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Wairoa District Council

Wairoa WWTP Outfall Model Build and Assessment Report

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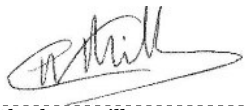

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Wairoa District Council

Wairoa WWTP

Outfall Model Build and Assessment Report

Contents

1 Introduction

Opus International Ltd. were asked by Wairoa District Council (WDC) to investigate issues with the Wairoa Wastewater Treatment Plant (WWTP) outfall. These issues relate to the capacity of the outfall resulting in localised flooding and breaches of its consent. The purpose of this modelling study has been to assess the capacity of the outfall pipe, identify root cause(s) of the issues and develop potential solutions to resolve these issues.

A model of the outfall has been built using the as-built drawings and survey data provided by WDC. A number of scenarios have been tested to assess the performance of the outfall pre and post modifications and under various conditions.

The potential WWTP average discharge rate has been calculated based on the data provided. An average dry day discharge rate of 117 l/s over a six hour period has been calculated. Based on the minimum and maximum dry day volume recorded, this could potentially vary from 28 l/s to 855 l/s. The data also shows a strong correlation between the daily volume and the season. This indicates a significant inflow and infiltration issue during winter. It is recommended that this is investigated further.

During wet days, the average discharge rate of 145 l/s over a six hour period has been calculated.

The potential current discharge rate during normal operating conditions through the outfall has been assessed. The model predicts that the peak discharge capable is 185 l/s, and the minimum is 127 l/s.

The model predicts that under normal operating conditions (i.e. no blockages) the outfall will be surcharged. The level of surcharge will vary depending on the WWTP discharge rate, with the surcharge predicted to be above cover level during current peak discharge (185 l/s). Any restrictions of the outfall (i.e. blockages due to sediment or tide level) further increase the surcharge level.

Solutions are required to reduce the blockage risk and reduce the level of surcharge during normal operating conditions. It is recommended that the outfall is modified to reduce the blockage risk, and the flow control is modified to reduce the discharge rate. It is also recommended that a scheme to reduce inflow and infiltration within the catchment, and therefore the required discharge rate, is investigated further.

2 Background

Wairoa District Council (WDC) manage and operate Wairoa Wastewater Treatment Plant (WWTP). The outfall to this WWTP has issues affecting its capacity resulting in localised flooding incidents and breaches of its consent. WDC have requested Opus build a hydraulic model to investigate these issues and identify any upgrades required. They have also requested that a design of the required upgrades be completed and assistance in preparing the consent application documentation for the solution / any modifications.

Wairoa WWTP discharges treated effluent to the Wairoa River via a gravity overflow pipe. The consent for this discharge states it should only operate between 6pm and 6am and during the outgoing tide. The maximum daily discharge allowed is 5,400 m^3.

The following issues with the outfall have been highlighted by WDC:

- The outlet to the outfall pipe has been affected by sediment levels within the river. To overcome this, modifications have been made to the outlet to raise the discharge point above the sediment level.
- Flooding from manholes located on the outfall pipe has been observed. This is believed to be a result of the sediment issue described above and the capacity of the outfall pipe.
- Potential discharges outside the consented timeframe; bubbling observed near the outfall outlet.

The purpose of this project is to identify the root cause(s) of the issues described above and identify any upgrade work required to resolve these issues and ensure the outfall meets its consent.

2.1 Data Received

The following data has been supplied by Wairoa DC:

- Location plan of outfall
- As built drawings of pond outlet chamber, confirmed as correct and accurate
- As built drawing of outfall outlet modifications
- Level survey data of manholes located on the outfall
- Level survey data of outfall outlet
- Site photos and CCTV
- Terminal pumping station (Fitzroy PS) pump volume data for years 2013 to 2017.
- The WWTP Operator advised that the flow control is automatically controlled. The flow control device is opened as per the consented timeframes.
- Discharge consent.

3 Assumptions and Limitations

The following assumptions have been made when building the hydraulic model:

- The as-built drawings provided accurately represent the current configuration.
- The survey data provided is accurate and uses the same datum as the as-built drawings.
- The final sections of the overflow pipe have been indicated as being 350 mm diameter, and it is assumed that this refers to the internal diameter.
- The peak water level in the pond is 19.9m; just below the overflow weir level.
- The minimum depth in the pond is 18.9m.
- Only the pipe downstream of manhole SNO0020 is affected by sediment.
- Tide level reaches a peak of 1m above the invert of the outfall outlet.
- The penstocks controlling flow from the ponds are opened fully during discharge periods.
- The discharge period is six hours.
- The pond bypass pipes are not utilised during normal operation.
- Flow calculations have not taken into account any available storage. I.e. all flow arriving to the pond on any given day must be discharged through the outfall on that day.
- The WWTP has sufficient storage to manage daily volumes greater than the consented daily discharge volume of 5,400 m^3.

4 Model Build

4.1 Asset Data

The model has been built using the data required. With the following methodology:

- Manhole locations have been identified using the location plan provided
- Pipe sizes have been input based on GIS plans / As Built drawings provided
- Surveyed invert levels have been input where available
- Manhole SMO020 could not be surveyed, this value has been interpolated
- Low point of outfall pipe at the outlet could not be surveyed, this has been assumed based on the as built drawing provided
- All manholes have been set to sealed, as it was noted that all manholes have been bolted down. The operator advised that the seals on some manholes failed during times of high surcharge levels
- Headlosses within the pipes have been calculated by Infoworks software.

4.2 Model Scenarios

A number of model scenarios were created to help understand the performance of the outfall pipe:

1. **Base model**; existing outfall, all manholes sealed, outlet modifications included.
2. **Pre-modifications**; base model with outlet at previous elevation
3. **Overflow**; base model + overflow at SMO0030
4. **Sediment**; base model plus 300mm sediment within pipe SMO020.1
5. **Sediment + Overflow**; as scenario 3 + overflow at SMO0030

4.3 Inflow

Flow has been applied to the outfall pipe using two methods:

- 1. Inflow file applying average flow rate expected to be discharged during a six hour period.
- 2. Level file applied at a constant depth of 19.9m (100mm below overflow weir) to represent the pond being full.

With regards method 1, flow has been calculated from the pump volume data provided. The following observations have been noted:

- The volume data is not a complete set for the five years; years 2014 and 2015 are incomplete. As well as 2017, understandably.
- The volume calculations at the bottom of tab “flow comparison charts” double counts (see rows 1289 and 1290).
- The total volume calculations provided include all pump stations, whereas it is believed only Fitzroy pumps to the WWTP.

Therefore, the data provided has been analysed to determine suitable flow rates to assess;

- Total dry days in data set = 772. Total DWF volume = 1,952,767 m^3. Average Daily volume = 2,529 m^3. **Average flow = 117 l/s** (assumed over 6hrs).

- Total wet days = 503. Total wet weather volume = 3,258,507 m³. Average Daily volume = 3,122 m³. **Average flow = 145 l/s** (assumed over 6hrs).
- Max. daily storm volume within dataset = 21,102 m³.

It should be noted that the daily dry volume within the dataset varies between 607 m³ and 18,468 m³. Therefore, the required discharge rate would potentially have to vary between 28 l/s and 855 l/s respectively. However, as this is a surprisingly large range it is recommended that further investigations into the inflow data are required. The figure below shows a strong correlation between the daily volume and the season. This indicates a significant inflow and infiltration issue during winter.

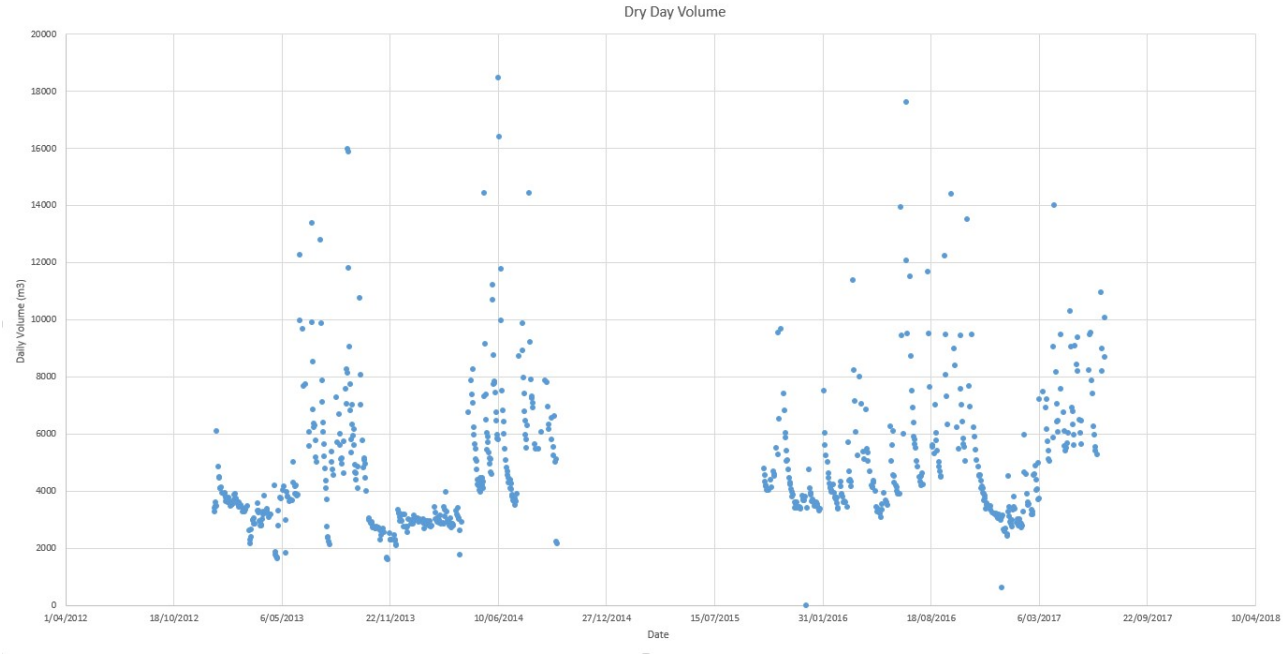


Figure 1 – Dry day pumped volume

The maximum storm volume recorded being pumped to the pond in the five year dataset provided is 21,102 m³ in one day. The model predicts that the outfall does not have capacity to discharge this during a six hour period. Also, the consent states that the maximum allowable discharge is 5,400 m³ per day. The consent does not state if the outfall can operate outside of the designated timeframe during storm conditions. Therefore, it has been assumed that there is suitable storage available to manage this increase in volume.

4.4 Boundary Condition

The system has been assessed with and without a tide level file. The tide level applied assumed a constant 1m depth above the invert of the outfall outlet. Although this is a simplistic method, it is considered suitable for the purpose of this assessment.

5 Results

Please refer to Appendix A for a table summarising the results. Long-sections are also available for these results in Appendix B.

The results indicate that the outfall pipe will surcharge for the majority of its length during normal operation (i.e. no blockages or other restrictions). The root cause of this surcharge is the capacity of the outfall pipe from manhole SMO0120 onwards.

The flow control chamber is opened fully when the pond is discharging. Therefore, the discharge rate is determined by the level in the pond. Based on the assumption that the pond level fluctuates between 18.9m and 19.9m, the discharge rate will vary from 127 l/s to 185 l/s respectively. This equates to a maximum discharge volume of 3,996 m^3 per day, below the consented maximum of 5,400 m^3. For both these discharge rates the outfall pipe is fully surcharged under normal conditions. The model predicts that the surcharge level will be above cover levels. The model predicts that the overflow installed at manhole SMO030 does not operate under normal conditions.

The model indicates that the pipe full capacity of the outfall is 104 l/s at its flattest section. Please refer to long sections in Appendix B for further details of the pipe full capacities along the outfall (see row "r.pfc (m^3/s)").

However, with the addition of a tide level at the outlet the surcharge levels are predicted to increase. With the pond level at 19.9 m and the tide at 1 m above outfall outlet level, the surcharge levels increase such that the overflow at manhole SMO030 operates. These conditions are likely to occur at the start of the discharge time period.

With significant sediment added to the final section of the outfall pipe the surcharge levels increase further. The model predicts that the overflow is utilised in this scenario.

The impact of the discharge flow rate being optimised was assessed. Including discharging at an average dry day flow rate, and an average wet day flow rate.

During an average dry day (117 l/s discharge rate), the model predicted surcharge levels would be below cover level. During an average wet day (145 l/s discharge rate) this surcharge level would be above cover levels. The model predicts that the overflow installed at manhole SMO030 would not operate under normal conditions during a typical dry day or average wet day. With the addition of a tide level at the outlet the surcharge levels are predicted to increase. However, the overflow at manhole SMO030 is not predicted to operate during a typical dry day or average wet day.

With significant sediment added to the final section of the outfall pipe the surcharge levels increase further. The model predicts that the overflow is utilised in this scenario.

The model predicts that the modifications of the outlet have had a minor impact on surcharge levels. However, this is not considered to have been a significant hydraulic impact.

6 Solutions

The results indicate that there are two issues that need to be addressed on the outfall pipe; the level of surcharge due to hydraulic overload, and blockages due to sediment.

6.1 Surcharge Solutions

The model predicts that the outfall pipe will be surcharged due to hydraulic overload in all scenarios. The level of surcharge varies depending on the inflow and hydraulic restrictions.

With the current flow control mechanism, the peak flow predicted to be discharged is 185 l/s. This causes surcharge levels of up to 10 m above invert level within the pipe. It is unlikely that the pipe was designed cope with this level of surcharge. Therefore, the following is proposed:

- Modify the flow control device to reduce the discharge to the minimum required to meet the consent
- Review the pipeline design to ensure it can cope with the surcharge levels predicted
- Construct a new outfall with greater capacity.

With regards the solution of modifying the flow control, the results indicate the average dry day discharge rate is 117 l/s and the average wet day discharge rate is 145 l/s. The level of surcharge predicted with these inflow rates are significantly reduced. Therefore, modifying the flow control to limit the flow to these values will bring the surcharge level down to acceptable levels.

However, the data provided indicates that there may be significant seasonal inflow and infiltration issues within the catchment. Therefore, the level of inflow and infiltration may need to be reduced to achieve the maximum dry day discharge volume the outfall needs to manage.

6.2 Blockage Risk Solutions

The outfall outlet is known to block or partially block due to sediment. This significantly increases the surcharge levels and has resulted in an overflow being installed at manhole SMO030.

Therefore, solutions are required to ensure the outfall pipe can remain clean. These include:

- Modify the outlet so it is above the river sediment level
- Relocate the discharge location further into the channel.

The model predicts that the tide level has minimal impact on the capacity of the outfall pipe. Therefore, if the outfall can be extended or modified so it is not affected by the sediment levels, but still below the high tide level, this will be acceptable.

7 Conclusion

A model of the Wairoa WWTP outfall has been built using the as-built drawings and survey data provided. A number of scenarios have been tested to assess the performance of the outfall pre and post modifications and under various conditions.

The potential WWTP average discharge rate has been calculated based on the data provided. An average dry day discharge rate of 117 l/s over a six hour period has been calculated. During wet days, the average discharge rate of 145 l/s over a six hour period has been calculated. The data for dry day volume arriving at the WWTP varies greatly, a review of this data has indicated that this may be due to seasonal inflow and infiltration.

The potential current discharge rate during normal operating conditions through the outfall has been assessed. The model predicts that the peak discharge capable is 185 l/s, and the minimum is 127 l/s, based on pond levels of 19.9 m and 18.9 m respectively.

The model predicts that under normal operating conditions (i.e. no blockages) the outfall will be surcharged. The level of surcharge will vary depending on the WWTP discharge rate, with the surcharge predicted to be above cover level during current peak discharge (185 l/s). Any restrictions of the outfall (i.e. blockages due to sediment or tide level) further increase the surcharge level.

Solutions are required to reduce the blockage risk and reduce the level of surcharge during normal operating conditions.

To reduce the risk of pipe blockages due to river sediment, outfall modifications are required. These include:

- Modify the outlet so it is above the river sediment level
- Relocate the discharge location further into the channel

To reduce the risk of high surcharge levels as a result of hydraulic overload, the following solutions have been considered:

- Modify the flow control device to reduce the discharge to the minimum required to meet the consent
- Review the pipeline design to ensure it can cope with the surcharge levels predicted
- Construct a new outfall with greater capacity.

It is recommended that the outfall is modified to reduce the blockage risk, the flow control is modified to reduce the discharge rate. It is also recommended that a scheme to reduce inflow and infiltration within the catchment, and therefore the required discharge rate, is investigated further.

Appendix A

Results Summary Table

Inflow	Pipe Flow	Tide Level	Scenario 1 Results Base model – clean pipe, no overflow, and outlet at post modification level.	Scenario 2 Results Pre-modifications model – clean pipe, no overflow, and outlet at pre-modification level.	Scenario 3 Results Overflow model – clean pipe, overflow at SMO030, and outlet at post-modification level.	Scenario 4 Results Sediment model – 300mm sediment in SMO020.1, no overflow, and outlet at post-modification level.	Scenario 5 Results Sediment model – 300mm sediment in SMO020.1, overflow at SMO030, and outlet at post-modification level.
19.9m level	185 l/s	None	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 4.83m above cover level at manhole SMO0110. Surcharged above cover levels at following manholes up to SMO040.	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 4.49m above cover level at manhole SMO0110. Surcharged above cover levels at following manholes up to SMO040.	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 4.33m above cover level at manhole SMO0110. Surcharged above cover levels at following manholes up to SMO050. Overflow utilised.	Pipe is fully surcharged from pond outlet chamber onwards. Surcharged almost up to pond level. Outlet pipe flow reduced to 40 l/s. Increasing time required to empty the pond.	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 4.83m above cover level at manhole SMO0110. Surcharged above cover levels at manholes SMO0120 to SMO040. Overflow utilised.
18.9m level	127 l/s	None	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 0.3m above cover level at manholes SMO0100 and SMO090.	Pipe is fully surcharged from SMO0110 onwards. Surcharge levels do not reach cover levels.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 0.3m above cover level at manholes SMO0100 and SMO090. Overflow not utilised.	Pipe is fully surcharged from pond outlet chamber onwards. Surcharged almost up to pond level. Outlet pipe flow reduced to 40 l/s. Increasing time required to empty the pond.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.57m above cover level at manholes SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO050. Overflow utilised.
117 l/s inflow	117 l/s	None	Pipe is fully surcharged from SMO0110 onwards. Surcharge levels do not reach cover levels.	Pipe is fully surcharged from SMO0110 onwards. Surcharge levels do not reach cover levels.	Pipe is fully surcharged from SMO0110 onwards. Surcharge levels do not reach cover levels. Overflow not utilised.	Surcharge level goes above overflow weir at outlet chamber. Unable to achieve this flow rate in these conditions with pond at normal level.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.13m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO050. Overflow utilised.
145 l/s inflow	145 l/s	None	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.68m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO070.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.33m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO080.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.68m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO070. Overflow not utilised.	Surcharge level goes above overflow weir at outlet chamber. Unable to achieve this flow rate in these conditions with pond at normal level.	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 2.44m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO050. Overflow utilised.
19.9m level	185 l/s	1m above outlet	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 6.07m above cover level at manhole SMO0110. Surcharged above cover levels from SMO0120 onwards.	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 6.07m above cover level at manhole SMO0100. Surcharged above cover levels from SMO0120 onwards.	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 4.38m above cover level at manhole SMO0110. Surcharged above cover levels from SMO0120 to SMO050. Overflow utilised.	Pipe is fully surcharged from pond outlet chamber onwards. Surcharged almost up to pond level. Outlet pipe flow reduced to 40 l/s. Increasing time required to empty the pond.	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 4.84m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0120 to SMO040. Overflow utilised.

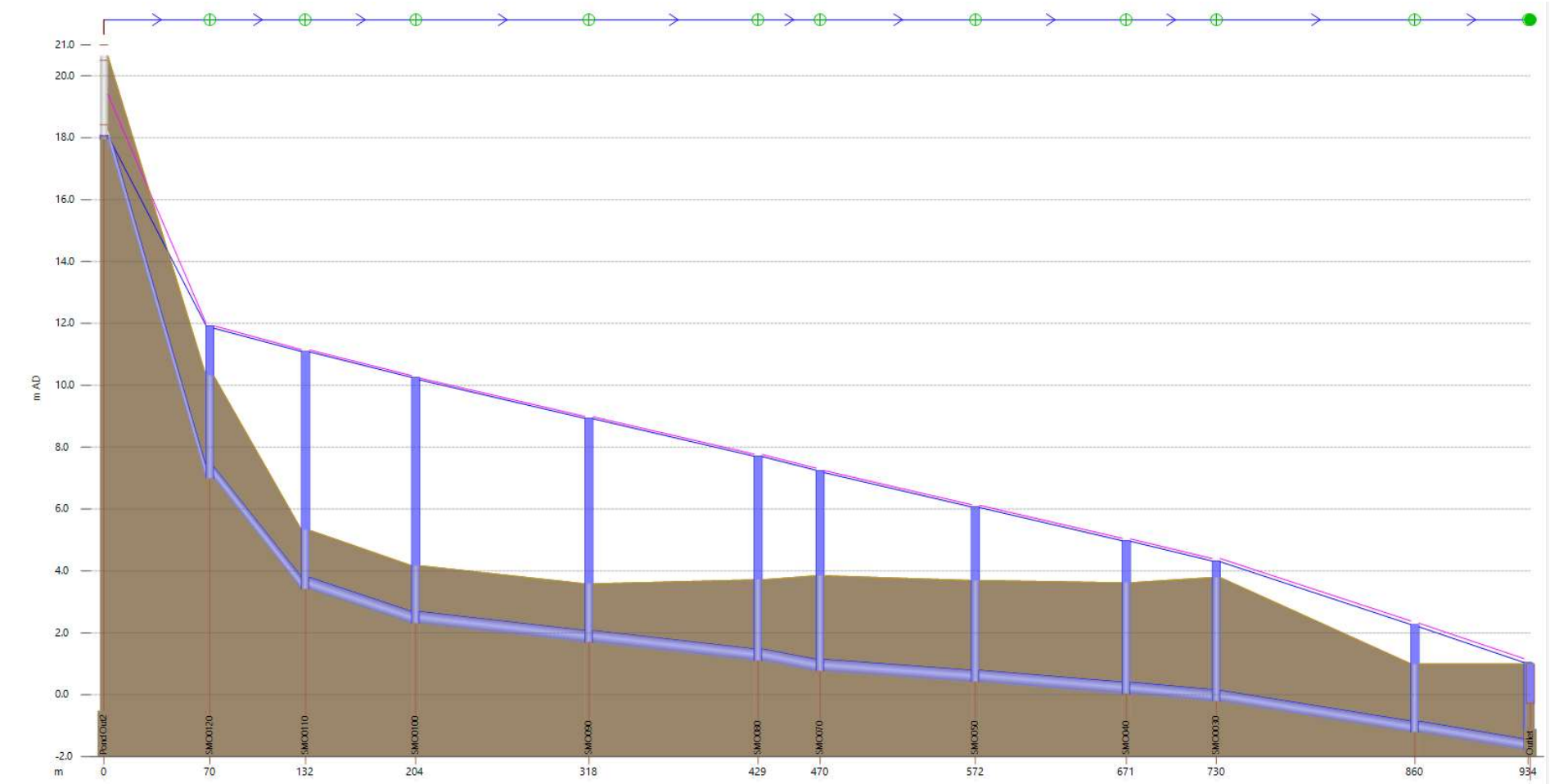
18.9m level	127 l/s	1m above outlet	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.29m above cover level at manholes SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO070.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.29m above cover level at manholes SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO070.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.29m above cover level at manholes SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO070. Overflow not utilised.	Pipe is fully surcharged from pond outlet chamber onwards. Surcharged almost up to pond level. Outlet pipe flow reduced to 40 l/s. Increasing time required to empty the pond.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.57m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO050. Overflow utilised.
117 l/s inflow	117 l/s	1m above outlet	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 0.63m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0100 to SMO080.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 0.63m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0100 to SMO080.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 0.63m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0100 to SMO080. Overflow not utilised.	Surcharge level goes above overflow weir at outlet chamber. Unable to achieve this flow rate in these conditions with pond at normal level.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.13m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO050. Overflow utilised.
145 l/s inflow	145 l/s	1m above outlet	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.68m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO070.	Pipe is fully surcharged from SMO0120 onwards. Surcharged up to 2.60m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO050.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 1.68m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO070. Overflow not utilised.	Surcharge level goes above overflow weir at outlet chamber. Unable to achieve this flow rate in these conditions with pond at normal level.	Pipe is fully surcharged from SMO0110 onwards. Surcharged up to 2.45m above cover level at manhole SMO0100. Surcharged above cover levels at manholes SMO0110 to SMO050. Overflow utilised.

Appendix B

Long-sections

Scenario 1: Base model – clean pipe, no overflow, and outlet at post modification level.

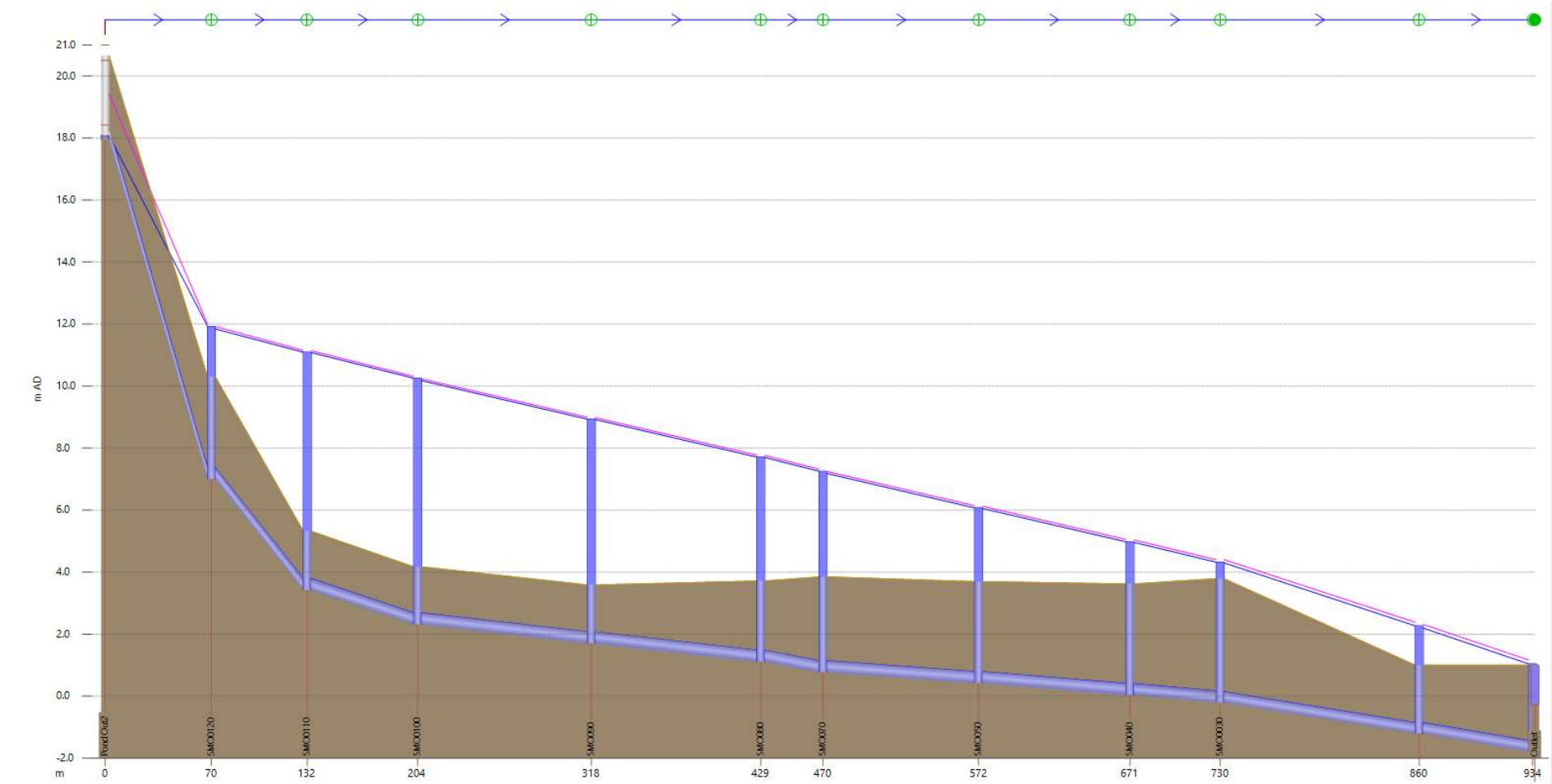
19.9m level with 1m tide.



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.18566	0.18950	0.18499	0.18468	0.18440	0.18416	0.18399	0.18385	0.18486	0.18730	0.19252
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.130
DS depth (m)	4.935	7.670	7.941	7.232	6.602	6.485	5.653	4.943	4.527	3.470	2.821
DS flow (m3/s)	0.18702	0.18653	0.18485	0.18455	0.18429	0.18412	0.18391	0.18422	0.18562	0.18977	0.19414
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 2: Pre-modifications model – clean pipe, no overflow, and outlet at pre-modification level.

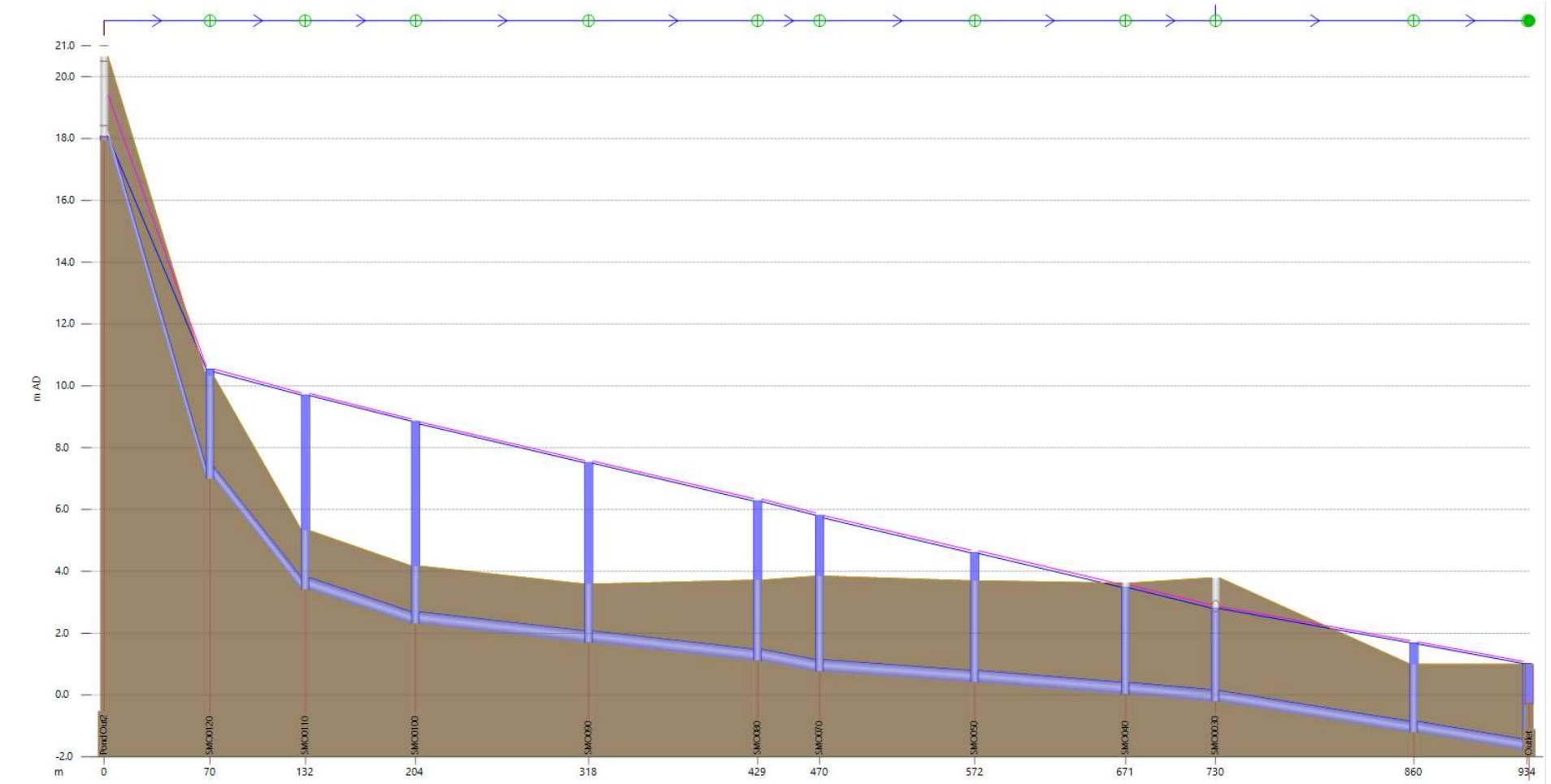
19.9m level with 1m tide.



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.18566	0.18950	0.18499	0.18468	0.18440	0.18416	0.18399	0.18385	0.18486	0.18729	0.19251
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.130
DS depth (m)	4.935	7.670	7.941	7.232	6.602	6.485	5.654	4.944	4.528	3.471	2.821
DS flow (m3/s)	0.18702	0.18653	0.18485	0.18455	0.18429	0.18412	0.18391	0.18422	0.18562	0.18977	0.19414
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 3: Overflow model – clean pipe, overflow at SMO030, and outlet at post-modification level.

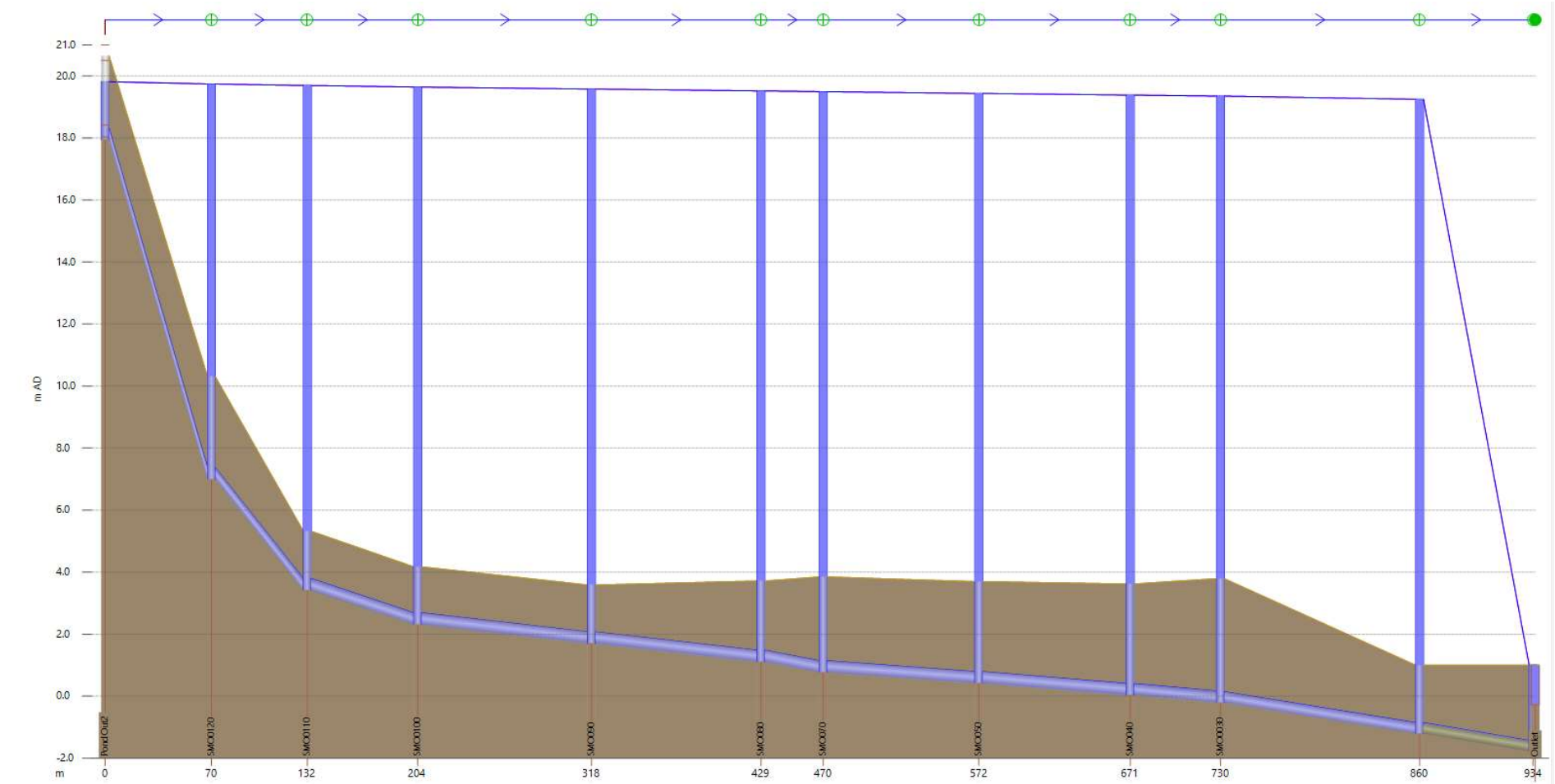
19.9m level with 1m tide.



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.18566	0.18950	0.18536	0.18534	0.18533	0.18531	0.18530	0.18529	0.18530	0.15484	0.15986
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.130
DS depth (m)	3.558	6.278	6.543	5.813	5.169	5.044	4.183	3.450	3.019	2.895	2.801
DS flow (m3/s)	0.18702	0.18653	0.18536	0.18534	0.18532	0.18531	0.18530	0.18529	0.18534	0.15714	0.16150
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 4: Sediment model – 300mm sediment in SMO020.1, no overflow, and outlet at post-modification level.

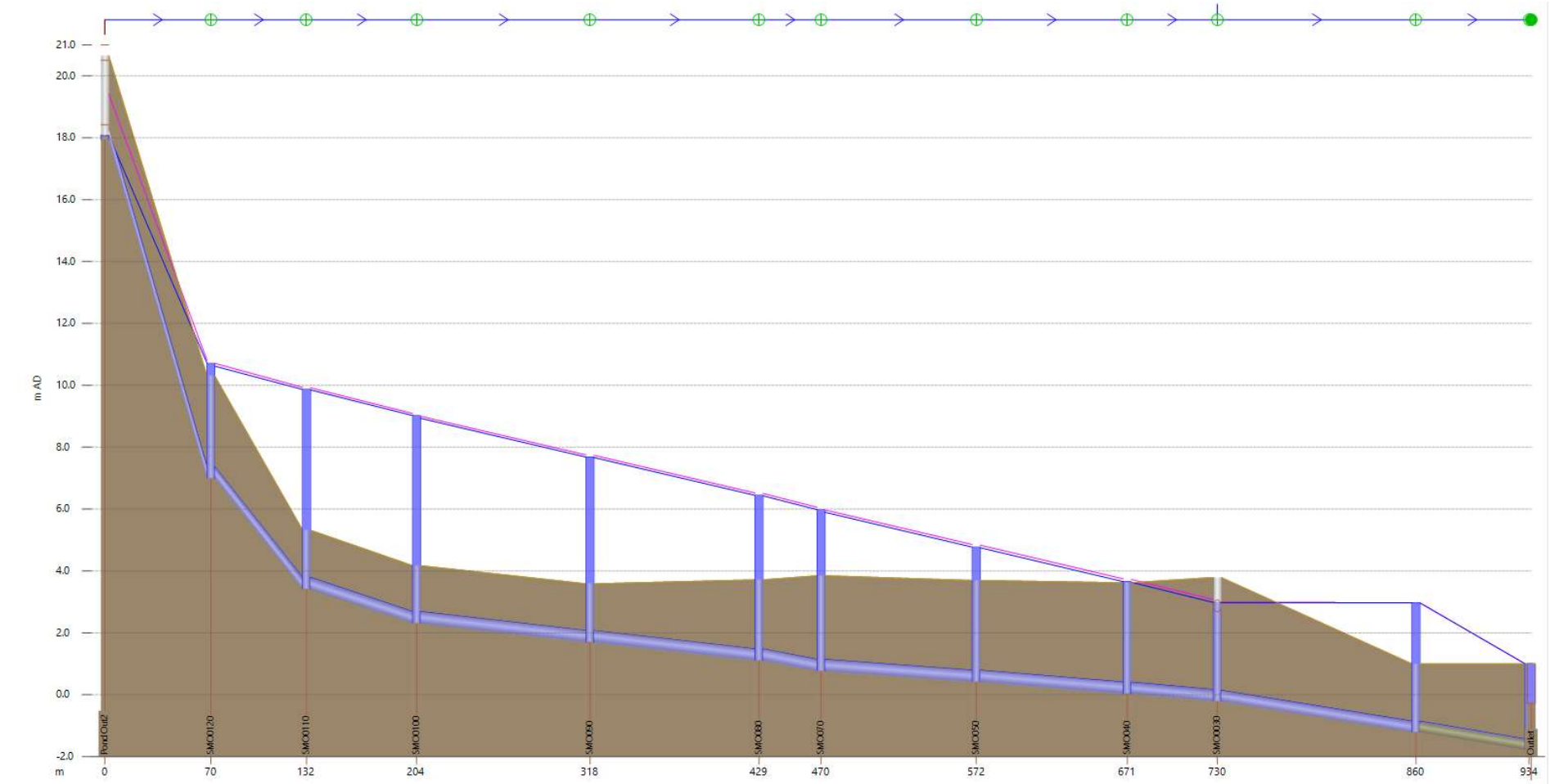
19.9m level with 1m tide.



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.18566	0.18856	0.18499	0.17134	0.15549	0.11698	0.09828	0.08324	0.06839	0.05639	0.04222
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.007
DS depth (m)	12.751	16.270	17.329	17.879	18.410	18.725	19.019	19.349	19.556	20.449	2.781
DS flow (m3/s)	0.18702	0.18653	0.17530	0.15700	0.12779	0.10688	0.09178	0.07691	0.06471	0.04907	0.04335
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 5: Sediment model – 300mm sediment in SMO020.1, overflow at SMO030, and outlet at post-modification level.

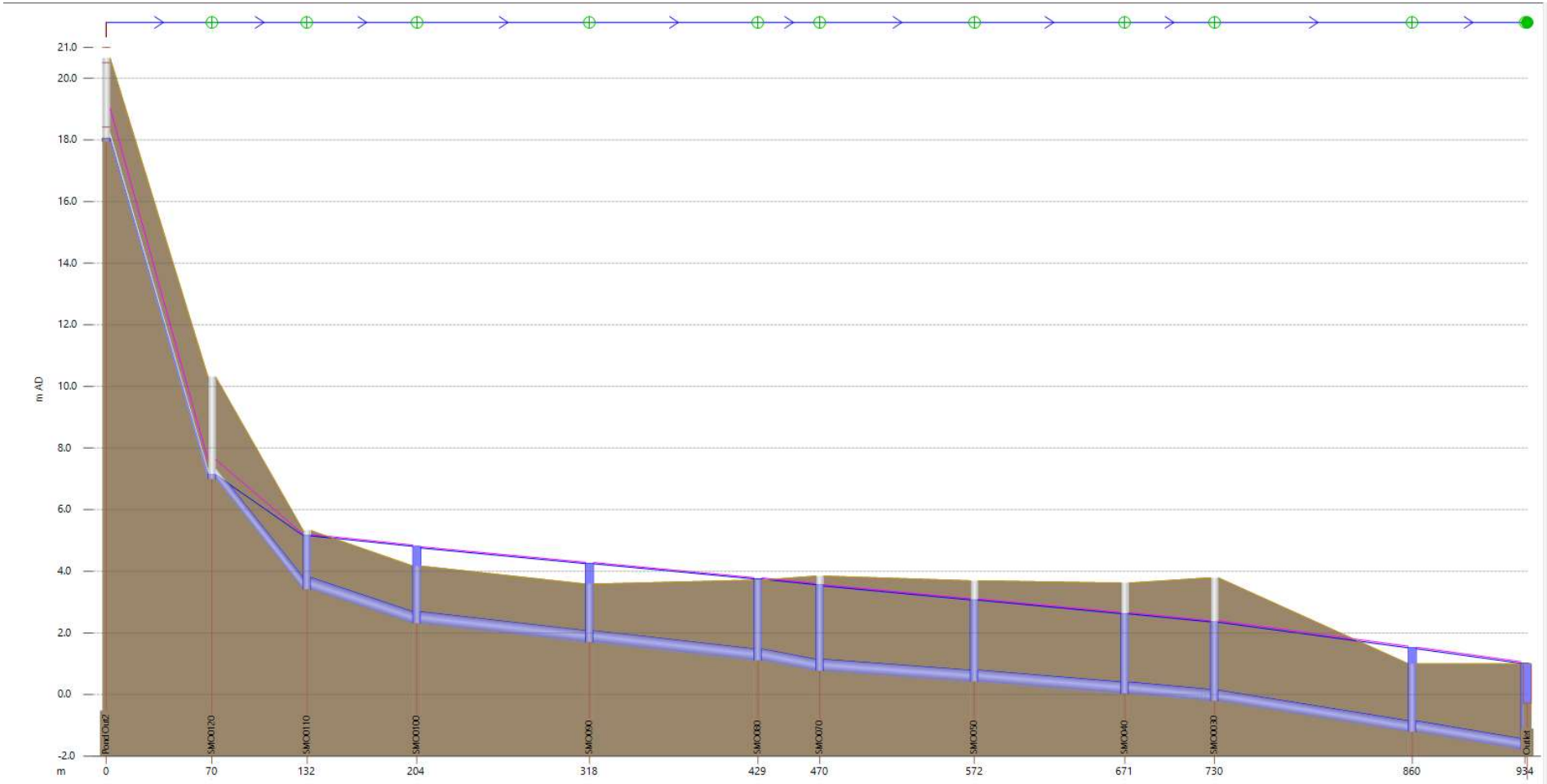
19.9m level with 1m tide.



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.18566	0.18997	0.18535	0.18533	0.18530	0.18528	0.18527	0.18526	0.18526	0.03709	0.01601
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.007
DS depth (m)	3.722	6.443	6.709	5.981	5.336	5.212	4.353	3.621	3.191	4.175	2.780
DS flow (m3/s)	0.18702	0.18653	0.18534	0.18532	0.18529	0.18528	0.18527	0.18526	0.18526	0.02683	0.01723
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 1: Base model – clean pipe, no overflow, and outlet at post modification level.

117 l/s with 1m tide

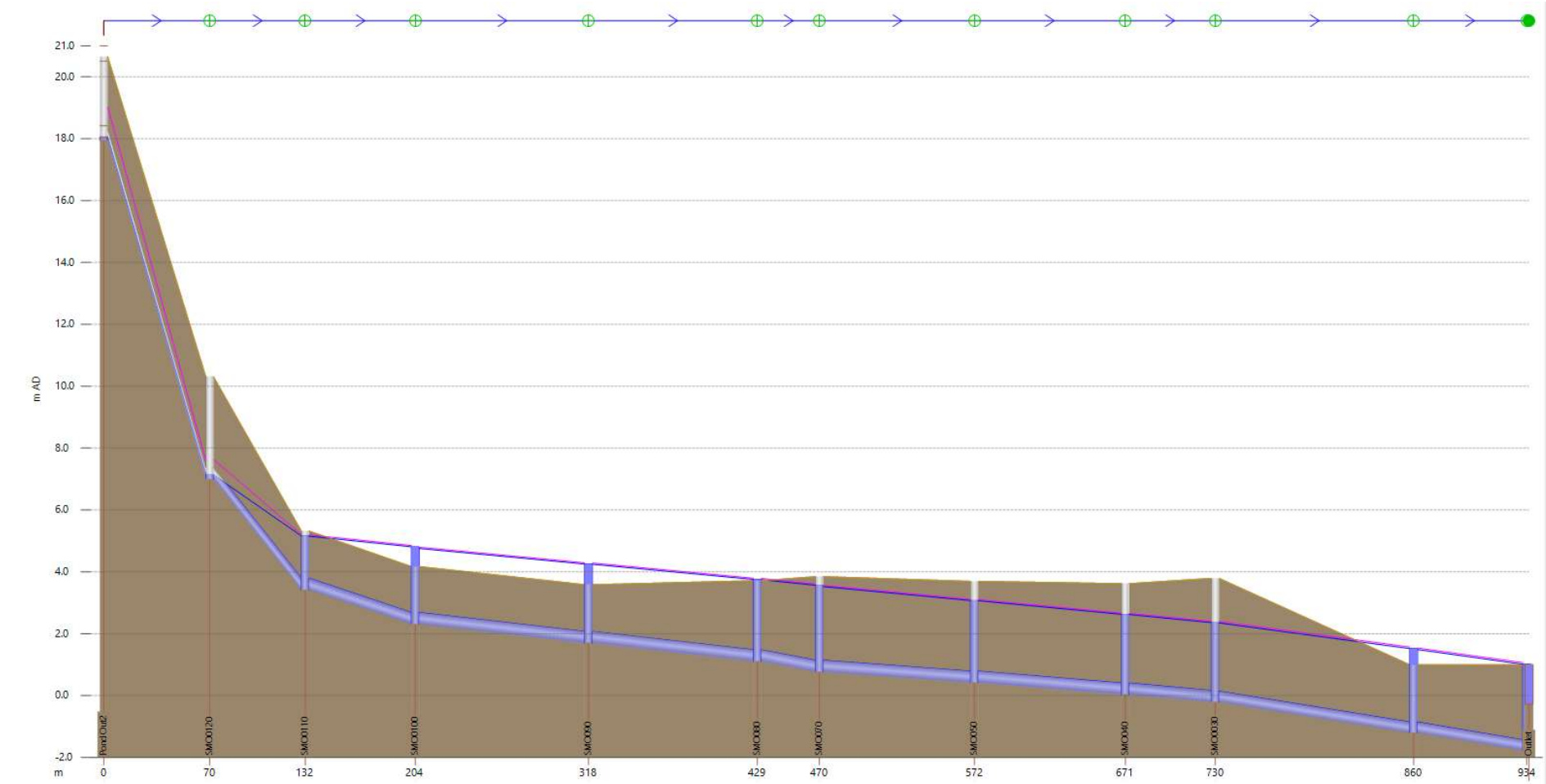


Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.11700	0.11702	0.12006	0.12149	0.12325	0.12516	0.12659	0.12888	0.13128	0.13404	0.13888
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.130
DS depth (m)	0.143	1.739	2.498	2.555	2.649	2.799	2.658	2.596	2.567	2.722	2.795
DS flow (m3/s)	0.11702	0.11915	0.12056	0.12229	0.12407	0.12548	0.12748	0.12983	0.13202	0.13619	0.14039

Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 2: Pre-modifications model – clean pipe, no overflow, and outlet at pre-modification level

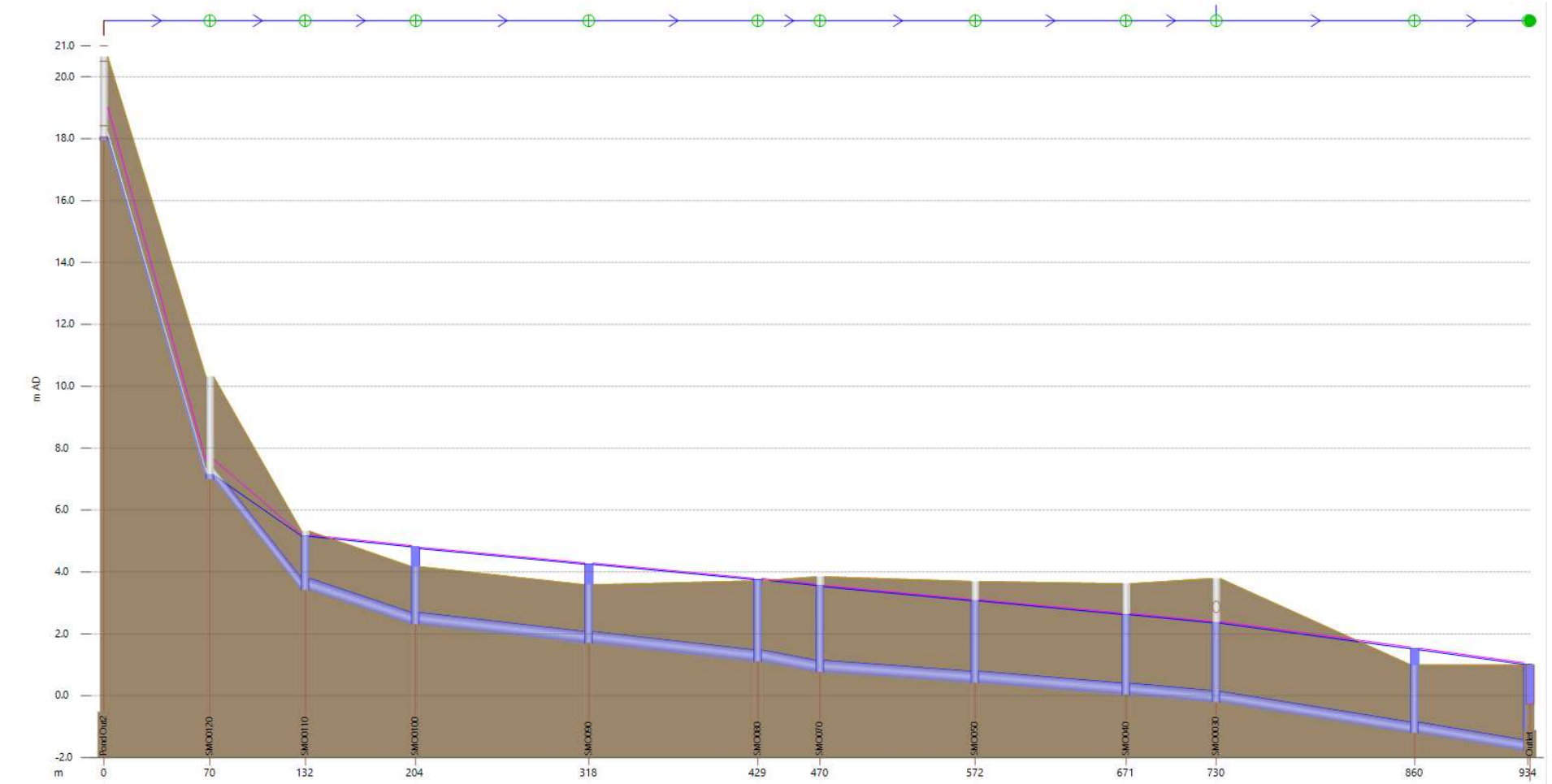
117 l/s with 1m tide



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.11700	0.11702	0.12008	0.12151	0.12327	0.12521	0.12664	0.12898	0.13140	0.13425	0.13931
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.130
DS depth (m)	0.143	1.740	2.498	2.555	2.649	2.800	2.658	2.596	2.567	2.723	2.796
DS flow (m3/s)	0.11702	0.11916	0.12057	0.12231	0.12411	0.12553	0.12756	0.12993	0.13219	0.13650	0.14094
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 3: Overflow model – clean pipe, overflow at SMO030, and outlet at post-modification level.

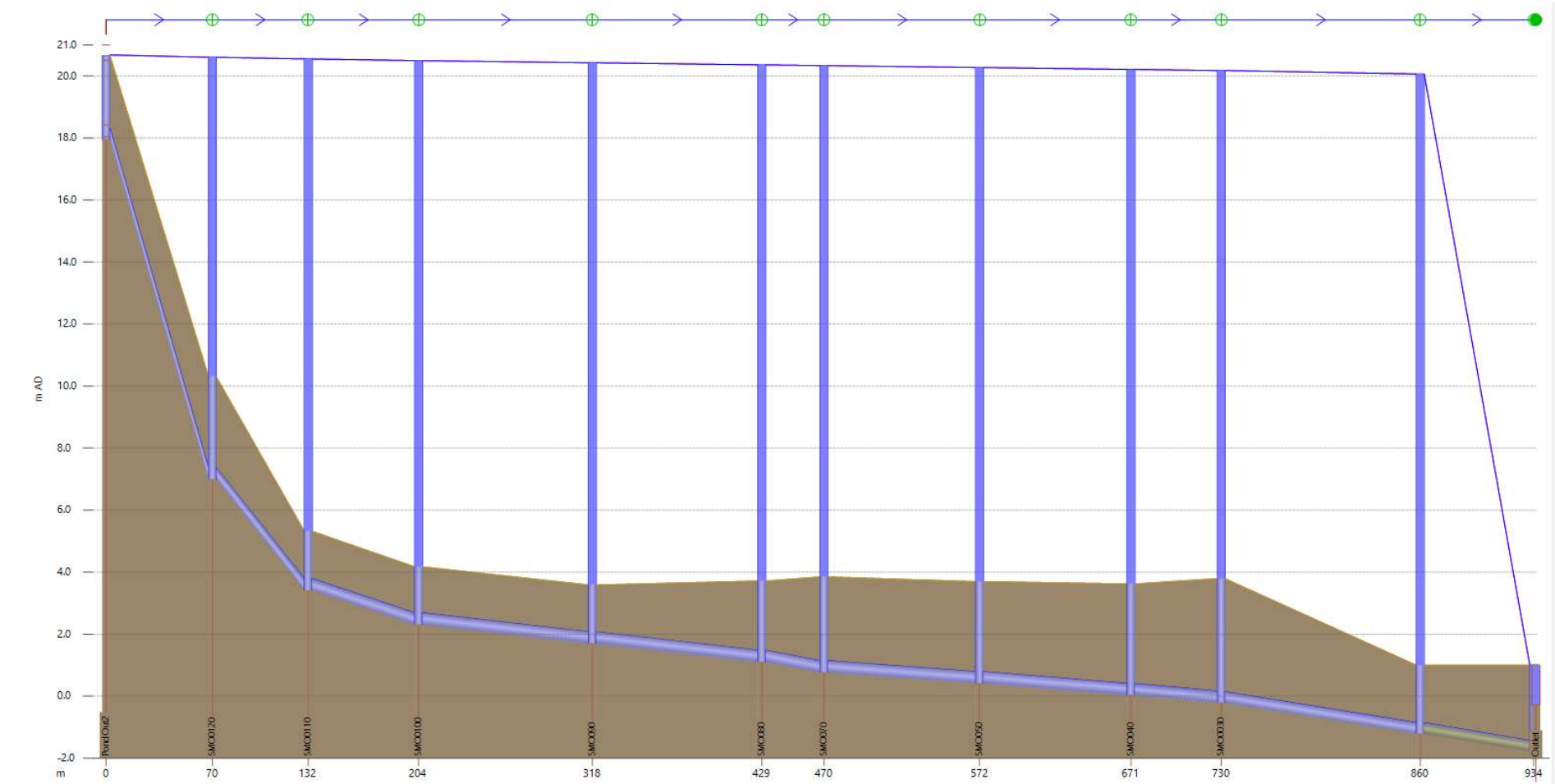
117 l/s with 1m tide



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.11700	0.11702	0.12006	0.12149	0.12325	0.12516	0.12659	0.12888	0.13128	0.13404	0.13888
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.130
DS depth (m)	0.143	1.739	2.498	2.555	2.649	2.799	2.658	2.596	2.567	2.722	2.795
DS flow (m3/s)	0.11702	0.11915	0.12056	0.12229	0.12407	0.12548	0.12748	0.12983	0.13202	0.13619	0.14039
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 4: Sediment model – 300mm sediment in SMO020.1, no overflow, and outlet at post-modification level.

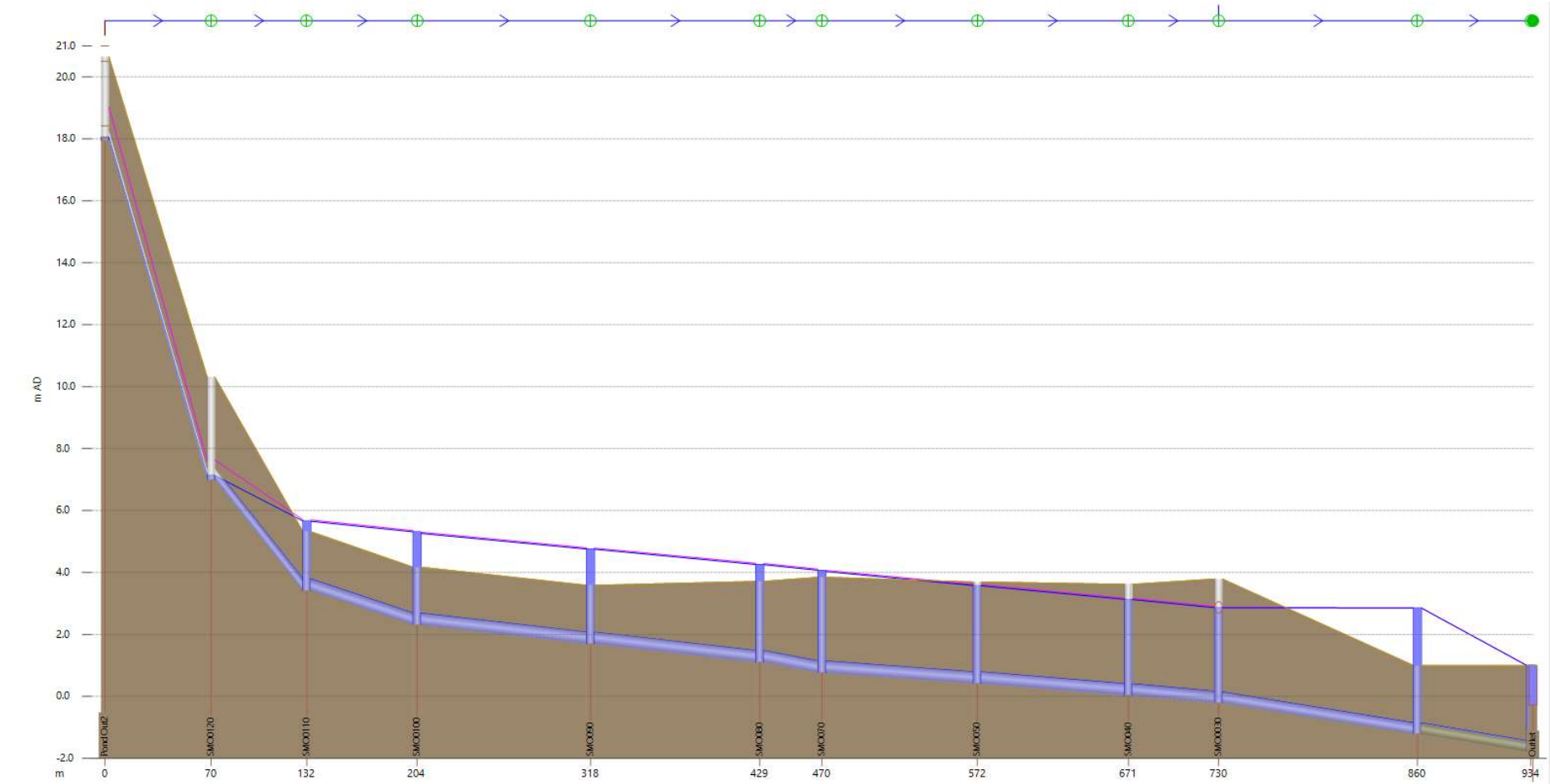
117 l/s with 1m tide



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.11700	0.11702	0.11701	0.11666	0.10770	0.07687	0.07085	0.06286	0.05496	0.04931	0.04320
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.007
DS depth (m)	13.610	17.126	18.181	18.726	19.251	19.564	19.853	20.178	20.382	21.264	2.781
DS flow (m3/s)	0.11879	0.11701	0.11672	0.10811	0.08153	0.07546	0.06741	0.05950	0.05296	0.04628	0.04233
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

Scenario 5: Sediment model – 300mm sediment in SMO020.1, overflow at SMO030, and outlet at post-modification level.

117 l/s with 1m tide



Link	Pond Out2.1	SMO0120.1	SMO0110.1	SMO0100.1	SMO090.1	SMO080.1	SMO070.1	SMO050.1	SMO040.1	SMO0030.1	SNO0020.1
US flow (m3/s)	0.11700	0.11702	0.11701	0.11702	0.11703	0.11703	0.11704	0.11705	0.11706	0.02439	0.01450
r.pfc (m3/s)	0.705	0.423	0.219	0.130	0.129	0.161	0.104	0.110	0.113	0.129	0.007
DS depth (m)	0.143	2.241	2.999	3.059	3.153	3.303	3.163	3.101	3.071	4.058	2.780
DS flow (m3/s)	0.11702	0.11701	0.11701	0.11702	0.11703	0.11704	0.11705	0.11705	0.11706	0.01918	0.01702
Node	-	SMO0120	SMO0110	SMO0100	SMO090	SMO080	SMO070	SMO050	SMO040	SMO0030	SNO0020	SNO0010

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