
800	17.8	17.5	13.8	15.6	600	0.4	6.3
855	17.9	17.4	13.6	15.6	600	0.4	5.8
910	17.9	17.1	13.9	15.5	600	0.6	11.1
965	18.0	16.9	14.4	15.5	600	0.6	13.9
1020	17.7	17.7	13.6	15.4	600	0.3	3.5
1075	17.6	17.7	13.5	15.4	600	0.5	6.9
1130	17.3	17.6	13.7	15.3	600	0.5	8.9
1185	17.5	17.4	13.8	15.3	600	0.6	12.0
1245	17.4	17.3	13.5	15.2	600	0.7	14.3

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

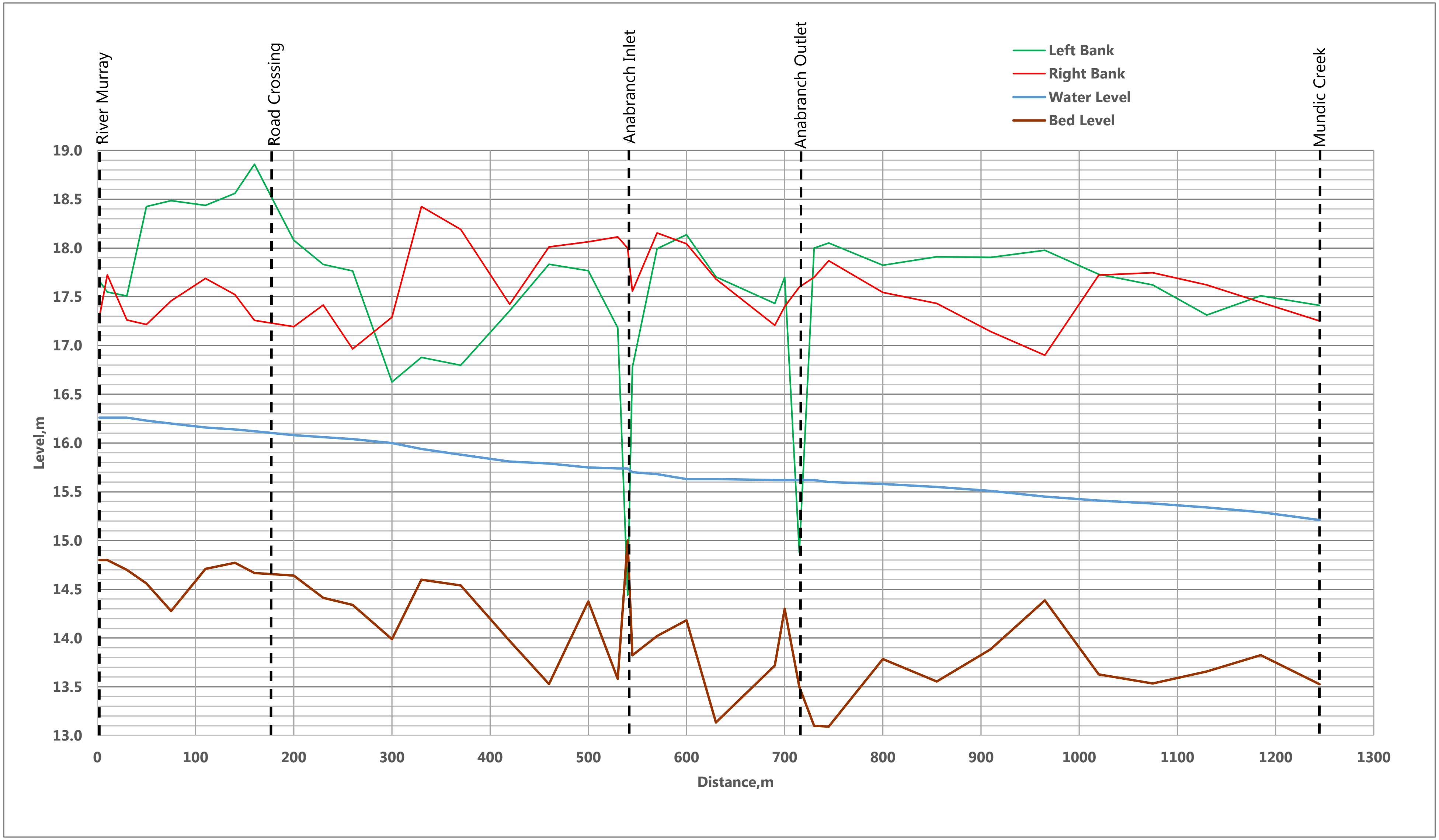

Figure 6.1 Water level profile for Scenario L
(Flow set at 600 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n (0.06)

Table 6.2 Modelling Results for Scenario M

(Flow set at 600 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n (0.03)

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	15.9	600	1.0	6.9
10	17.5	17.7	14.8	15.9	600	0.8	5.5
30	17.5	17.3	14.7	15.9	600	0.6	3.2
50	18.4	17.2	14.6	15.9	600	1.1	10.5
75	18.5	17.5	14.3	15.9	600	1.0	8.1
110	18.4	17.7	14.7	15.9	600	0.9	6.6
140	18.6	17.5	14.8	15.8	600	0.8	5.7
160	18.9	17.3	14.7	15.8	600	0.8	5.9
200	18.1	17.2	14.6	15.8	600	0.7	4.7
230	17.8	17.4	14.4	15.8	600	0.6	3.4
260	17.8	17.0	14.3	15.8	600	0.7	4.3
300	16.6	17.3	14.0	15.8	600	0.8	5.2
330	16.9	18.4	14.6	15.7	600	1.1	11.8
370	16.8	18.2	14.5	15.7	600	0.8	5.8
420	17.4	17.4	14.0	15.7	600	0.8	6.0
460	17.8	18.0	13.5	15.7	600	0.5	2.1
500	17.8	18.1	14.4	15.6	600	0.7	4.6
530	17.2	18.1	13.6	15.7	536	0.4	1.4
545	16.8	17.6	13.8	15.4	536	0.6	3.1
570	18.0	18.2	14.0	15.4	536	0.7	4.7
600	18.1	18.0	14.2	15.3	536	1.0	8.8
630	17.7	17.7	13.1	15.3	536	0.3	0.8
690	17.4	17.2	13.7	15.3	536	0.5	2.0
745	18.1	17.9	13.1	15.3	600	0.5	1.6
800	17.8	17.5	13.8	15.3	600	0.6	3.3
855	17.9	17.4	13.6	15.3	600	0.6	2.5
910	17.9	17.1	13.9	15.3	600	0.7	4.8
965	18.0	16.9	14.4	15.2	600	0.9	8.0
1020	17.7	17.7	13.6	15.2	600	0.4	1.7
1075	17.6	17.7	13.5	15.2	600	0.6	2.6
1130	17.3	17.6	13.7	15.2	600	0.6	3.2
1185	17.5	17.4	13.8	15.2	600	0.7	4.7
1245	17.4	17.3	13.5	15.1	600	0.7	4.5

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

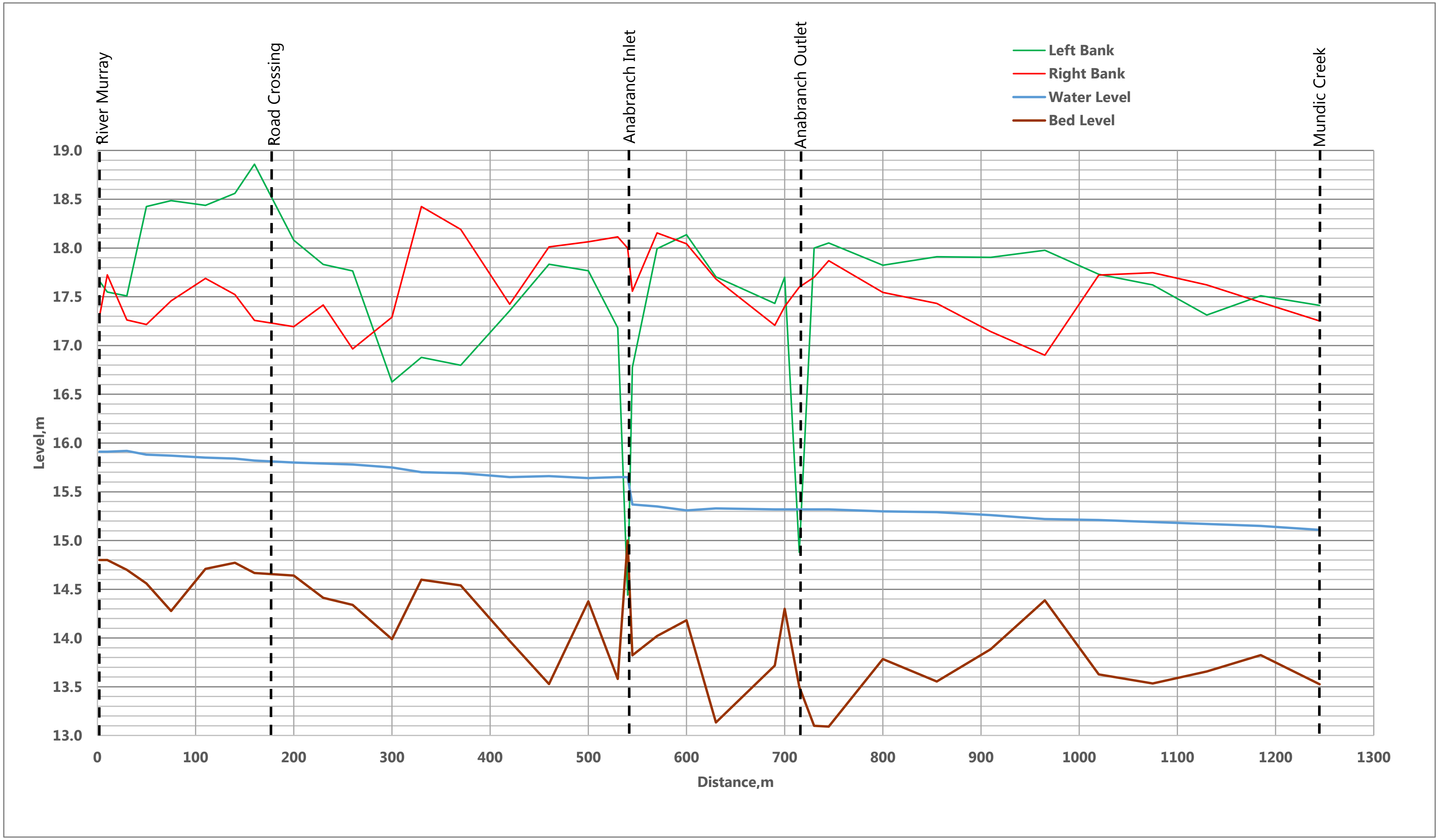

Figure 6.2 Water level profile for Scenario M

(Flow set at 600 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n (0.03)

Table 6.3 Modelling Results for Scenario N

(Flow set at 600 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n (0.08)

Chainage m	Left Bank m AHD	Right Bank m AHD	Bed Level m AHD	Water Level m AHD	Flow ML/d	Velocity m/s	Bed Shear Stress N/m²
2	17.7	17.3	14.8	16.5	600	0.7	22.3
10	17.5	17.7	14.8	16.5	600	0.6	15.6
30	17.5	17.3	14.7	16.5	600	0.4	10.0
50	18.4	17.2	14.6	16.4	600	0.6	21.9
75	18.5	17.5	14.3	16.4	600	0.6	19.0
110	18.4	17.7	14.7	16.4	600	0.5	16.3
140	18.6	17.5	14.8	16.3	600	0.4	11.3
160	18.9	17.3	14.7	16.3	600	0.4	11.3
200	18.1	17.2	14.6	16.3	600	0.4	10.9
230	17.8	17.4	14.4	16.2	600	0.4	8.8
260	17.8	17.0	14.3	16.2	600	0.4	10.7
300	16.6	17.3	14.0	16.2	600	0.5	12.4
330	16.9	18.4	14.6	16.1	600	0.7	26.5
370	16.8	18.2	14.5	16.1	600	0.5	15.1
420	17.4	17.4	14.0	16.0	600	0.6	20.1
460	17.8	18.0	13.5	16.0	600	0.4	8.3
500	17.8	18.1	14.4	15.9	600	0.5	16.4
530	17.2	18.1	13.6	15.9	536	0.4	6.5
545	16.8	17.6	13.8	15.9	536	0.4	10.1
570	18.0	18.2	14.0	15.9	536	0.5	13.2
600	18.1	18.0	14.2	15.8	536	0.6	21.0
630	17.7	17.7	13.1	15.8	536	0.3	3.9
690	17.4	17.2	13.7	15.8	536	0.3	6.5
745	18.1	17.9	13.1	15.8	600	0.3	4.9
800	17.8	17.5	13.8	15.7	600	0.4	7.9
855	17.9	17.4	13.6	15.7	600	0.4	7.9
910	17.9	17.1	13.9	15.7	600	0.5	14.9
965	18.0	16.9	14.4	15.6	600	0.5	16.6
1020	17.7	17.7	13.6	15.5	600	0.3	4.3
1075	17.6	17.7	13.5	15.5	600	0.4	9.6
1130	17.3	17.6	13.7	15.5	600	0.5	12.5
1185	17.5	17.4	13.8	15.4	600	0.5	16.2
1245	17.4	17.3	13.5	15.3	600	0.6	21.5

The green cells denote desirable velocities.

The grey cells denote high risk of erosion.

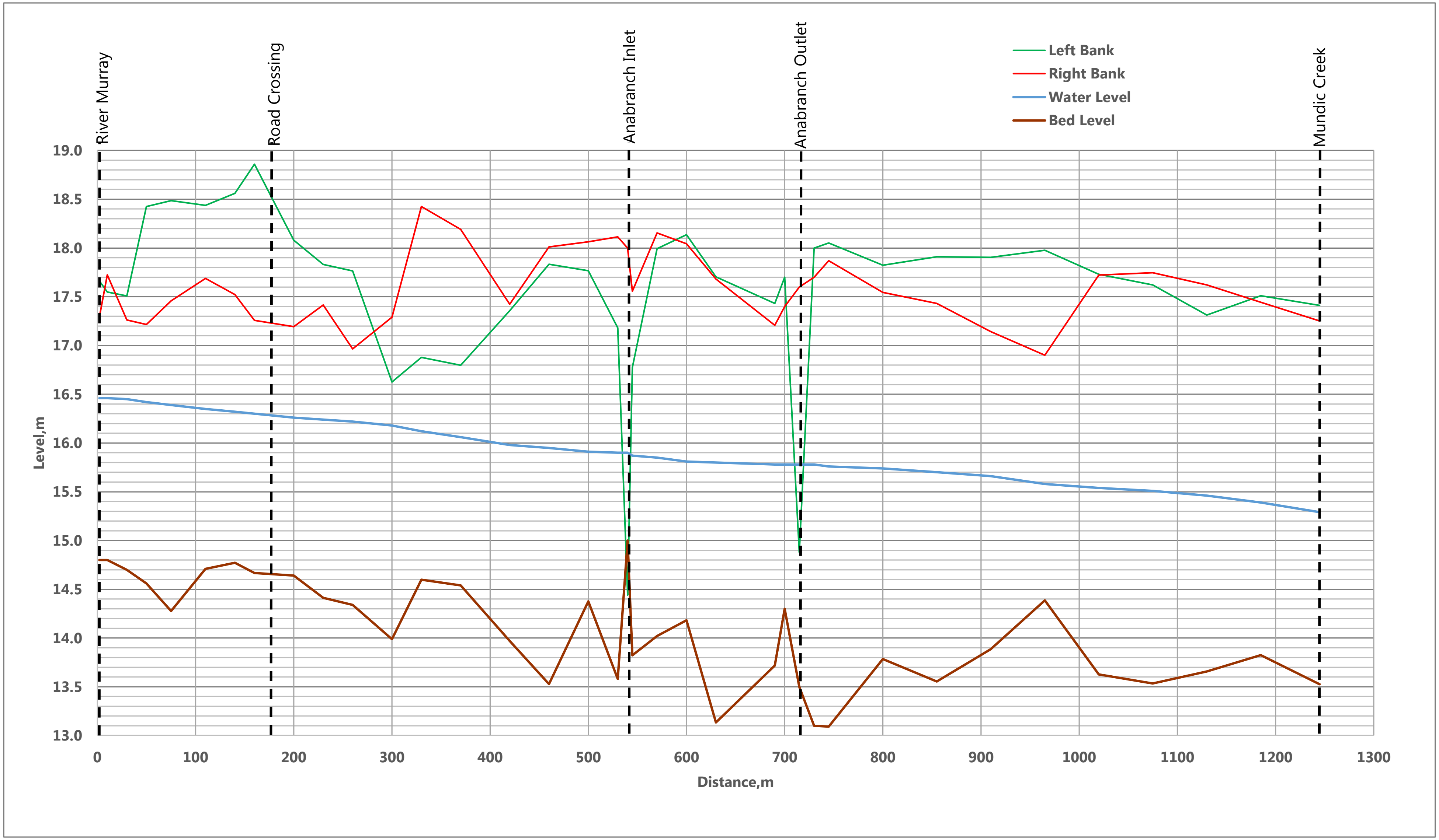

Figure 6.1 Water level profile for Scenario N
(Flow set at 600 ML/d) - Normal Lock 5 Weir Pool Level = 16.3 m AHD - Manning's n (0.08)

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