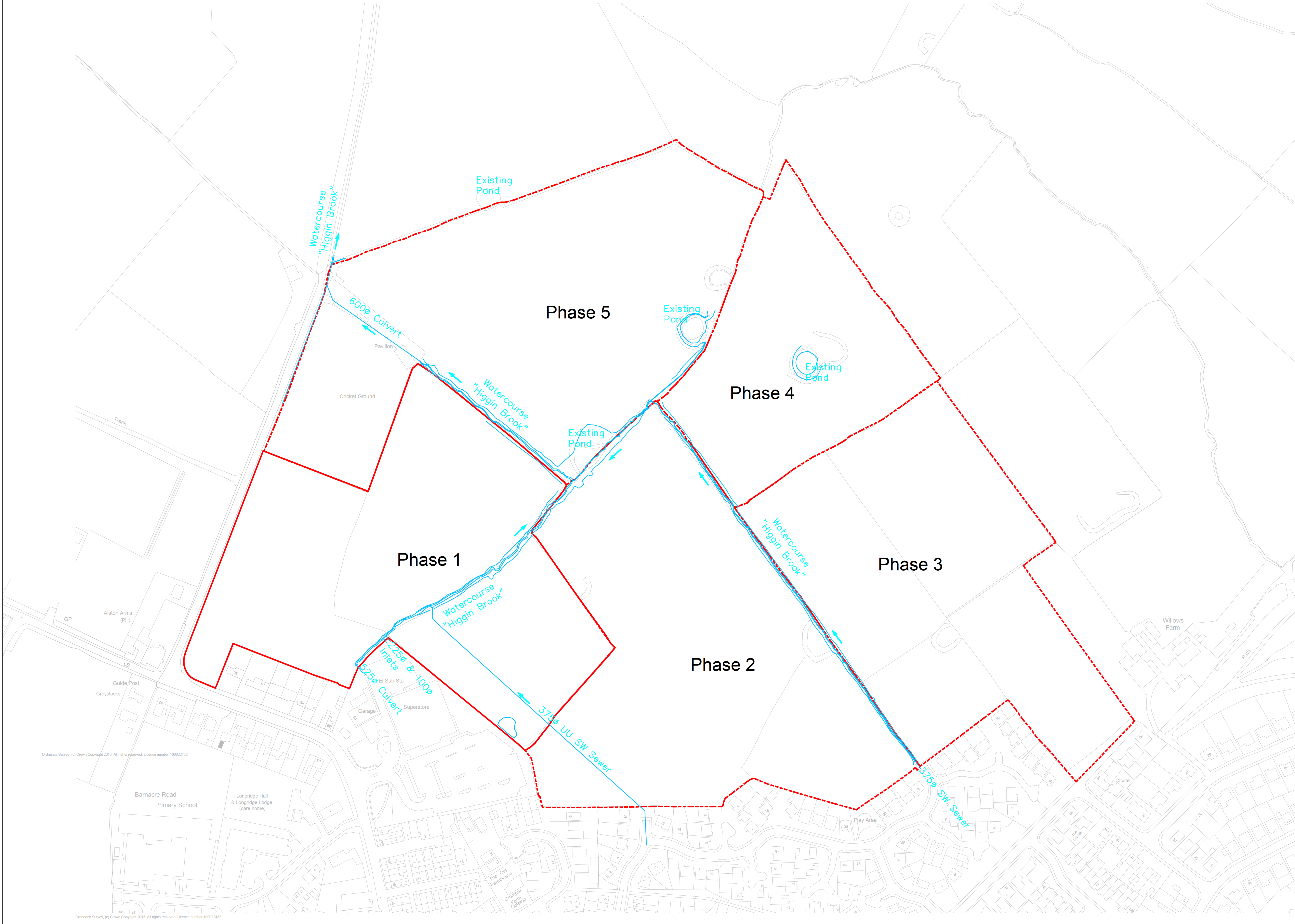

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Title
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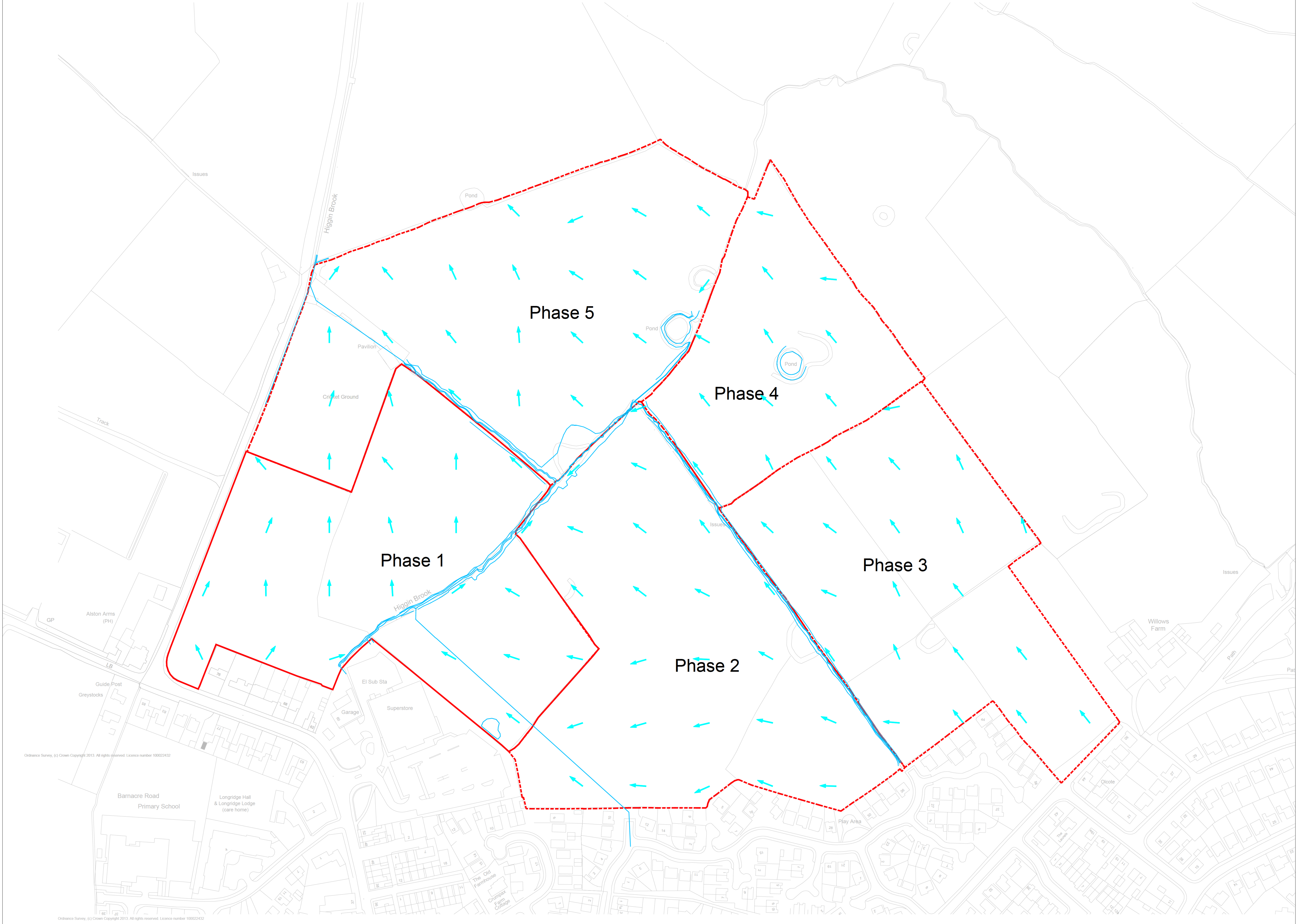
CD	1:1000		



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Job
Chipping Lane
Longridge

Title
Existing Overland Flow Routes

Design By	Date	Drawing Number	Rev
CD	Sept 2023	459/ED/170	-
C A.D By: CD	Scale @ A0: 1:1000		

LAND AT CHIPPING LANE, LONGRIDGE

HYDRAULIC ASSESSMENT

For
Barratt Homes Manchester
4 Brindley Road,
City Park,
Manchester,
M16 9HQ.

July 2016

BETTS HYDRO
CONSULTING ENGINEERS

LAND AT CHIPPING LANE,
LONGRIDGE

HYDRAULIC ASSESSMENT

Document Tracking Sheet

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CONTENTS

Figures & Tables

Specialist Software

- Flood Estimation Handbook FEH CD-ROM (v.3.0) – Determination of Catchment Descriptors and depths of rainfall.

- ISIS (3.7) – 2013 - 1D Hydraulic Model

Abbreviations & Acronyms

AEP	Annual Exceedance Probability	mAOD	Metres Above Ordnance Datum
BGL	Below Ground Level	NGR	National Grid Reference
CC	Climate Change	NPPF	National Planning Policy Framework
EA	Environment Agency	OS	Ordnance Survey
FEH	Flood Estimation Handbook	PFRA	Preliminary Flood Risk Assessment
FRA	Flood Risk Assessment	PPS	Planning Policy Statement
FZ	Flood Zone	SFRA	Strategic Flood Risk Assessment
Ha	Hectare	LCC	Lancashire County Council
LLFA	Lead Local Flood Authority	TWL	Top Water Level
LPA	Local Planning Authority	UU	United Utilities

1.0 EXISTING SITE SITUATION

1.1 The proposed development site is located on land at Chipping Lane, Longridge and is directly accessed off Chipping Lane. The Ordnance Survey National Grid Reference (OS NGR) for the site is Eastings 360073, Northings 437980 and the nearest postcode is PR3 2NA.

1.2 The proposed development area is edged in red Figure 1 (below). A location plan is included Appendix A.

Figure 1: Aerial Photograph of site (proposed development area edged in red)

1.3 Two small watercourses enter the site from the south east and south west and flow in a north westerly direction, leaving the site via 600mm diameter culvert outfall by Chipping Lane north of the site.

1.4 The Environment Agency flood zone maps indicated that the site is entirely within Flood Zone 1, implying that the site is at low risk of fluvial flooding.

1.6 From a flood risk perspective it was considered prudent to undertake a hydraulic assessment of the watercourse to assess the peak water levels in the watercourse in both the existing and the post development scenarios.

2.0 DEVELOPMENT PROPOSALS

2.1 The initial proposals are a residential development within the red edge boundary indicated in Figure 2 and in Appendix B.

Figure 2: Indicative Planning Proposals

3.0 CATCHMENT DESCRIPTORS

3.1 The Flood Estimation Handbook (FEH) CD-ROM provided catchment descriptors for Higgin Brook upstream of a point north of the development site. Three smaller sub-catchments (Sub A, Sub B and Sub C) upstream of the 600mm culvert were identified using LiDAR data.

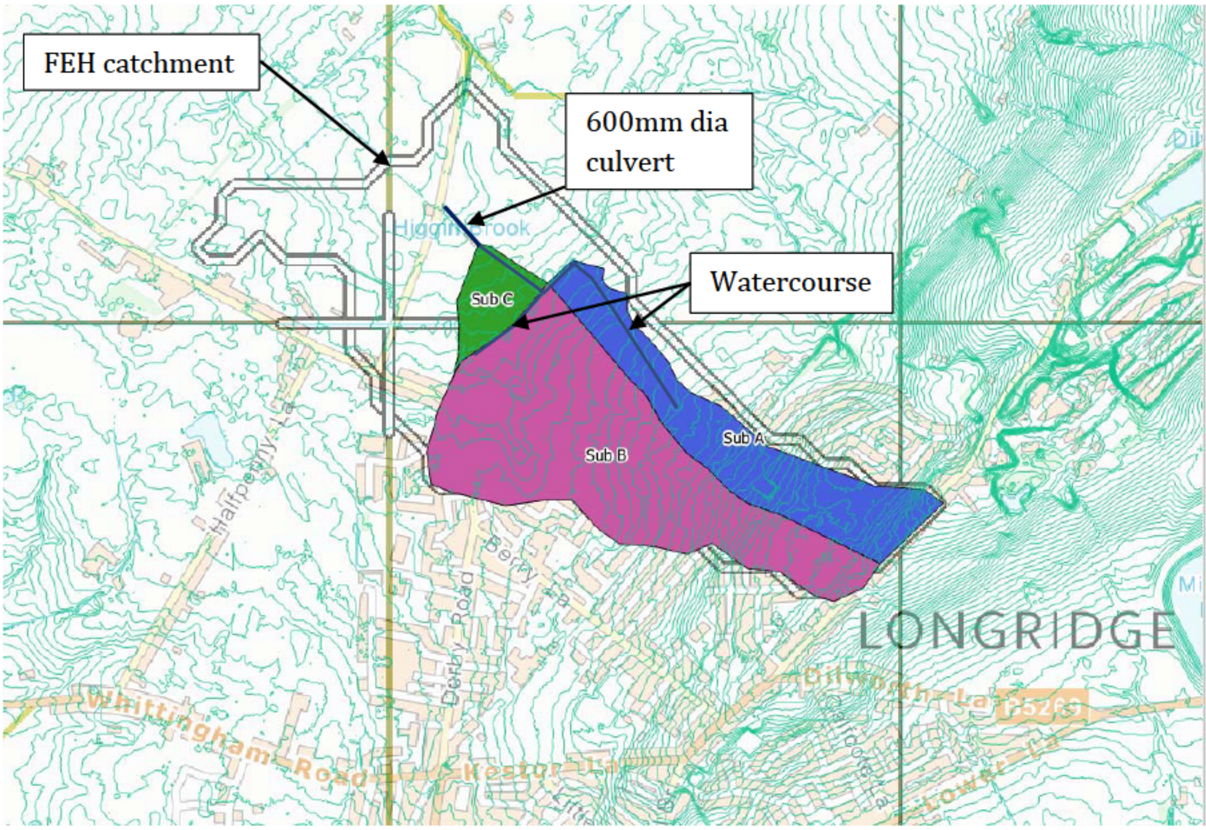

Figure 3: Upstream Sub-catchments

3.2 The FEH Catchment descriptors are summarised below and included in full in Appendix C.

Important Catchment Descriptors: All sub-catchments

DPSBAR (m/km)	22.3	Mean slope between nodes (m/km)
SAAR (mm)	1200	Standard annual average rainfall – 1961-1990
FARL	1.00	Flood attenuation due to reservoirs/lakes (no attenuation)
BFIHOST	0.417	Baseflow index from Hydrology of Soil Types
SPRHOST	35.03	Standard percentage runoff from soil types
PROPWET	0.51	Proportion of time catchment is wet
URBEXT1990	0.1643	Urban extent in 1990 (essentially rural)

3.3 The areas for the sub-catchments were calculated using GIS and mean drainage path length (DPLBAR) was calculated using formula 7.1 from the FEH Volume 5: Catchment Descriptors as follows: $DPLBAR = AREA^{0.548}$. The sub-catchment areas and DPLBAR values are shown in Table 1.

Sub-catchment	Area (km^2)	DPLBAR (km)
Sub A	0.093	0.272
Sub B	0.200	0.414
Sub C	0.022	0.123

Table 1: Sub-catchment specific characteristics

4.0 HYDROLOGY

4.1 The Revitalised Flood Hydrograph (ReFH) method was applied for each sub-catchment based on catchment descriptors. The $URBEXT_{1990}$ <0.5 and BFIHOST<0.65 for all sub-catchments, therefore the use of the ReFH method is appropriate.

4.2 This study has considered the 1 in 5 year (20% AEP), 1 in 30 year (3.3% AEP), 1 in 100 year (1% AEP) and the 1 in 100 year (1% AEP) plus climate change (CC) return period flows in the watercourses.

4.3 These are considered to represent conservative flow estimates (i.e. adopts the precautionary approach). The site is considered to be predominantly greenfield and the catchment characteristics from the FEH CD-ROM were utilised. The peak flow estimates are shown in Table 2 below. Full details are shown in Appendix D.

Sub-Catchment	20% AEP	3.3% AEP	1% AEP	1% AEP + CC
Sub A	0.11	0.18	0.24	0.29
Sub B	0.20	0.32	0.45	0.54
Sub C	0.03	0.06	0.08	0.10

Table 2: ReFH Peak Flow Estimates

4.4 The critical storm duration for the largest sub-catchment (Sub B) was 1.065 hours. It was assumed that the same storm would occur in all sub-catchments, as they are adjacent to one another.

4.5 The full hydrographs for all sub-catchments in all return periods are shown in Figures D.1 to D.10 in Appendix D.

5.0 HYDRAULIC MODELLING

Model Details

5.1 An unsteady state 1D model of the watercourse was developed using ISIS for the existing and the proposed development scenarios.

5.2 A topographical survey of the site and watercourse was undertaken and a 3D ground model was generated. Cross sections through the watercourse were generated from the ground model at locations shown in the model schematics shown in Figure 4. The cross sections (Figures E.1 to E.30) and watercourse profile (Figure E.15) are included in Appendix E.

5.3 The watercourse was modelled in the existing scenario for the 20%, 3.3%, 1% and 1% plus climate change AEP events.

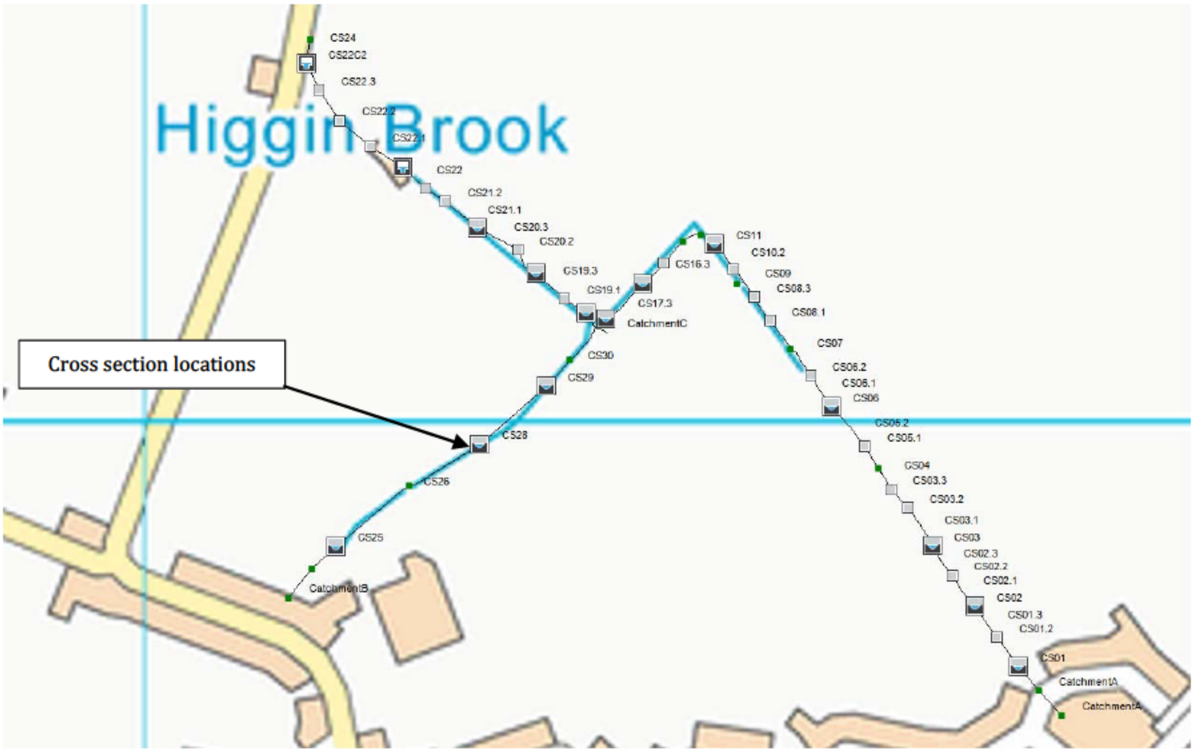

Figure 4: ISIS Model Schematic

5.4 Roughness coefficient allocation was based on aerial imagery. The watercourse channel is straight with some vegetation and as such the channel was assigned a roughness Manning's n value of 0.04 (refer to photographs in Appendix H).

5.5 There are seven structures within the modelled reach of the watercourse:

- 4 no. 300mm diameter pipes;
- 1 no. 525mm diameter pipe;
- 1 no. 575mm diameter pipe;

- 1 no. 600mm diameter pipe.

5.6 Overtopping of the bridges has been modelled in 1-D using a spill unit.

Model Assumptions

5.7 The cross sections were generated from a 3D ground model and so the profile of the channel may not be as true as if cross sections had been specifically surveyed. In some cases, the top water level on the date of the survey may have been used as the bed level. This approach is, however, conservative.

5.8 The diameters of pipes at cross sections 4, 9 and 15 have been assumed to be 300mm due to surveyed information not being available.

Model Results

Existing Scenario

5.7 The hydraulic modelling results including longitudinal profile and cross sections (including peak water levels) are included in Appendix E. Peak water levels for the 20%, 3.3%, 1% AEP and 1% AEP plus climate change events for the existing scenario are shown in Table 3.

5.8 The results show that water levels remain in bank for most of the reach in all AEPs. The peak water level is out of bank at the inlet to the 600mm diameter culvert.

Proposed Scenario

5.9 A 600mm diameter pipe, approximately 26m long, was inserted upstream of cross section number 26 to simulate a proposed crossing. The location of the new crossing is shown in Figure 5.

5.10 The hydraulic modelling results including longitudinal profiles and cross sections (including peak water levels) are included in Appendix F. Peak water levels for the 20%, 3.3%, 1% AEP and 1% AEP plus climate change events for the existing scenario are shown in Table 4.

5.11 Comparison of the existing and post development levels in the 1% AEP plus climate change event shows that peak levels remain largely unchanged, although with some small increases in places. The largest increase is of 27mm at cross section 26/26A, upstream of the proposed new culvert. There is also an increase of 25mm at cross section 25. These increases are relatively small and do not increase flood risk or the likelihood of surcharging of surface water outfalls.

Sensitivity Testing

5.12 Sensitivity testing was carried out on certain key model parameters to determine the effects on the simulated flows and water levels due to controlled changes in accordance with best practice.

5.15 The flow rate was increased by 20% and Manning's n values (channel roughness) were increased and decreased by 20%. These were all undertaken on the 1% AEP flow event (refer to Appendix G for the full sensitivity analysis results).

5.16 The increase in Manning's roughness coefficient, n, resulted in a mean increase in level of 0.022m and a maximum increase of 0.043m, occurring at cross section CS32 at the confluence of sub-catchments A and B. Reducing roughness coefficient by 20% had the effect of maximum decrease in water level of 0.057m. The mean effect was to reduce peak water levels by 0.021m.

5.17 Increasing flow by 20% resulted in a mean increase in peak water level of 0.073m and a maximum of 0.323m occurring at cross section CS07.

5.19 The sensitivity analysis has shown that water levels are not particularly sensitive to changes in channel roughness, with all mean and maximum changes within +/- 0.057m. When the 1% flow was increased by 20%, there were some isolated relatively large increases in water level, the maximum being 0.323m. The mean change was 0.073m and the change throughout most of the modelled reach was less than 0.100m.

5.20 The sensitivity due to these parameters should be taken into account when setting design levels.

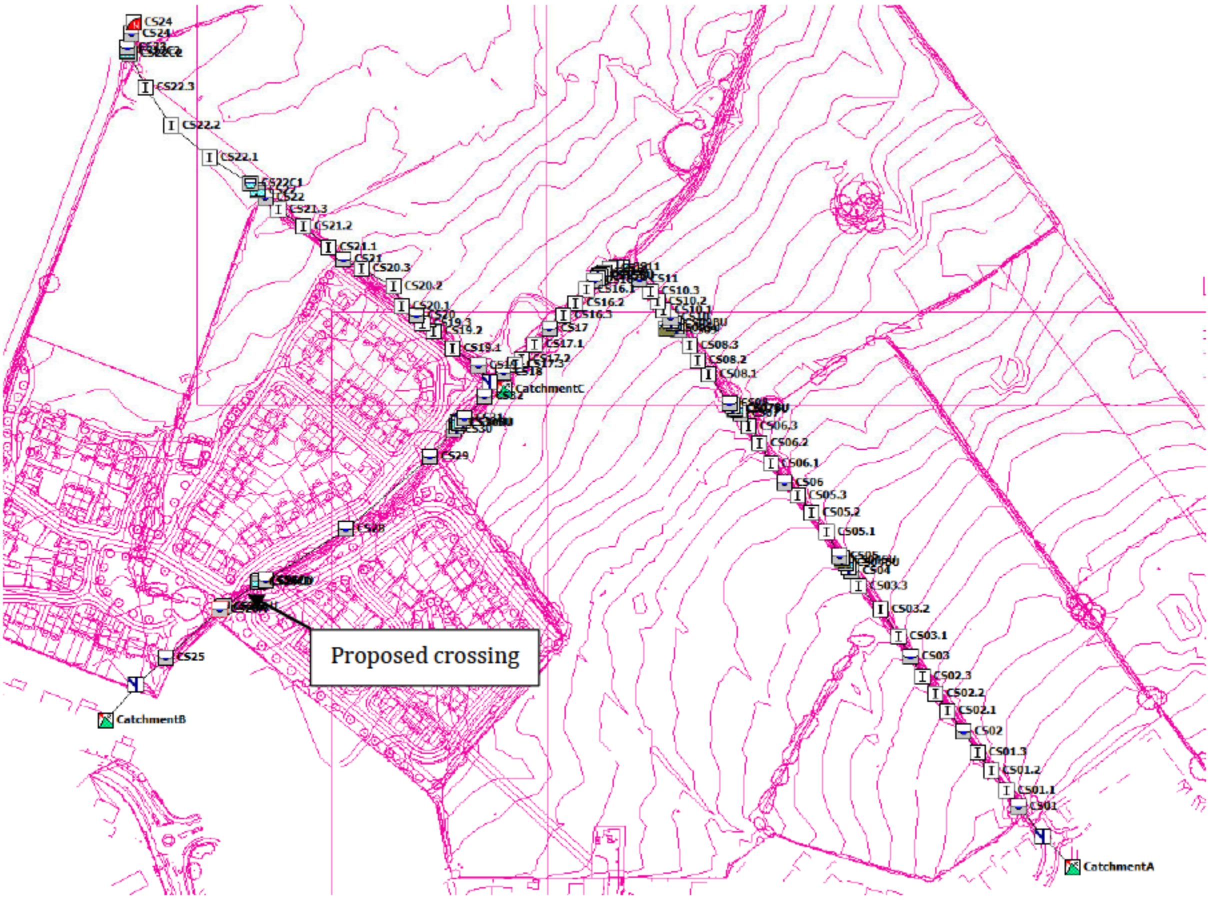

Figure 5: Proposed ISIS model schematic with new crossing

Cross Section	20% AEP (mAOD)	3.3% AEP (mAOD)	1% AEP level (mAOD)	0.1% AEP level (mAOD)
CS01	115.96	116.02	116.06	116.10
CS02	114.79	114.85	114.89	114.92
CS03	113.39	113.45	113.51	113.53
CS04	112.38	112.66	112.88	112.92
CS05	111.36	111.40	111.44	111.47
CS06	109.89	109.92	109.97	110.00
CS07	108.37	108.65	109.08	109.40
CS08	107.86	107.91	107.95	107.97
CS09	107.26	107.51	107.59	107.62
CS10	106.88	106.92	106.97	106.99
CS11	106.39	106.44	106.49	106.51
CS14	105.60	105.85	106.15	106.23
CS15	105.58	105.84	106.15	106.23
CS16	105.14	105.19	105.22	105.25
CS17	103.91	103.92	103.94	103.95
CS18	103.40	103.45	103.50	103.52
CS19	103.40	103.45	103.50	103.52
CS20	102.81	102.88	102.93	103.14
CS21	102.52	102.63	102.84	103.14
CS22	102.40	102.58	102.83	103.14
CS23	101.30	101.39	101.44	101.45
CS24	101.22	101.31	101.35	101.36
CS25	105.85	105.93	106.03	106.13
CS26	105.61	105.76	105.91	106.06
CS27	105.09	105.19	105.27	105.31
CS28	104.81	104.85	104.89	104.92
CS29	104.14	104.23	104.34	104.40
CS30	103.99	104.14	104.27	104.35
CS31	103.63	103.72	103.81	103.85
CS32	103.40	103.45	103.50	103.52

Table 3: Peak 20%, 3.3%, 1% and 0.1% AEP existing water levels

Cross Section	20% AEP (mAOD)	3.3% AEP (mAOD)	1% AEP level (mAOD)	0.1% AEP level (mAOD)
CS01	115.96	116.02	116.06	116.10
CS02	114.79	114.85	114.89	114.92
CS03	113.39	113.45	113.51	113.53
CS04	112.38	112.66	112.88	112.92
CS05	111.35	111.40	111.45	111.47
CS06	109.89	109.92	109.97	110.00
CS07	108.37	108.65	109.08	109.40
CS08	107.86	107.91	107.95	107.97
CS09	107.26	107.50	107.59	107.62
CS10	106.88	106.92	106.97	106.99
CS11	106.39	106.44	106.49	106.51
CS14	105.60	105.85	106.15	106.23
CS15	105.58	105.84	106.15	106.23
CS16	105.14	105.19	105.22	105.25
CS17	103.91	103.92	103.94	103.95
CS18	103.40	103.45	103.50	103.53
CS19	103.40	103.45	103.50	103.53
CS20	102.81	102.88	102.93	103.15
CS21	102.52	102.63	102.84	103.14
CS22	102.41	102.58	102.83	103.14
CS23	101.30	101.39	101.44	101.45
CS24	101.22	101.31	101.35	101.36
CS25	105.86	105.95	106.06	106.15
CS26A	105.67	105.81	105.97	106.09
CS27	105.09	105.19	105.28	105.31
CS28	104.81	104.85	104.89	104.92
CS29	104.14	104.24	104.34	104.41
CS30	103.99	104.14	104.28	104.36
CS31	103.63	103.72	103.81	103.86
CS32	103.40	103.45	103.50	103.53

Table 4: Peak 20%, 3.3%, 1% and 0.1% AEP proposed water levels

6.0 LOW FLOW ANALYSIS

6.1 In order to determine a typical water level above which to set the levels of the surface water outfalls, a low flow analysis was undertaken in accordance with the Institute of Hydrology Report number 108 (IH 108). The analysis included the soil HOST classification, the UK Hydrometric Register and the Flood Estimation Handbook (FEH) CD-ROM.

6.2 An extract from the soil HOST maps is shown in Figure 6, indicating that the soil classification for the catchment is 711m.

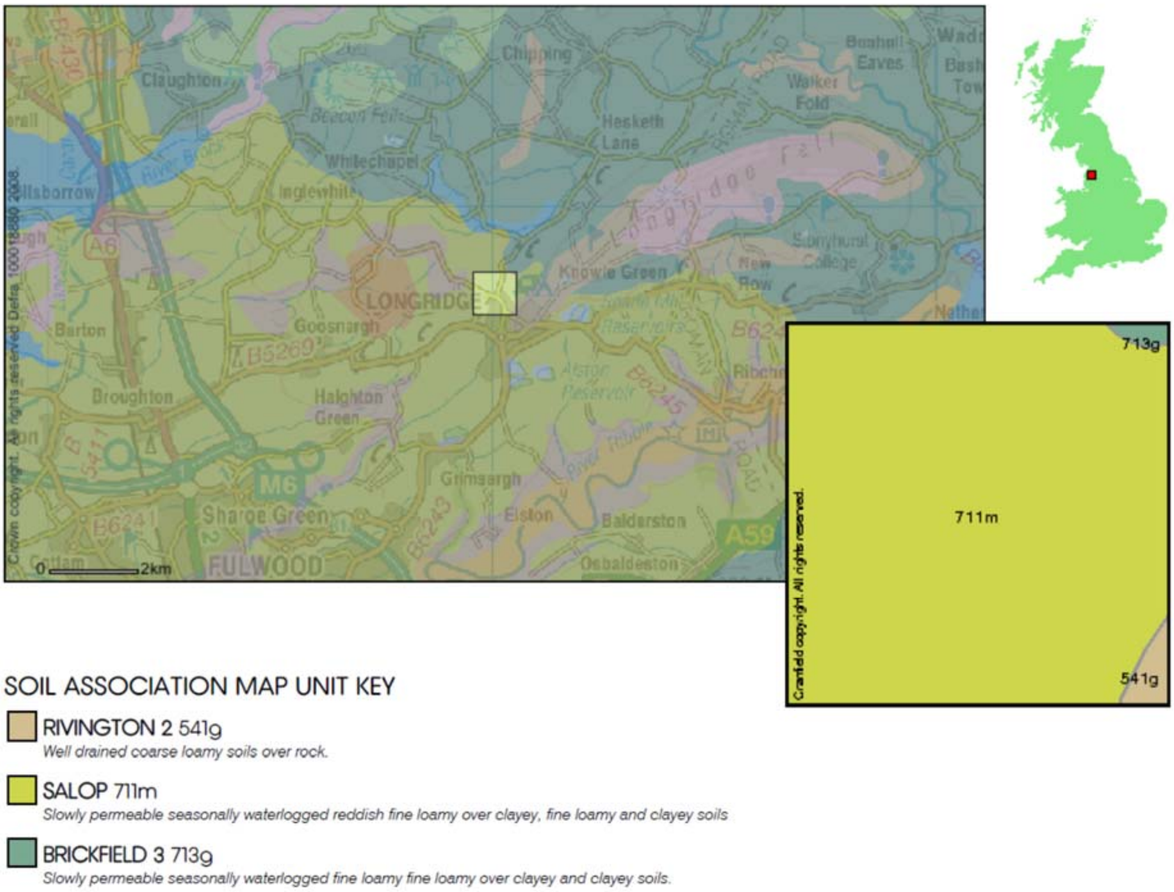

Figure 6: Soil HOST map classification

6.3 The FEH CD-ROM gives the Catchment Area = 0.52km^2 and standard average annual rainfall, SAAR = 1200mm. The FEH catchment is shown in Figure 7.

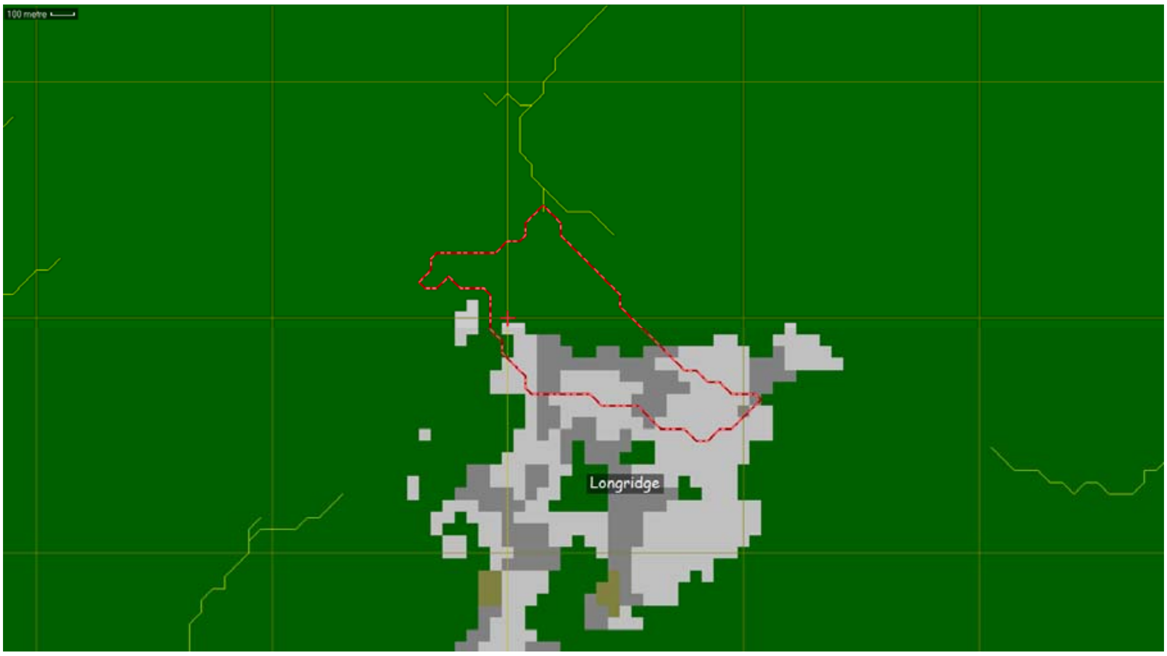

Figure 7: FEH CD-ROM catchment

6.4 From UK Hydrometric Register River Hodder @ Hodder Place (Station Number 71008):

Potential evaporation, PE = 600mm

6.5 From Institute of Hydrology (IH) report 108, section 7.3.2:

Annual Average Runoff Depth (AARD) = SAAR – Losses
Losses = r x PE where r=1 for SAAR>= 850mm

AARD = 1200 – 600
AARD = 600mm

Convert AARD to Mean Flow (MF)

MF = AARD x AREA x (3.17×10^{-5})
MF = 600 x 0.52 x 3.17×10^{-5}
MF = 0.0099 m^3/s

6.6 From IH 108 Appendix 4

Soil type 711m gives the 95 percentile 1-day flow, Q95(1), of 10.7% of mean flow, therefore

Q95(1) = MF x 10.7/100
Q95(1) = 0.0011 m^3/s

6.7 From IH 108 Table 7.1:

Curve 10: Q95(1) percentage of 10.0% is closest to Q95(1) of 10.7% given by soil

Percentile	% Mean Flow	Flow (m^3/s)
2	428.96	0.0425
5	303.93	0.0301
50	52.46	0.0052
80	21.25	0.0021
90	13.75	0.0014
95	10.00	0.0010
99	5.89	0.0006

Table 5: Flow duration

6.8 Flow duration curve is shown in Figure 8.

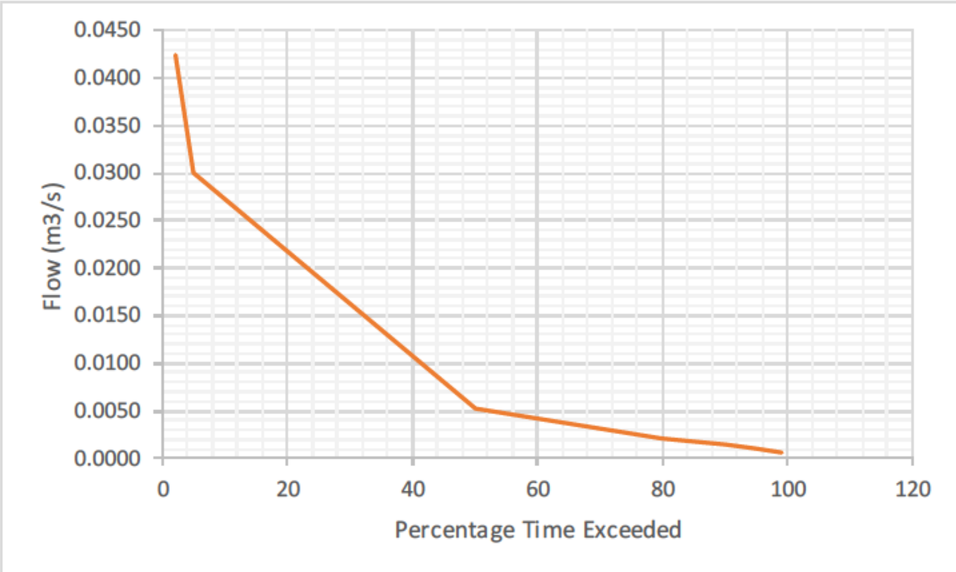

Figure 8: Flow Duration Curve

6.9 The Q95(1) flow of 0.001 m^3/s is too low to be run in the hydraulic model, and so a Manning's equation calculation has been undertaken on a typical cross section to determine the typical water level. The typical cross section is shown in Figure 9.

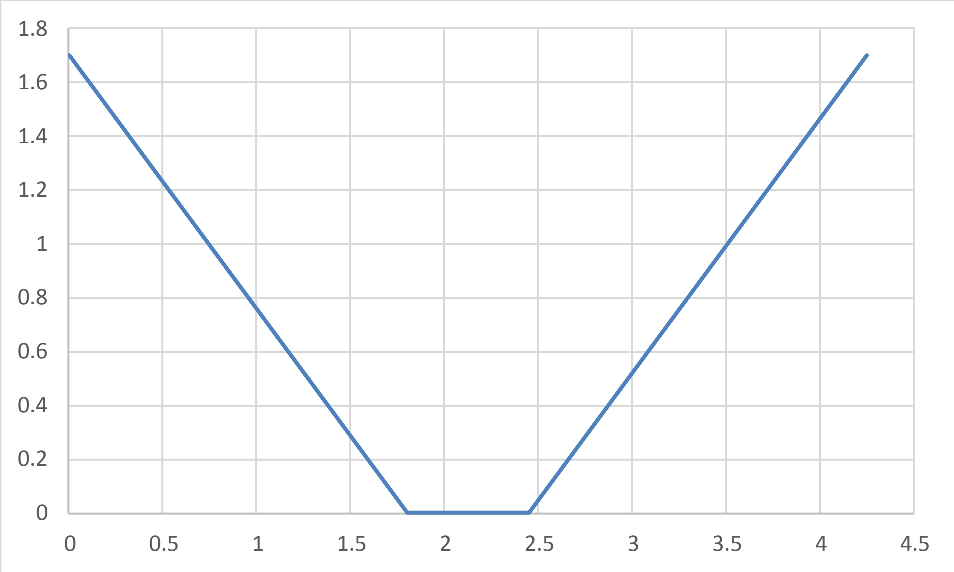

Figure 9: Typical cross section

6.10 Manning's equation is as follows:

$$Q = \frac{AR^{2/3}\sqrt{S}}{n}$$

where Q is flow, A is area of flow, R is hydraulic radius and S is gradient.

6.11 Using the average gradient of 0.025 and a Manning's roughness coefficient of 0.06, Manning's equation yields:

$$A = \frac{Qn}{R^{2/3}\sqrt{S}}$$

$$A = \frac{0.01 \times 0.06}{0.011^{2/3}\sqrt{0.025}}$$

$$A = 0.008\ m^3$$

6.12 The flow area of 0.008m^3 corresponds to a depth in the typical channel cross section of 0.012m. It is therefore recommended that the invert levels of surface water outfalls be set at 300mm above this level.

7.0 CONCLUSIONS

6.1 The hydraulic assessment has indicated that peak water levels in the watercourses remain largely within banks for events up to the 1% AEP plus climate change.

6.2 A thorough sensitivity analysis of key parameters has been undertaken and has shown that the model results are not significantly affected by changes in those parameters.

6.3 A low flow analysis was undertaken to determine the Q95(1) flow. The Q95(1) flow was calculated to be $0.001m^3/s$.

6.4 A Manning's equation calculation provided a typical depth in the channel of 0.012m. It is recommended that the invert levels of the surface water outfalls be set at 300mm above the Q95(1) water level.

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Planning Practice Guidance, CLG (2014)
Institute of Hydrology Report No. 108 (1992)

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CIRIA – http://www.ciria.org/
Cranfield University – http://www.landis.org.uk/soilscapes/
Environment Agency – www.environment-agency.gov.uk/
FloodProBE – http://www.floodprobe.eu/
Flood Forum – http://www.floodforum.org.uk/
Flood London – http://www.floodlondon.com/
Flood Resilience Group – http://www.floodresiliencegroup.org/frg/
Fylde Borough Council– http://www.fylde.gov.uk/
Google Maps – http://maps.google.co.uk/
Lancashire County Council- http://www.lancashire.gov.uk/home/2010/classic/index.asp
Streetmap – http://www.streetmap.co.uk/
United Utilities - http://www.unitedutilities.com/default.aspx

APPENDIX C: FEH CATCHMENT DATA & DESCRIPTIONS

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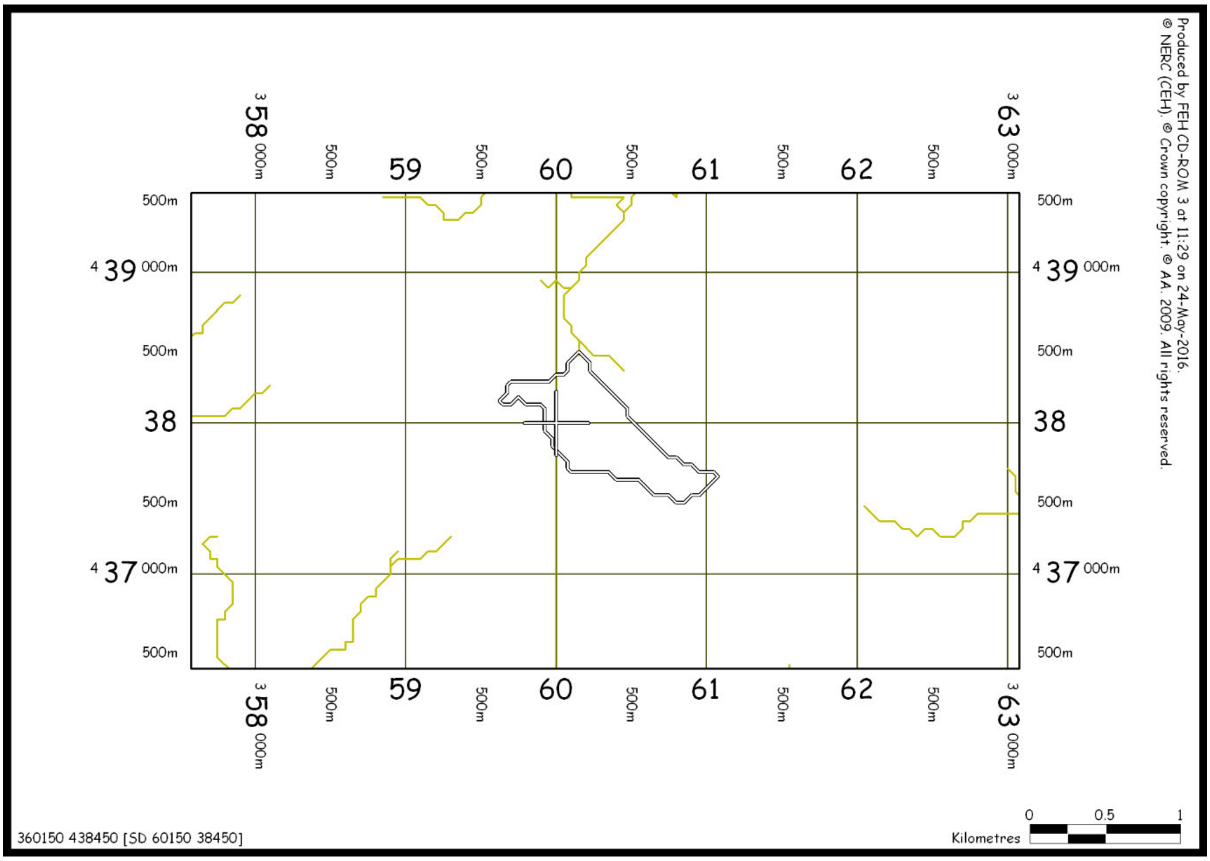
Higgin Brook catchment and catchment characteristics



AREA	0.52	URBLOC1990	1.515
ALTBAR	115	C	-0.025
ASPBAR	325	D1	0.40671
ASPVAR	0.65	D2	0.33211
BFIHOST	0.417	D3	0.41529
DPLBAR	0.77	E	0.29629
DPSBAR	22.3	F	2.45864
FARL	1	C(1 km)	-0.025
LDP	1.58	D1(1 km)	0.404
PROPWET	0.51	D2(1 km)	0.33
RMED-1H	10.5	D3(1 km)	0.417
RMED-1D	39.7	E(1 km)	0.296
RMED-2D	51.6	F(1 km)	2.453
SAAR	1200		
SAAR4170	1137		
SPRHOST	35.03		
URBCONC1990	0.964		
URBEXT1990	0.1643		

APPENDIX D: REVITALISED FLOOD HYDROGRAPH METHOD OUTPUTS [PEAK FLOW ESTIMATES]

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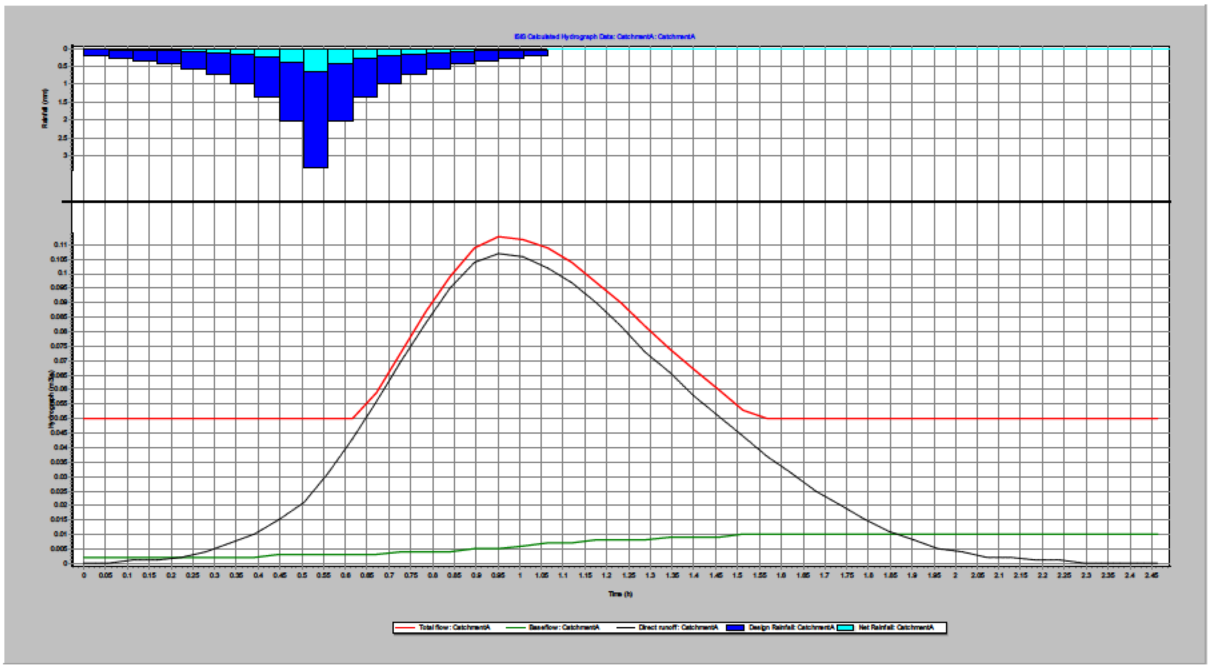

Figure D.1 Sub-catchment A 1 in 5 year (20% AEP) flow hydrograph

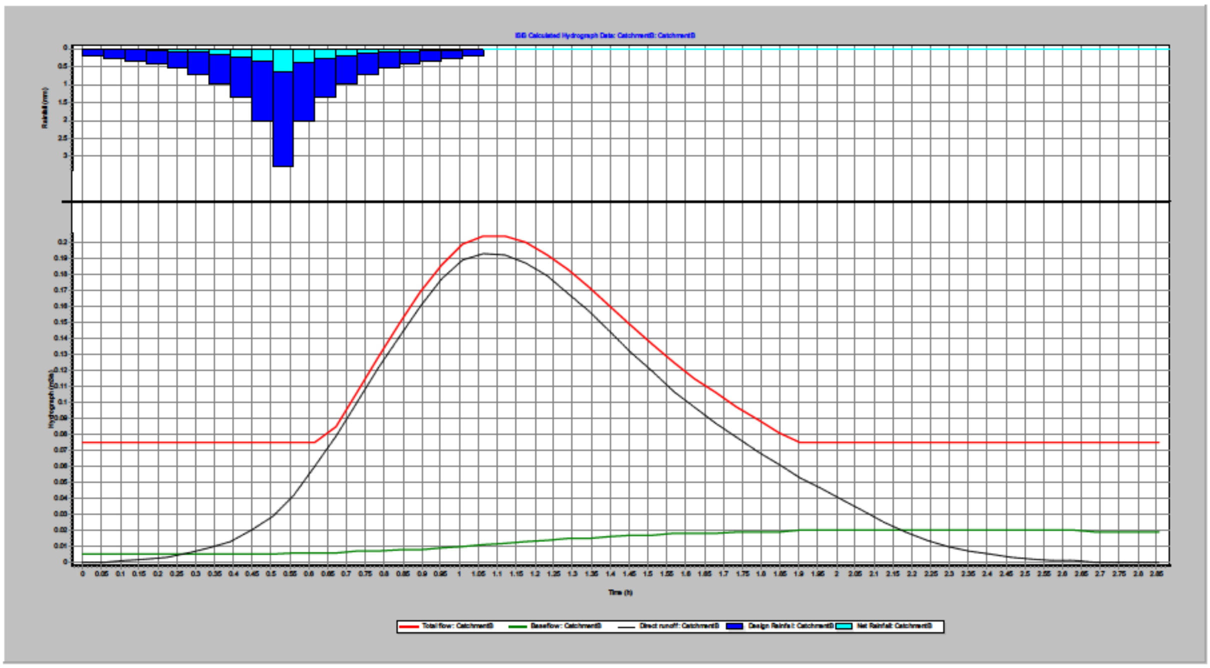

Figure D.2 Sub-catchment B 1 in 5 year (20% AEP) flow hydrograph

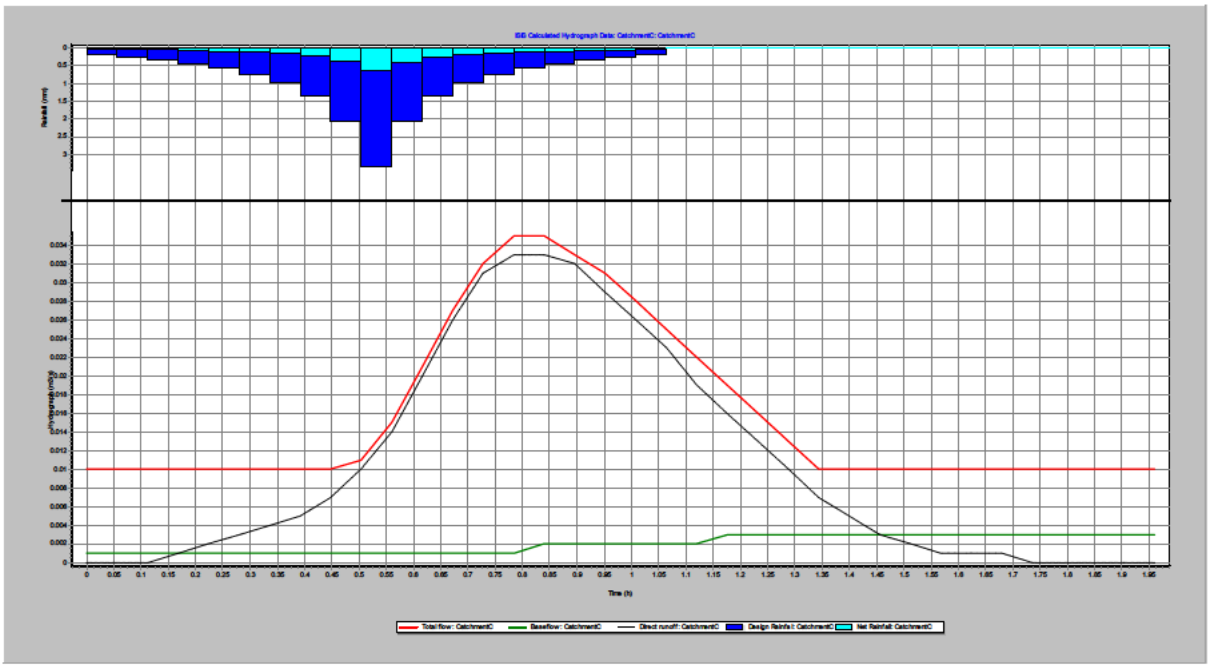

Figure D.3 Sub-catchment C 1 in 5 year (20% AEP) flow hydrograph

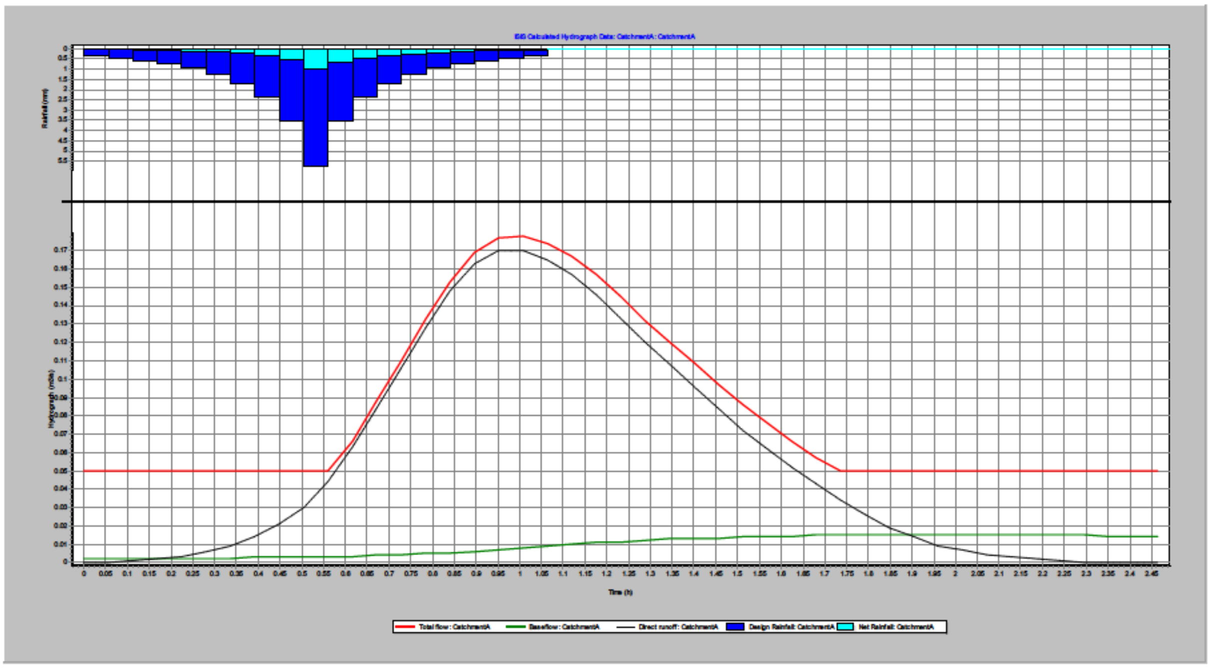

Figure D.4 Sub-catchment A 1 in 30 year (3.3% AEP) flow hydrograph

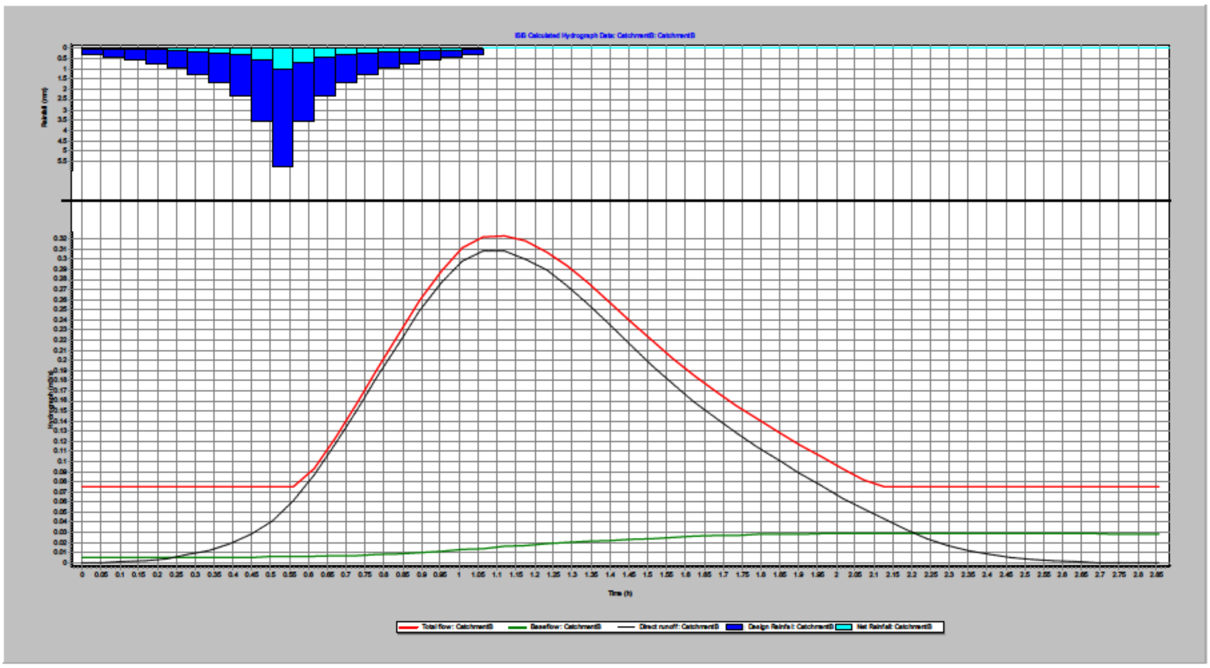

Figure D.5 Sub-catchment B 1 in 30 year (3.3% AEP) flow hydrograph

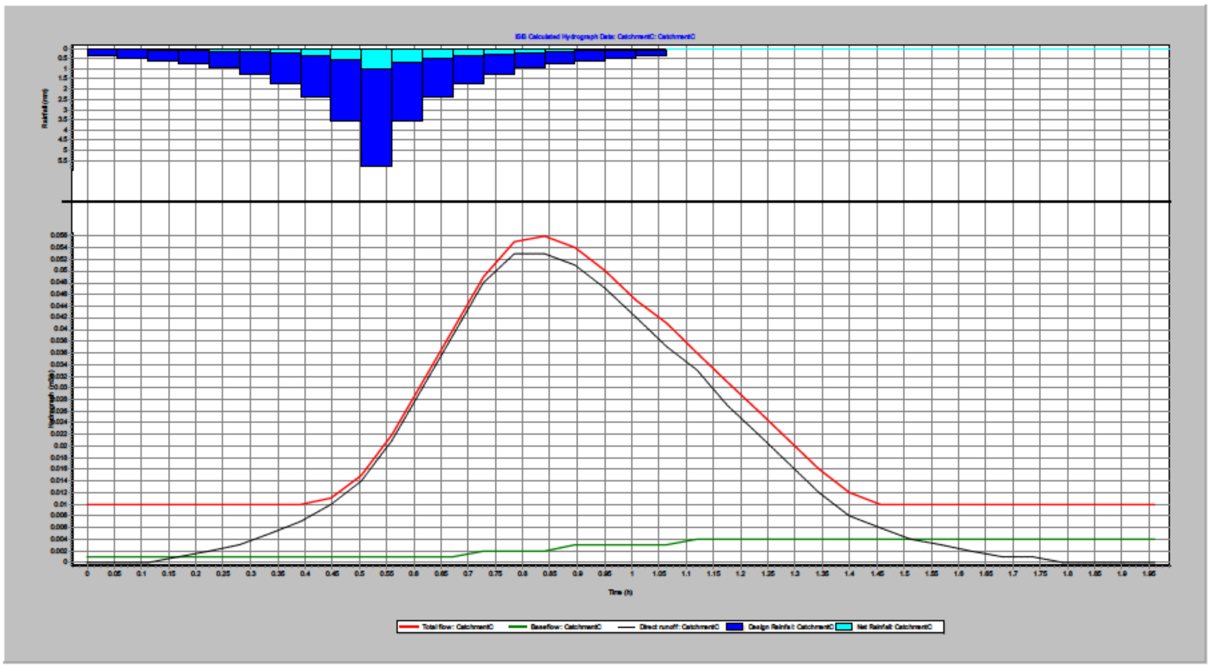

Figure D.6 Sub-catchment C 1 in 30 year (3.3% AEP) flow hydrograph

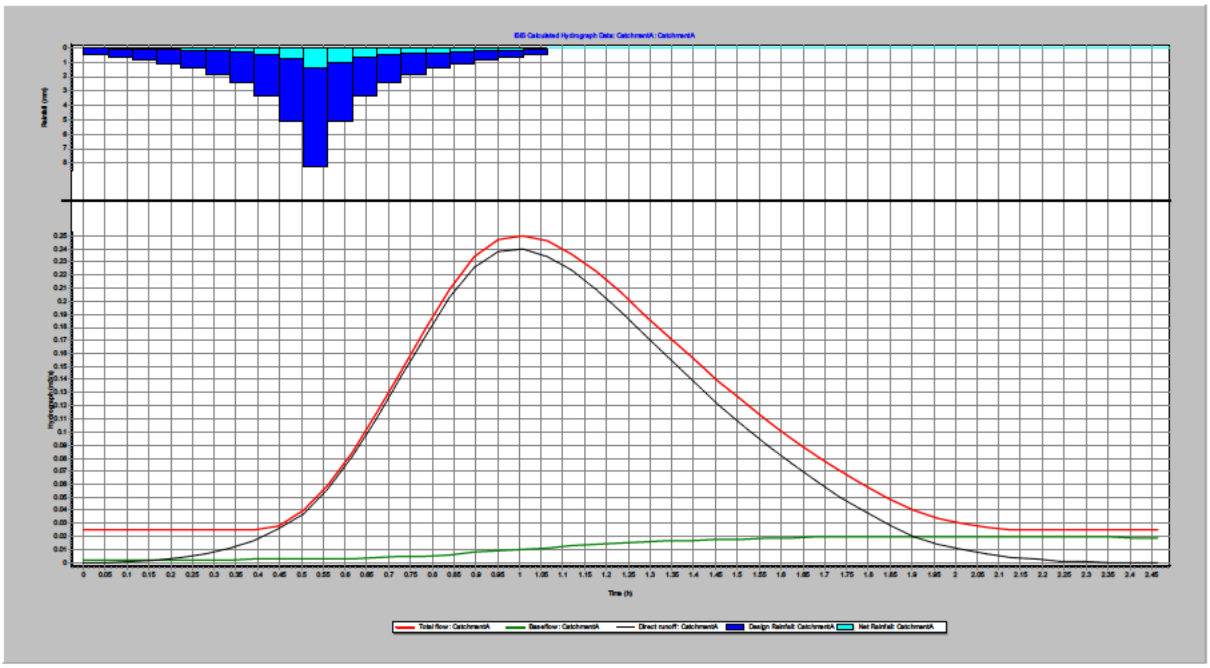

Figure D.7 Sub-catchment A 1 in 100 year (1% AEP) flow hydrograph

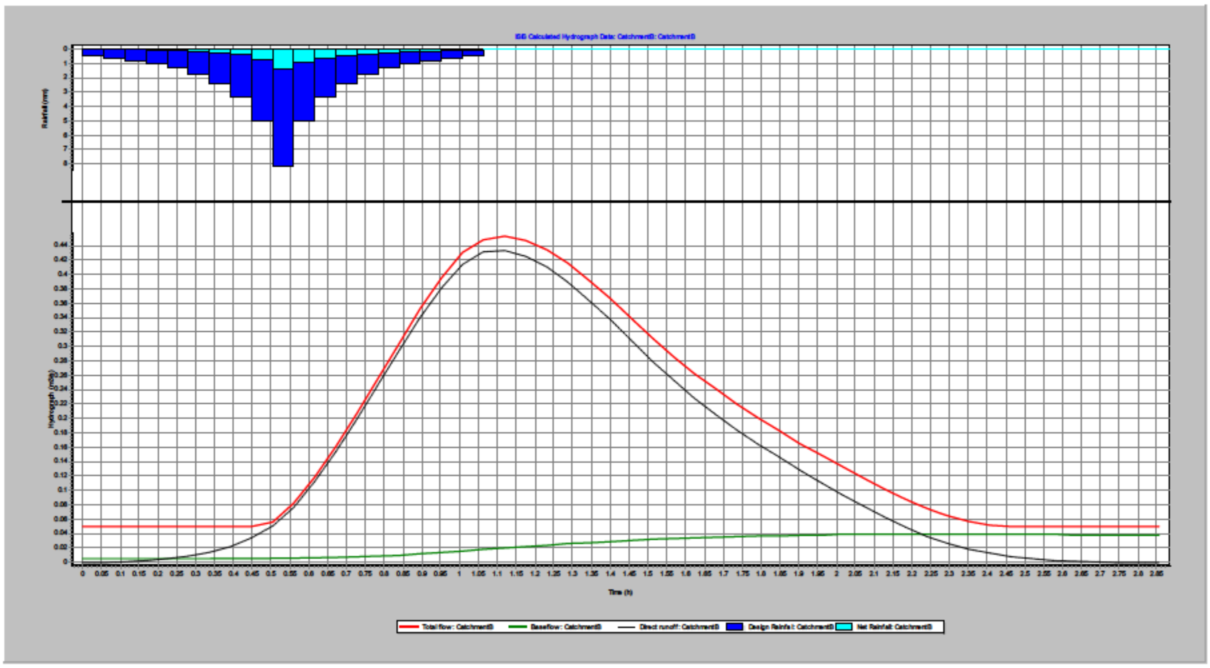

Figure D.8 Sub-catchment B 1 in 100 year (1% AEP) flow hydrograph

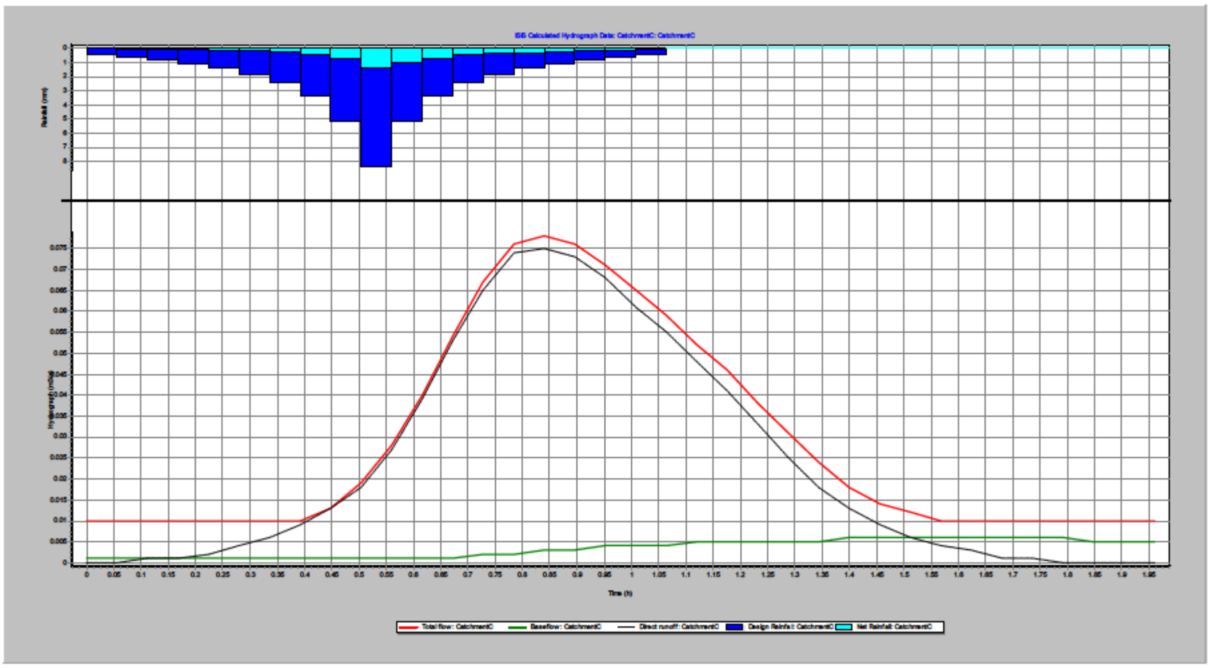

Figure D.9 Sub-catchment C 1 in 100 year (1% AEP) flow hydrograph

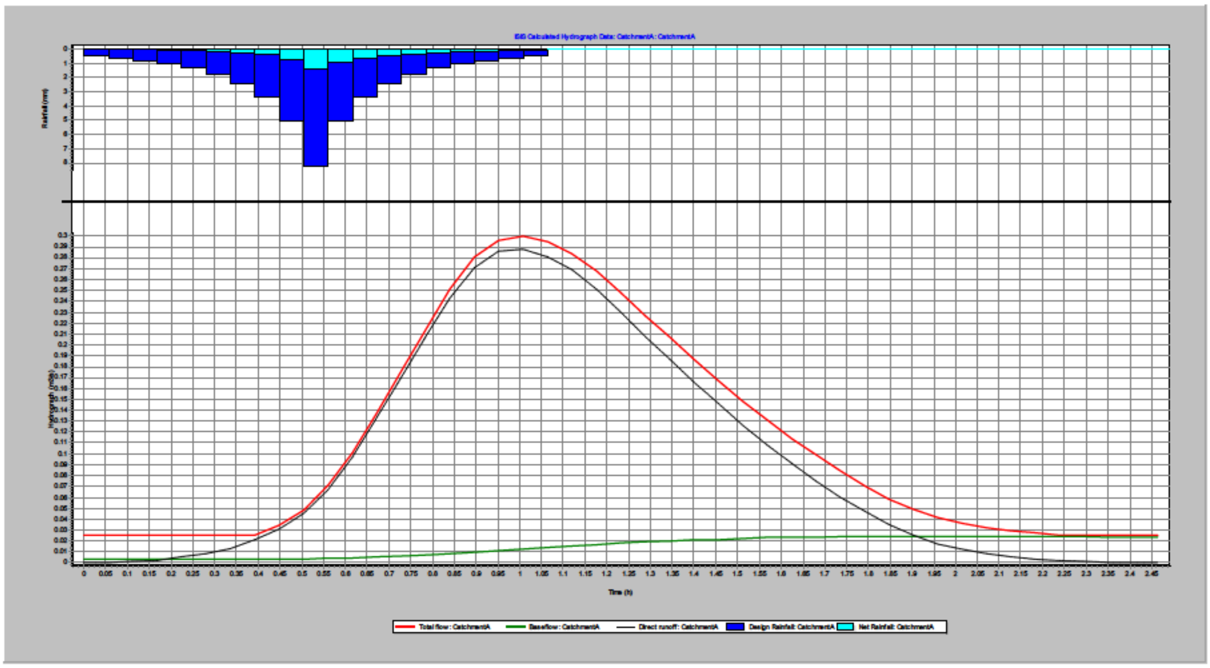

Figure D.9 Sub-catchment A 1 in 100 year (1% AEP) plus climate change flow hydrograph

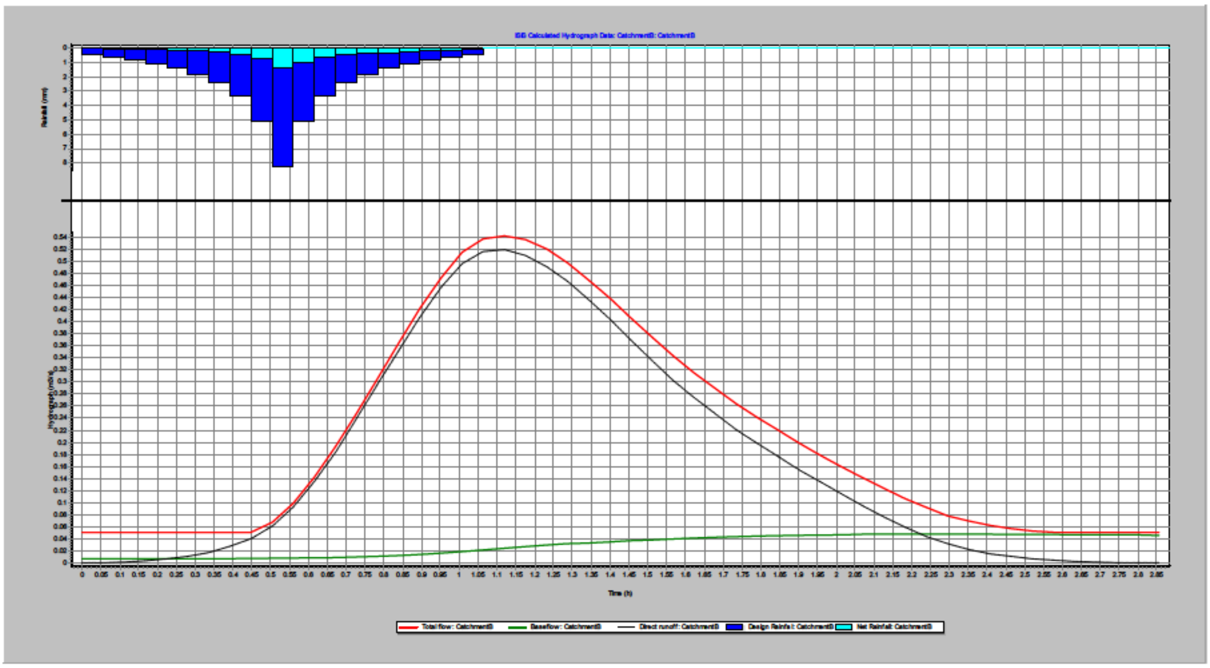

Figure D.9 Sub-catchment B 1 in 100 year (1% AEP) plus climate change flow hydrograph

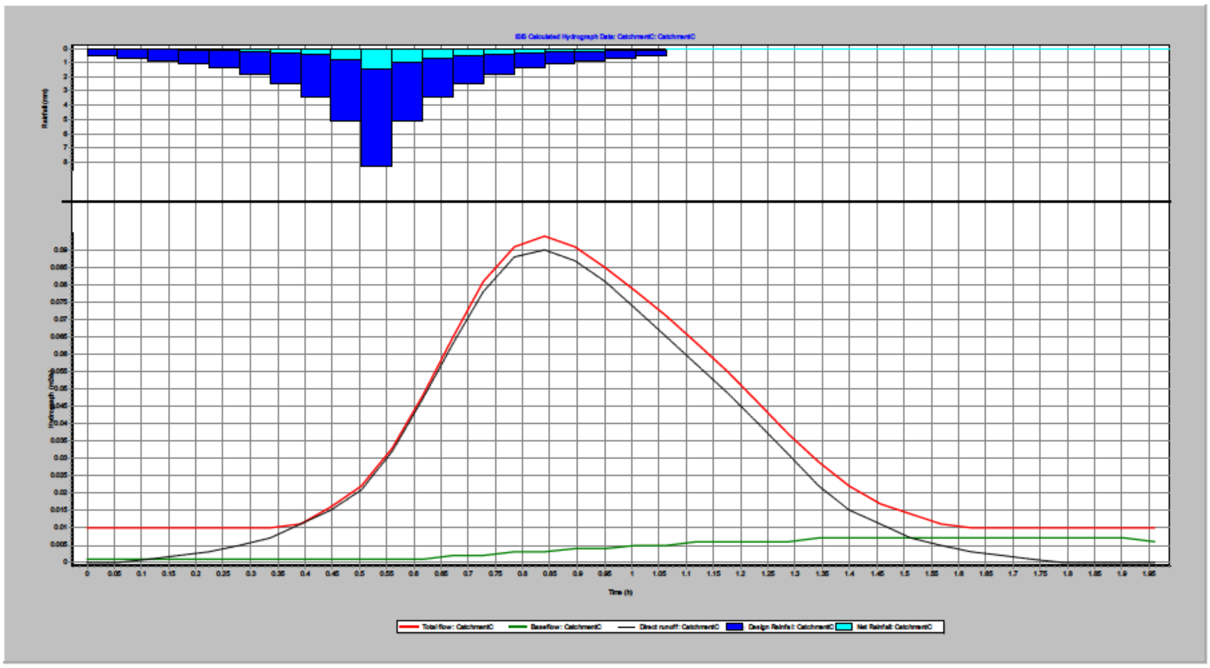

Figure D.10 Sub-catchment C 1 in 100 year (1% AEP) plus climate change flow hydrograph

APPENDIX E: ISIS OUTPUTS: EXISTING SCENARIO SCHEMATIC, LONG-SECTION AND CROSS-SECTIONS

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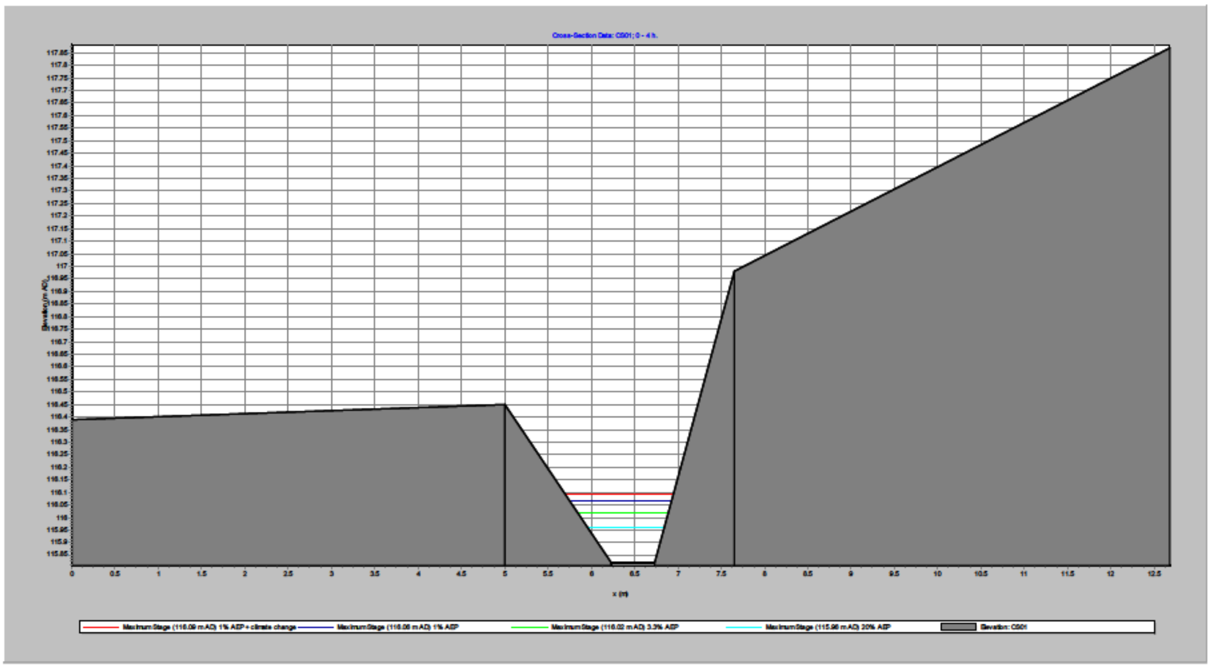

Figure E.1 Peak levels at cross section CS01

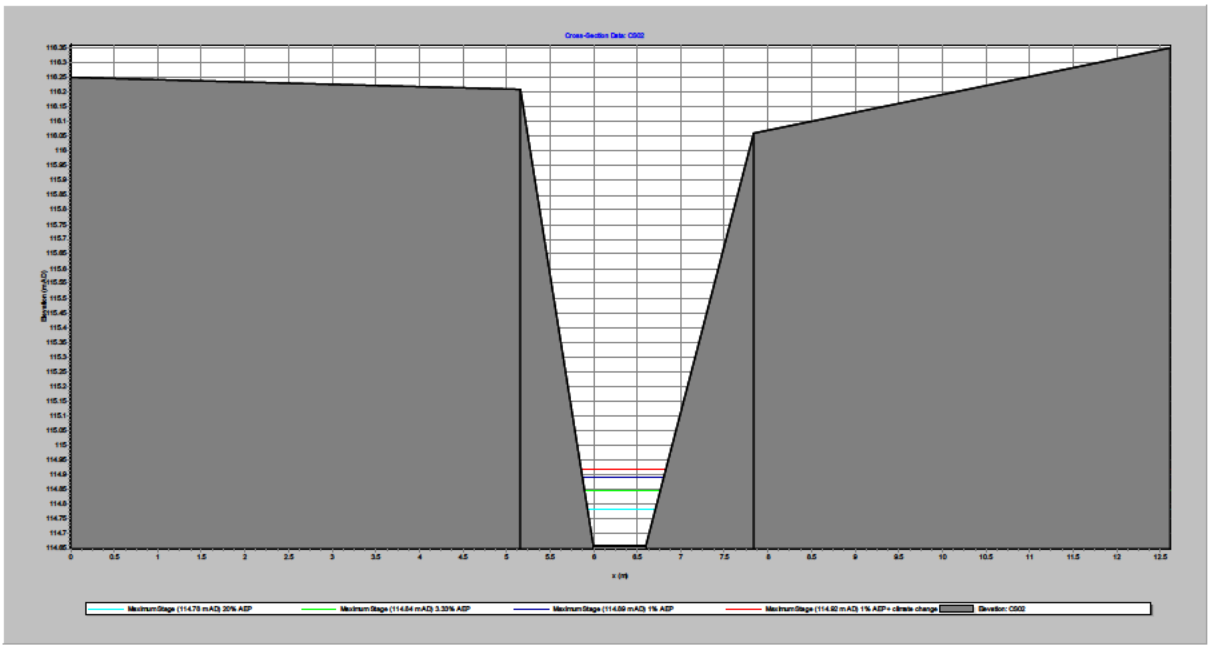

Figure E.2 Peak levels at cross section CS02

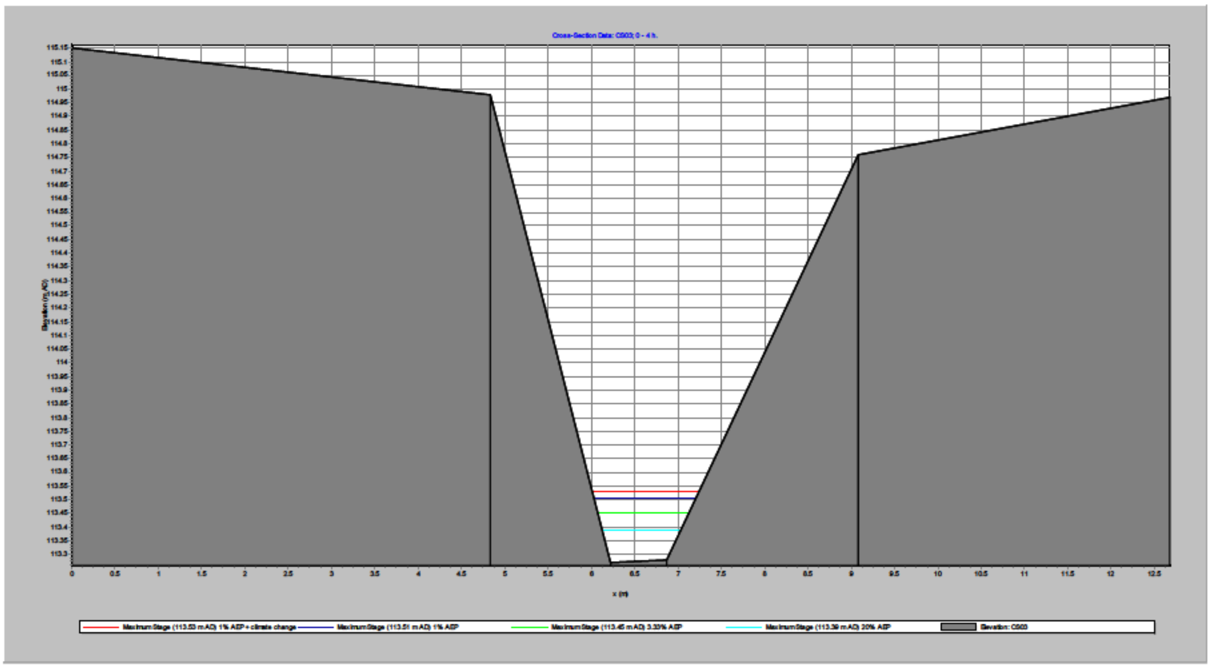

Figure E.3 Peak levels at cross section CS03

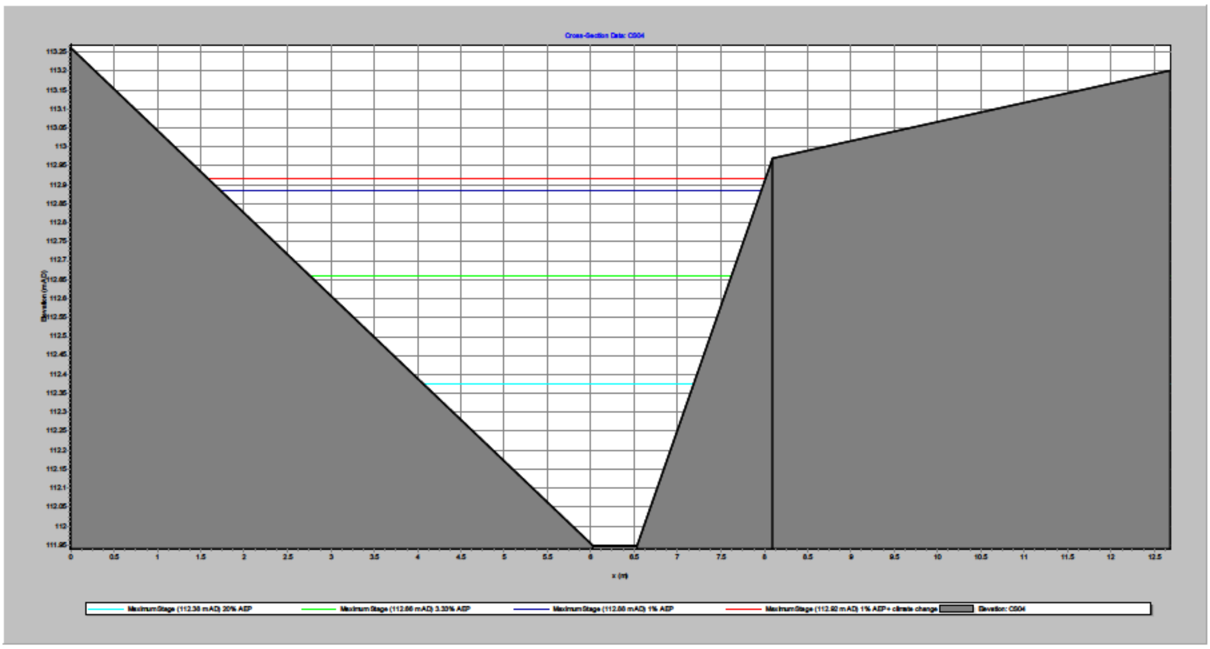

Figure E.4 Peak levels at cross section CS04

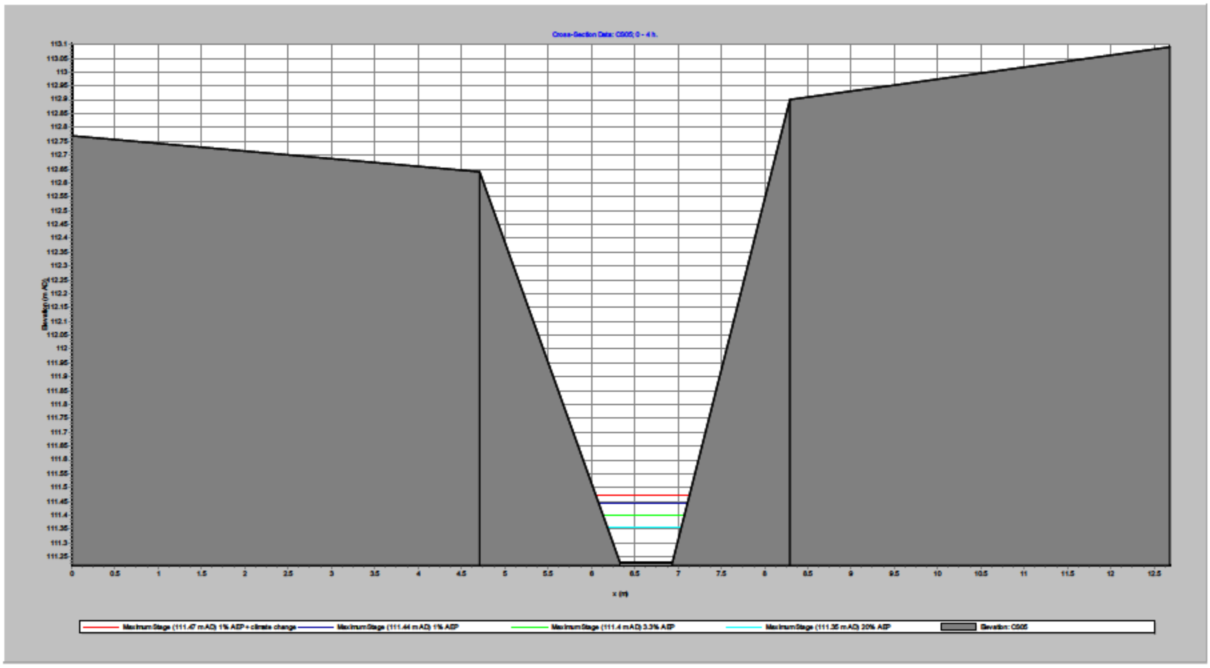

Figure E.5 Peak levels at cross section CS05

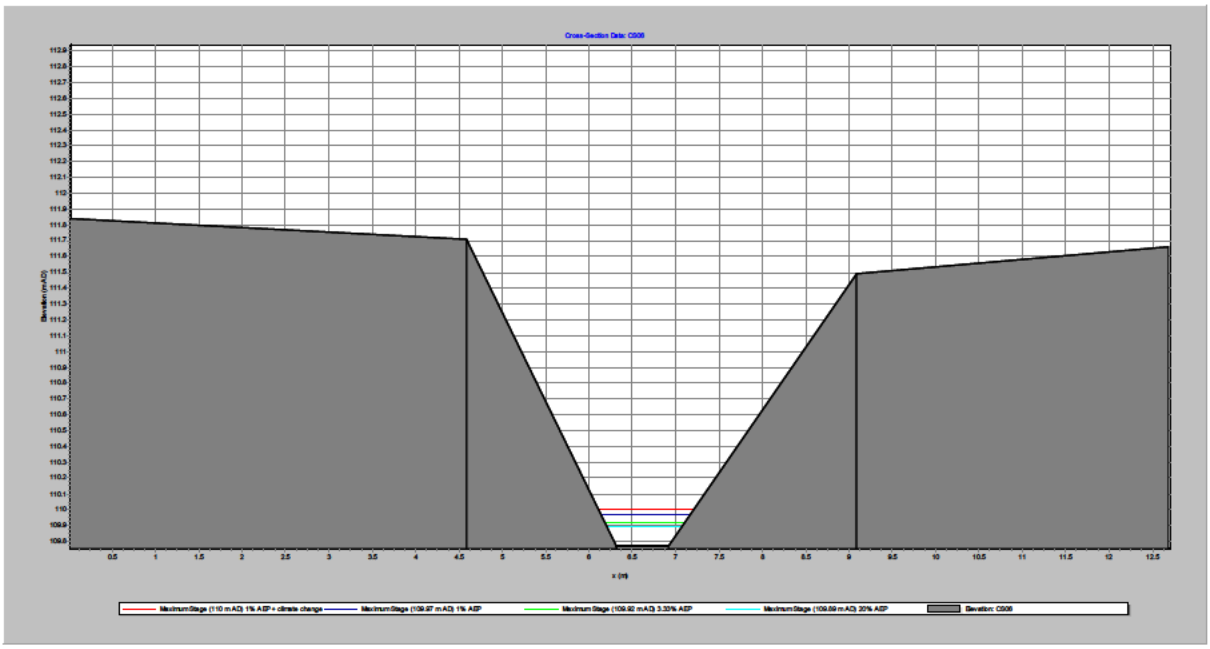

Figure E.6 Peak levels at cross section CS06

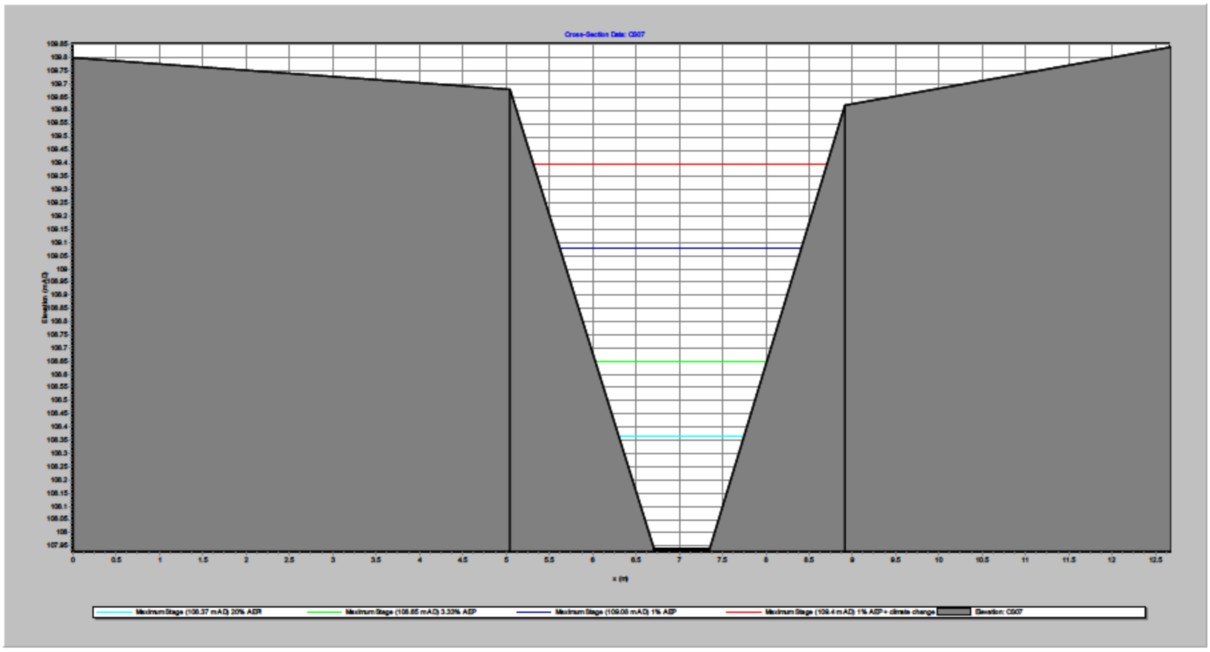

Figure E.7 Peak levels at cross section CS07

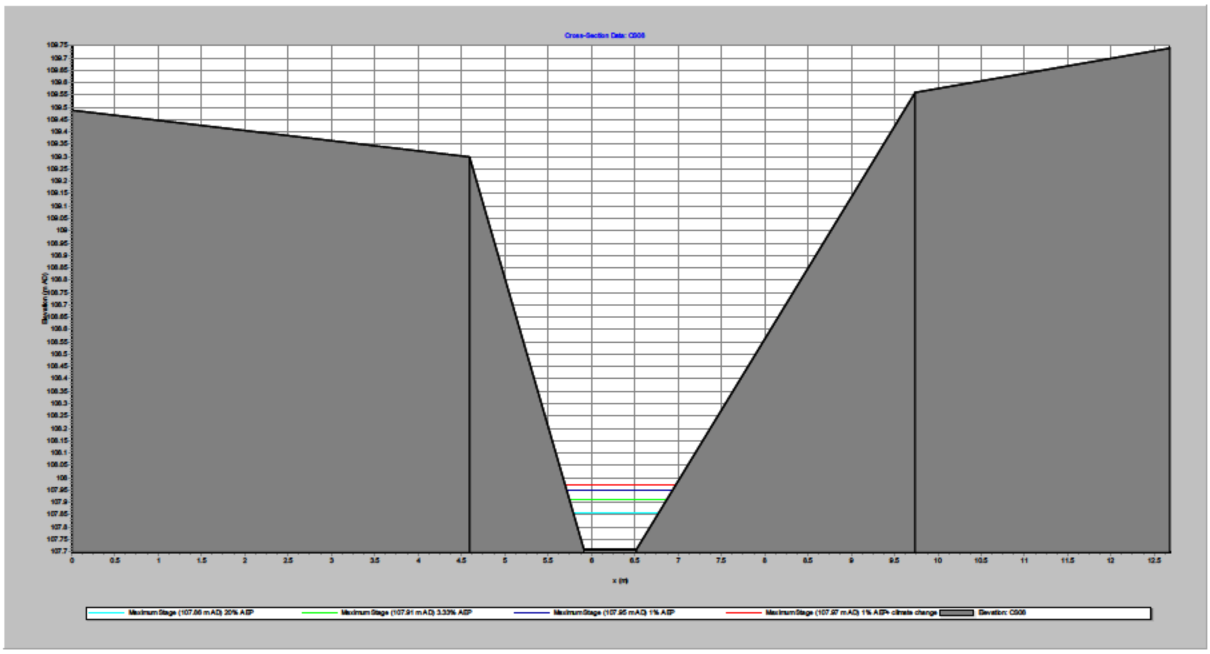

Figure E.8 Peak levels at cross section CS08

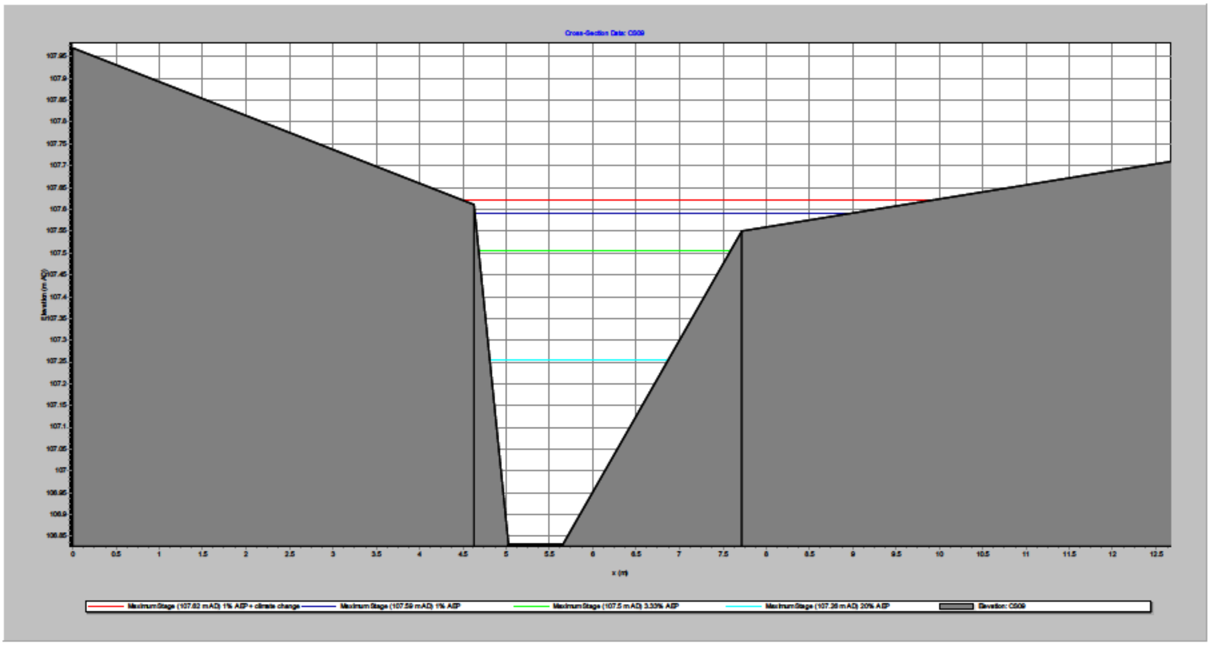

Figure E.9 Peak levels at cross section CS09

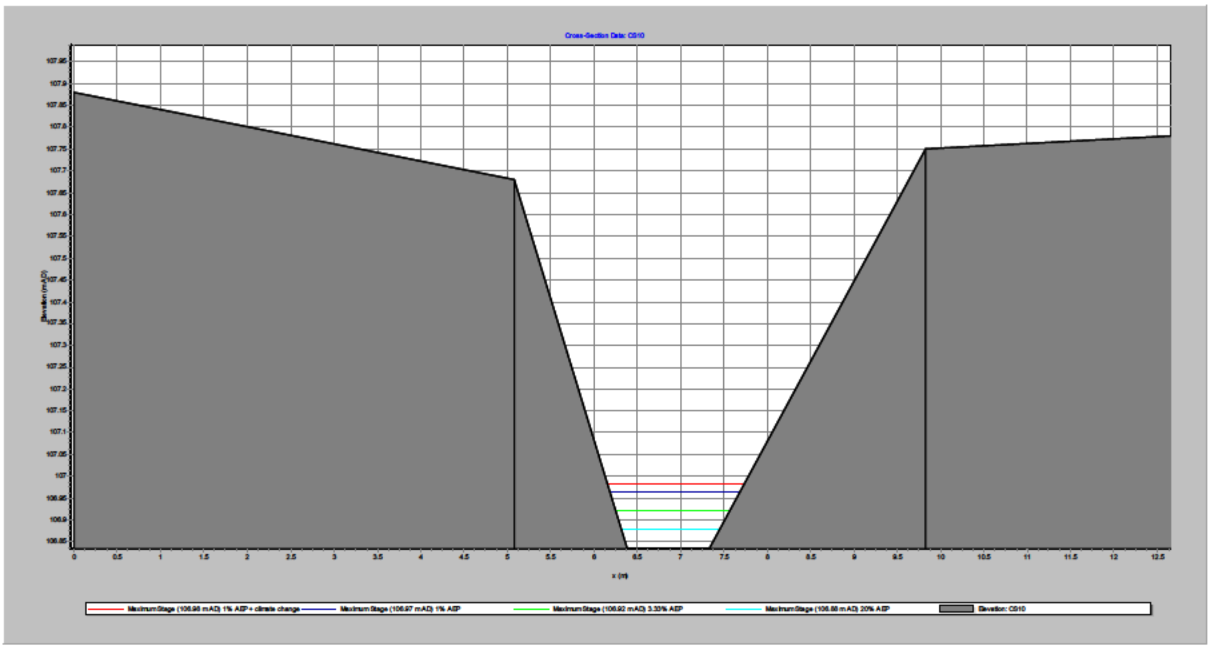

Figure E.10 Peak levels at cross section CS10

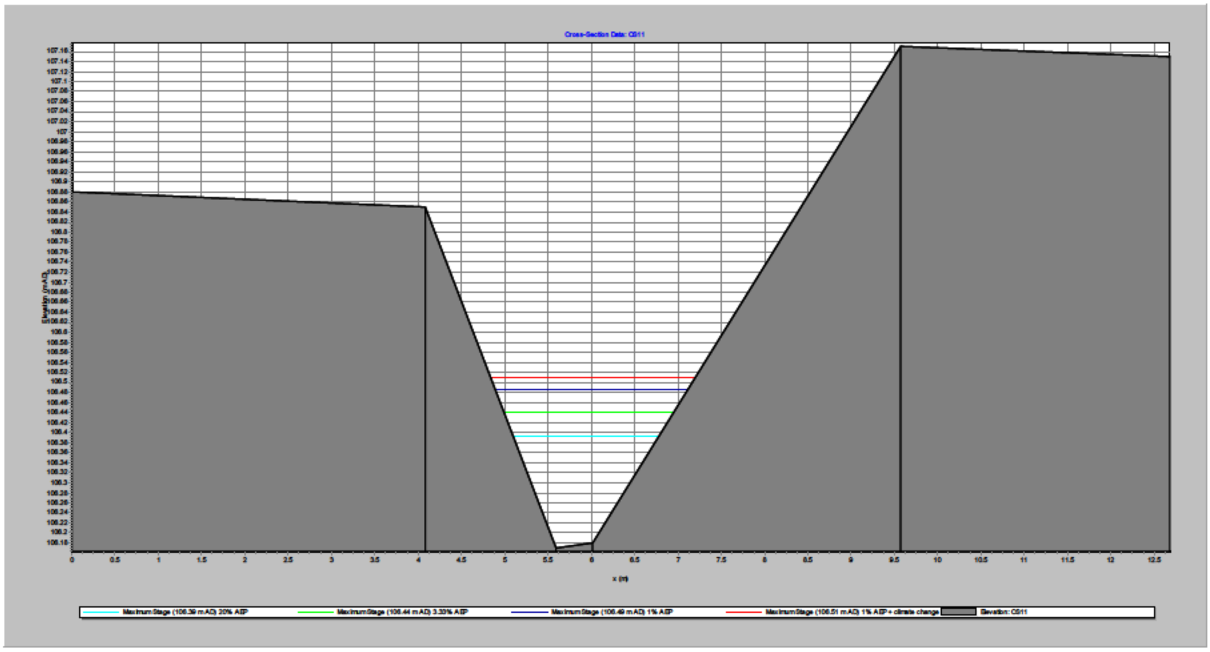

Figure E.11 Peak levels at cross section CS11

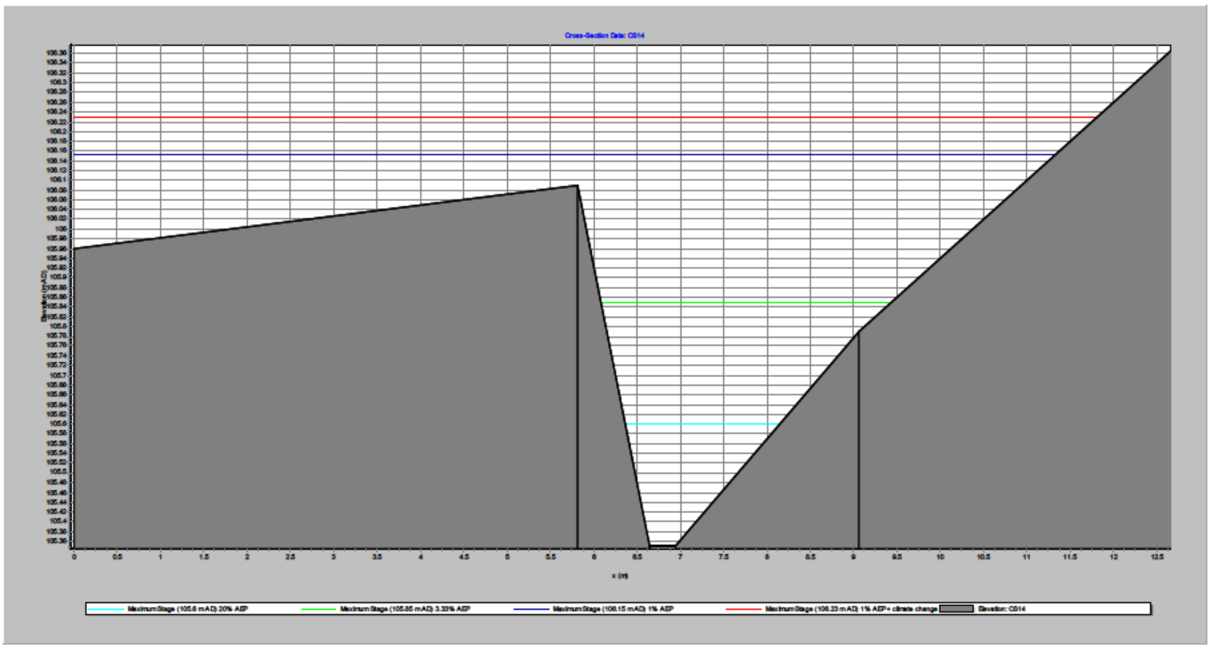

Figure E.12 Peak levels at cross section CS14

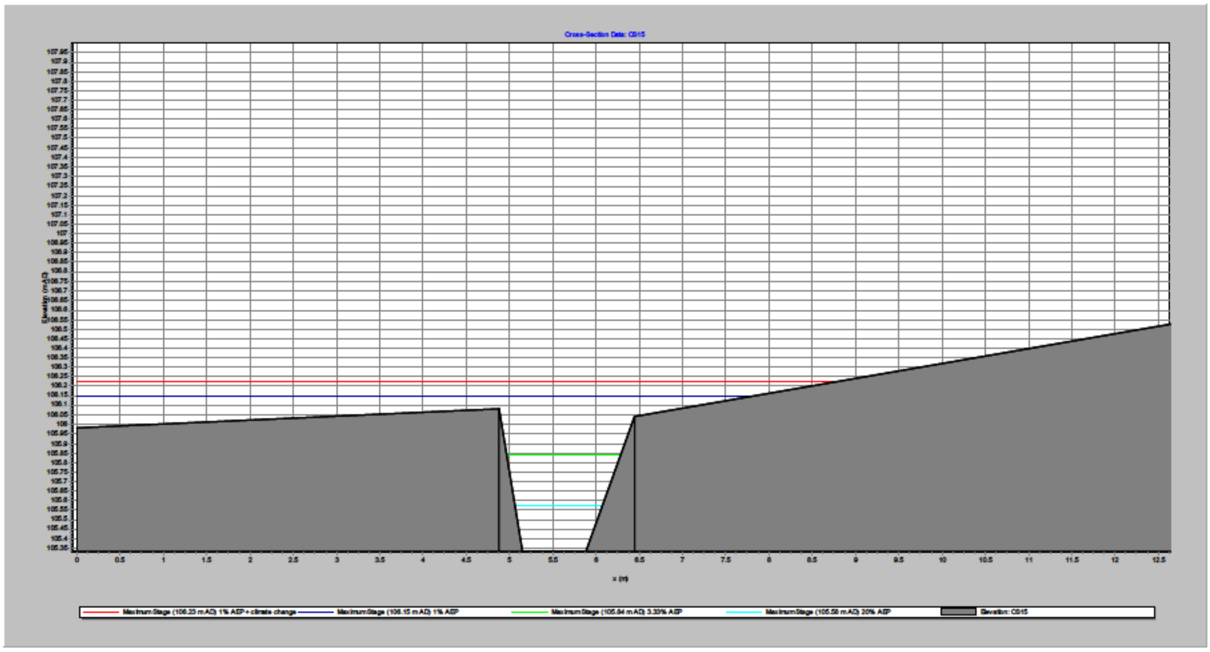

Figure E.13 Peak levels at cross section CS15

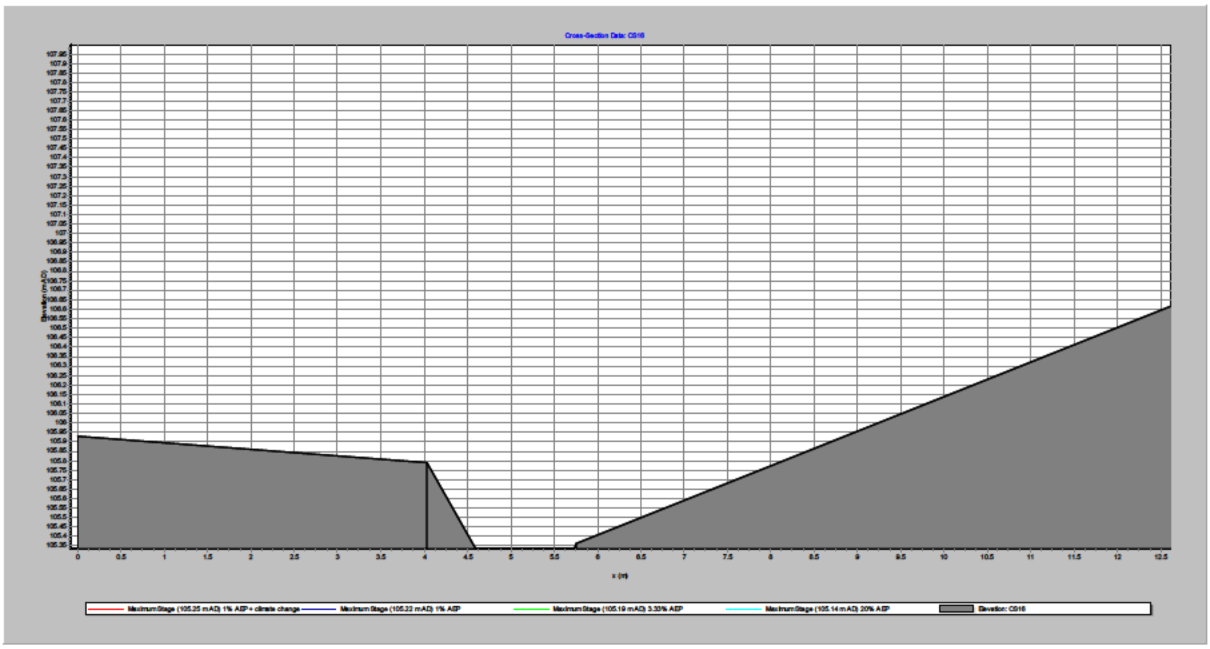

Figure E.14 Peak levels at cross section CS16

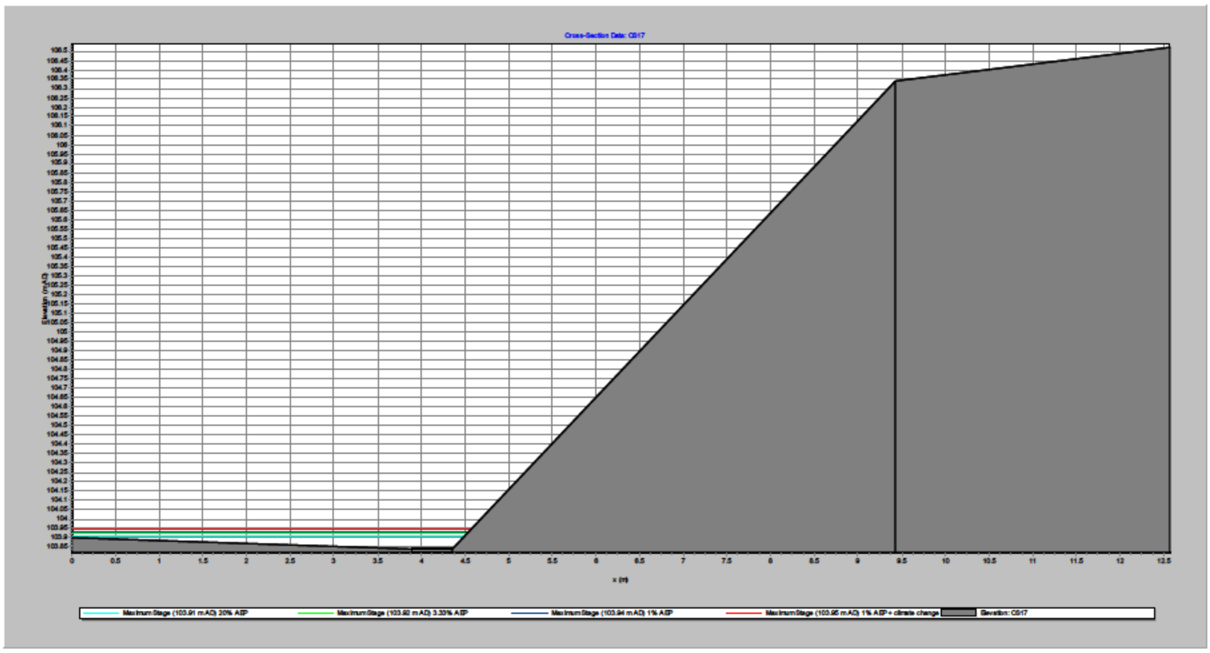

Figure E.15 Peak levels at cross section CS17

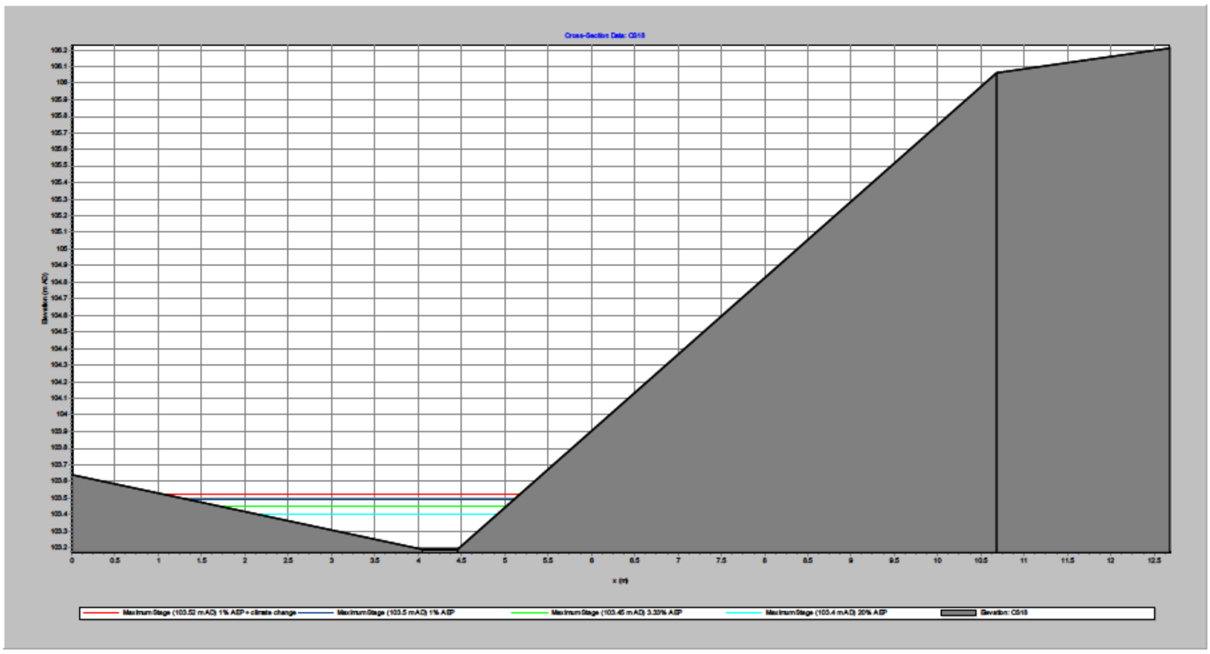

Figure E.16 Peak levels at cross section CS18

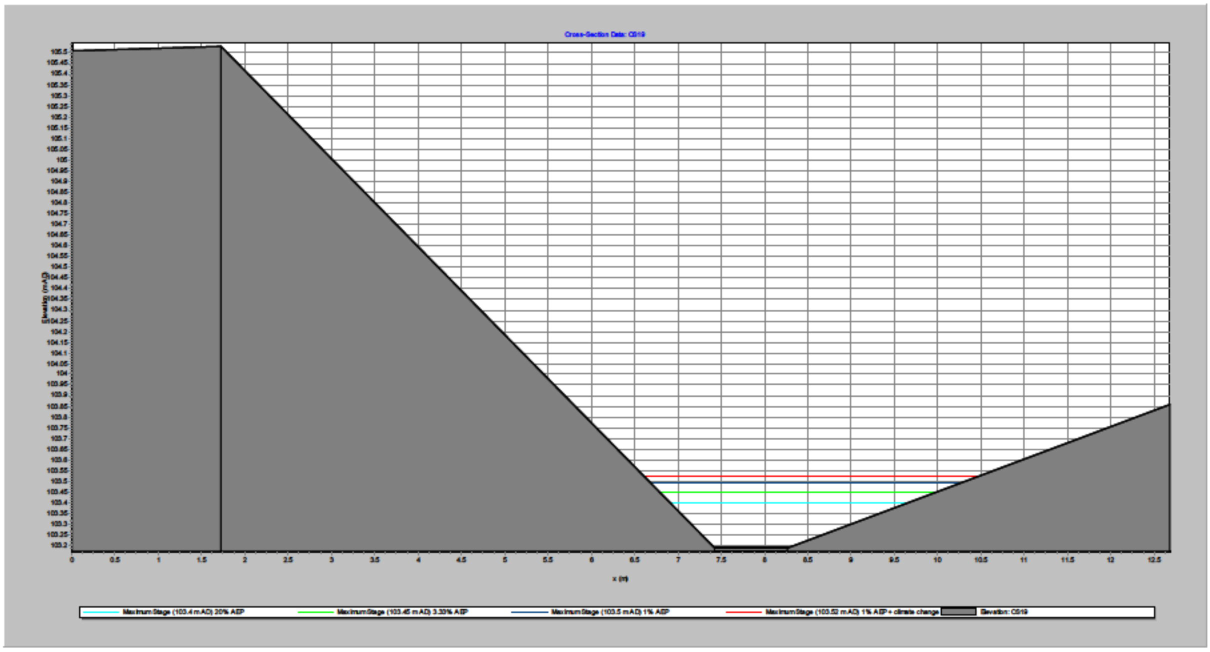

Figure E.17 Peak levels at cross section CS19

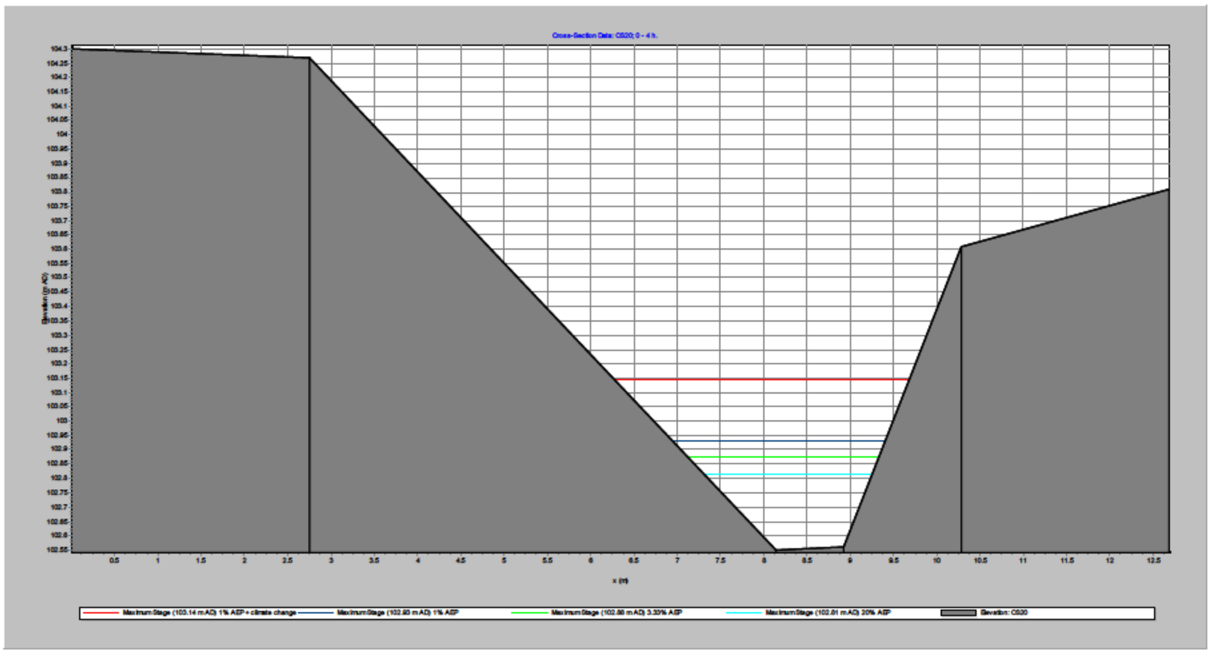

Figure E.18 Peak levels at cross section CS20

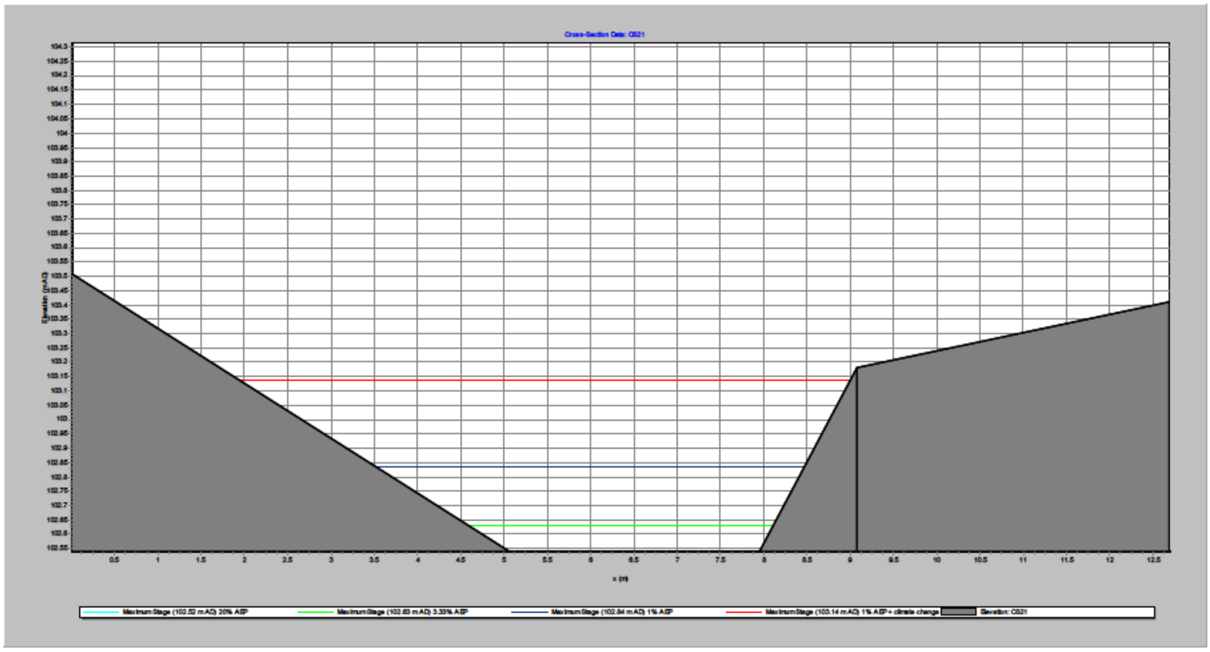

Figure E.19 Peak levels at cross section CS21

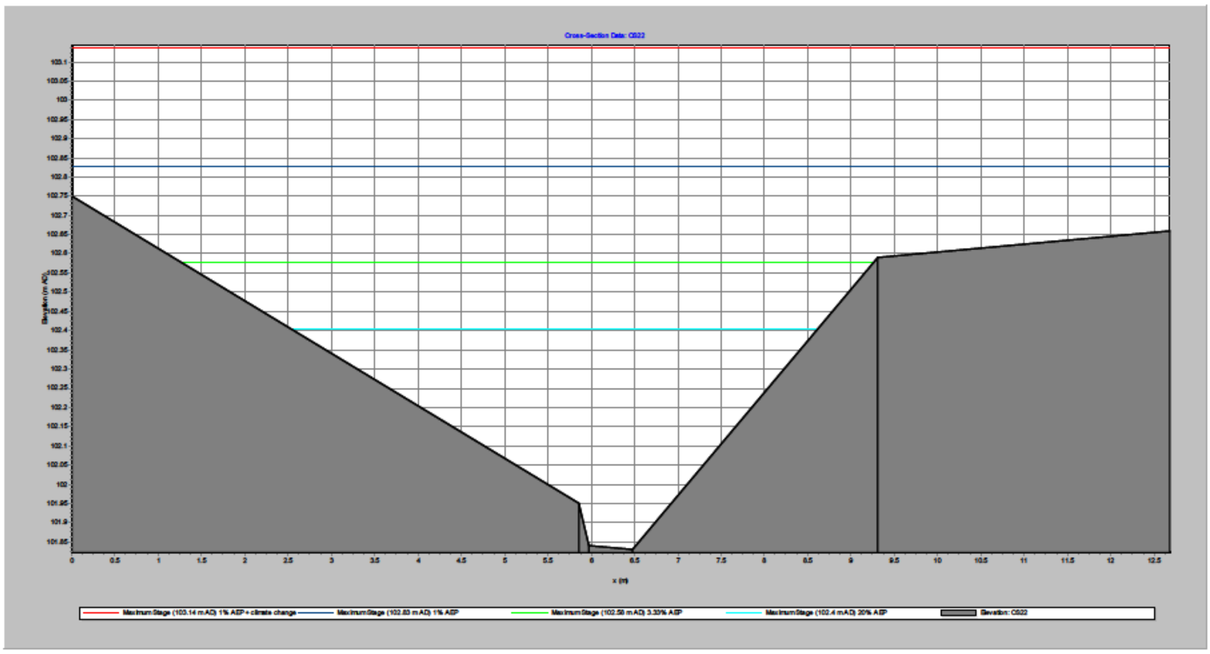

Figure E.20 Peak levels at cross section CS22

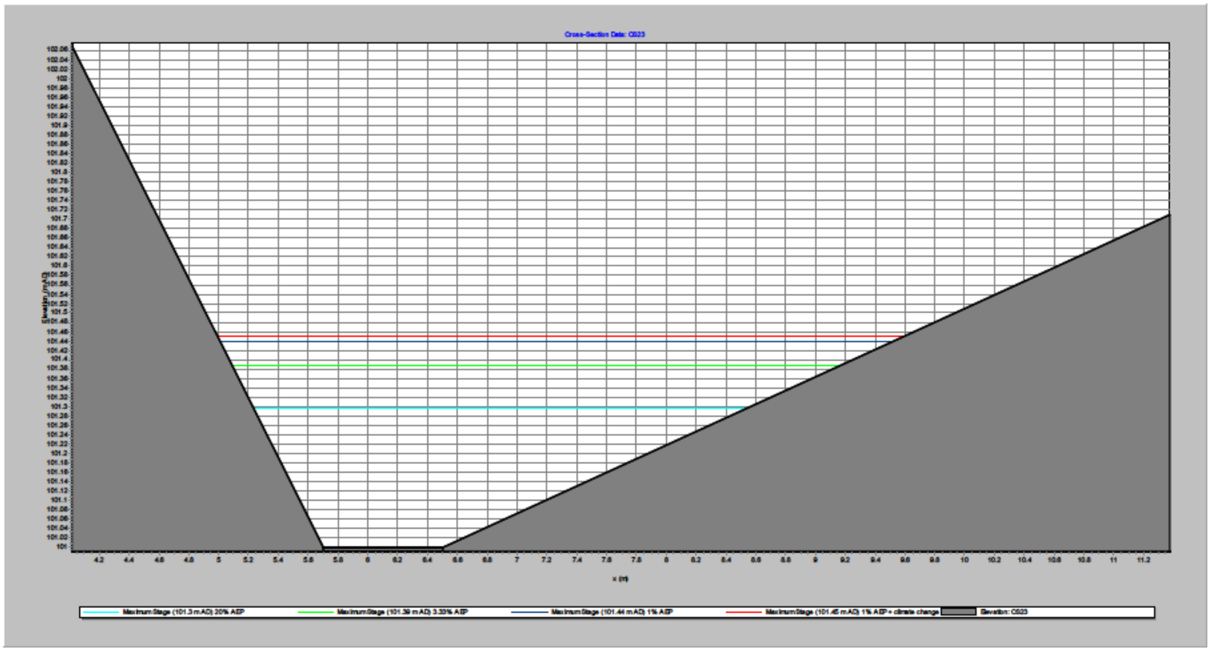

Figure E.21 Peak levels at cross section CS23

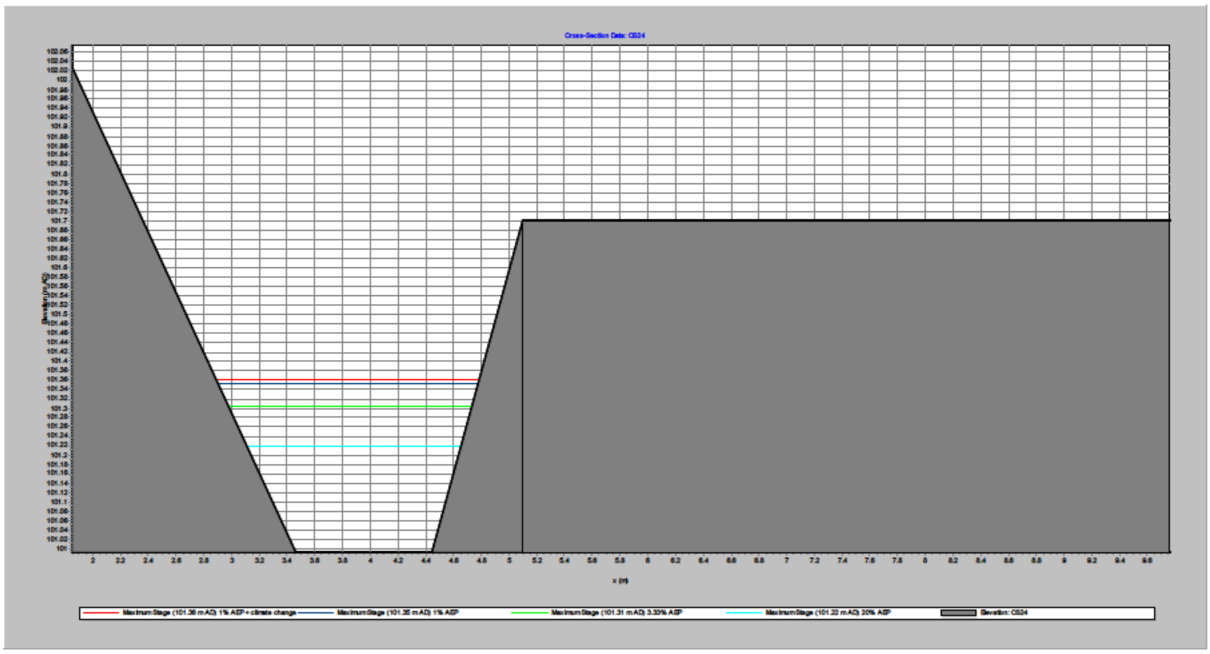

Figure E.22 Peak levels at cross section CS24

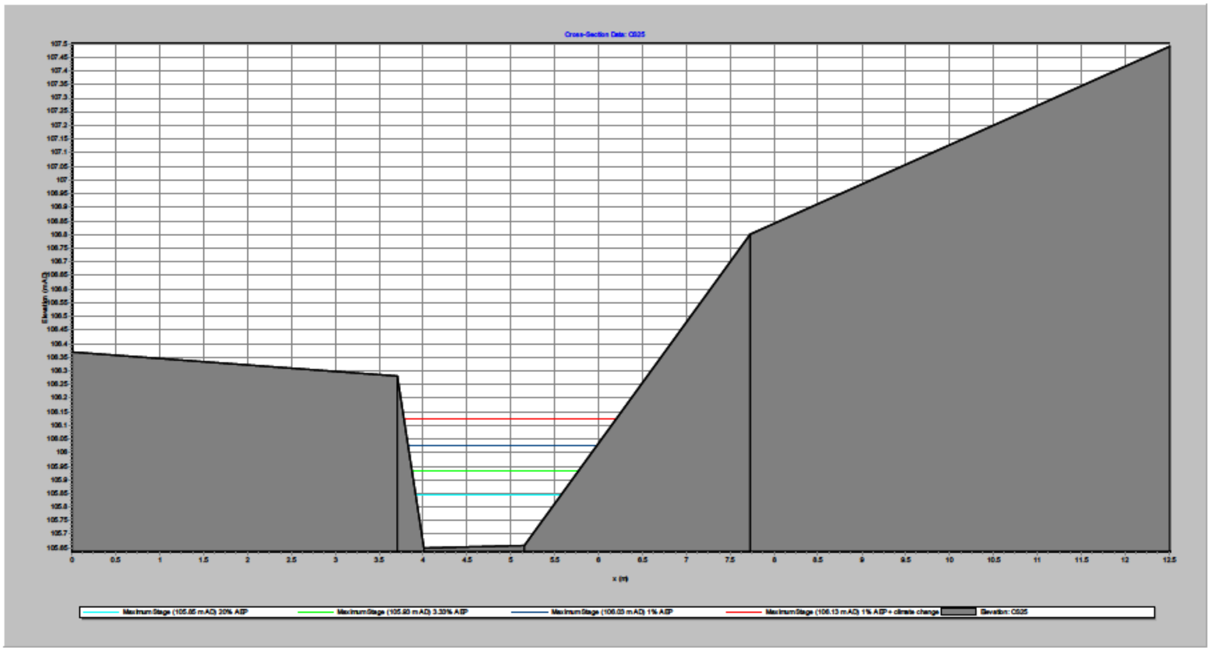

Figure E.23 Peak levels at cross section CS25

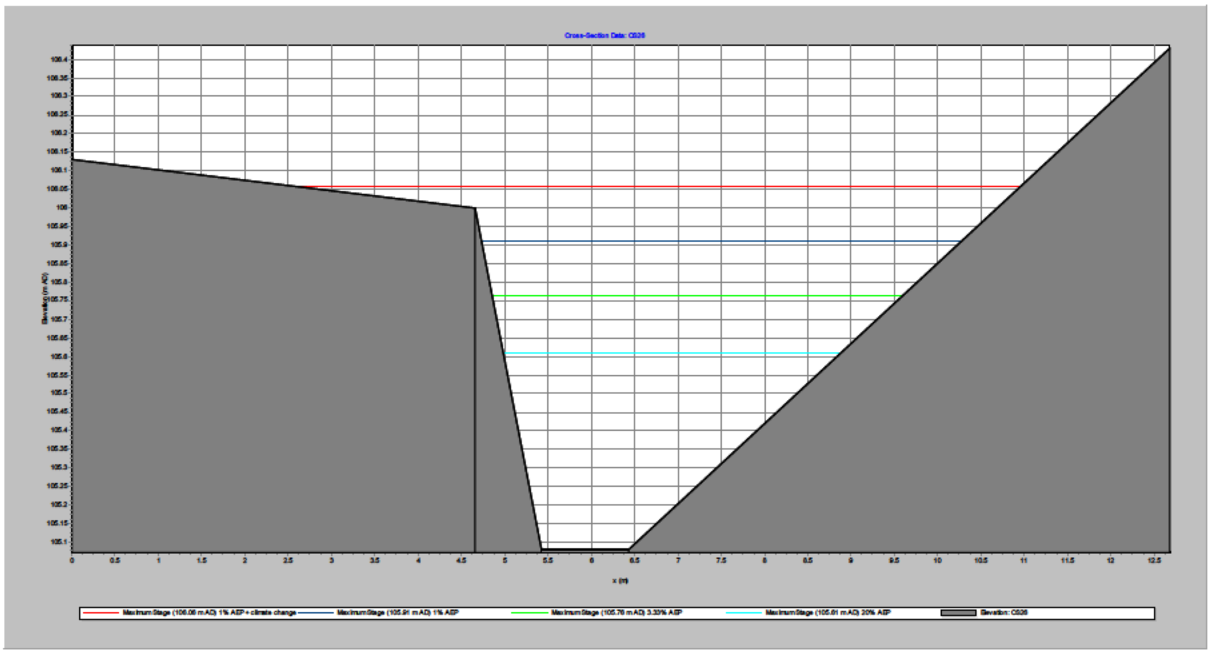

Figure E.24 Peak levels at cross section CS26

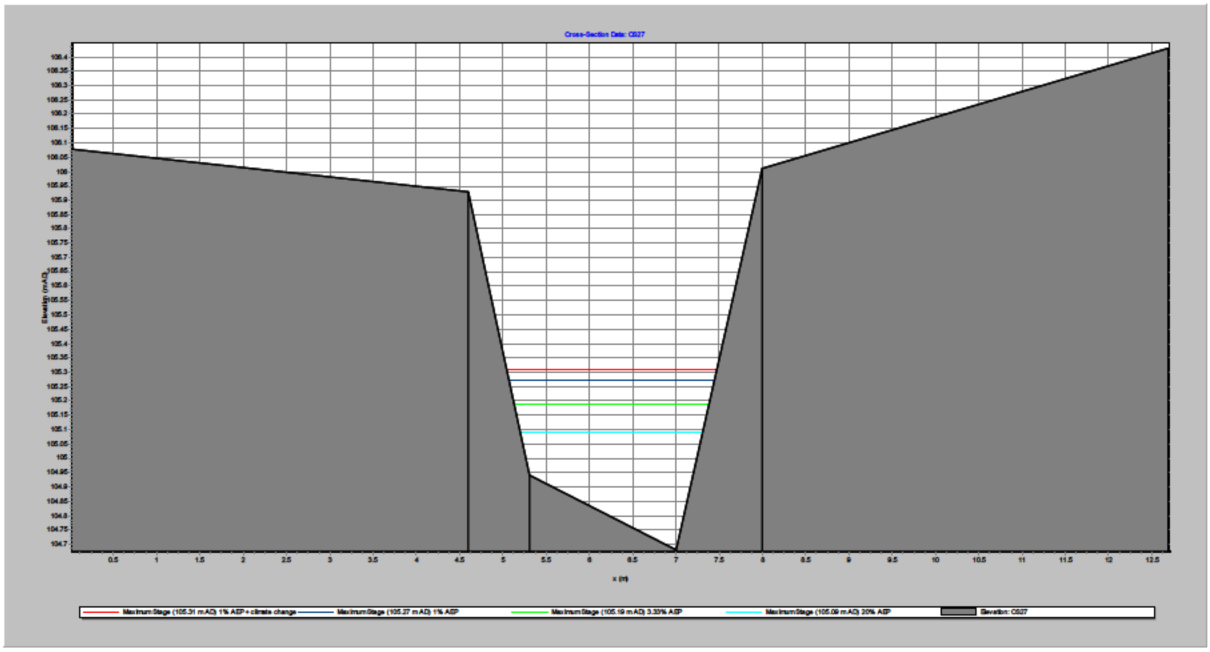

Figure E.25 Peak levels at cross section CS27

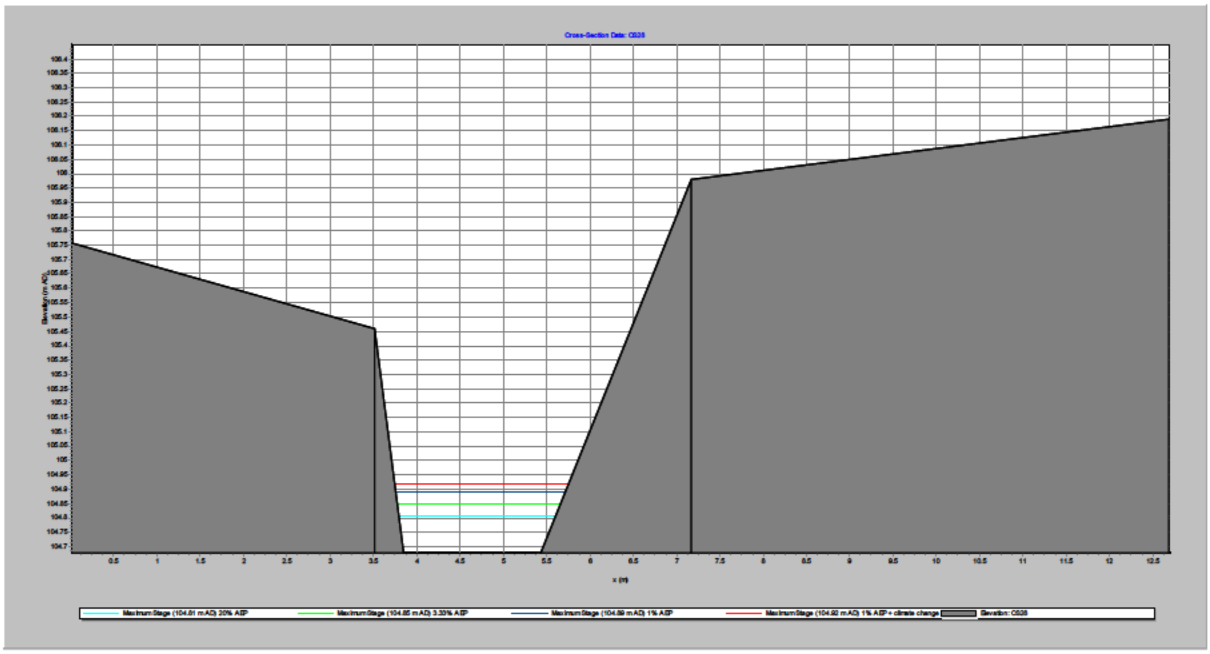

Figure E.26 Peak levels at cross section CS28

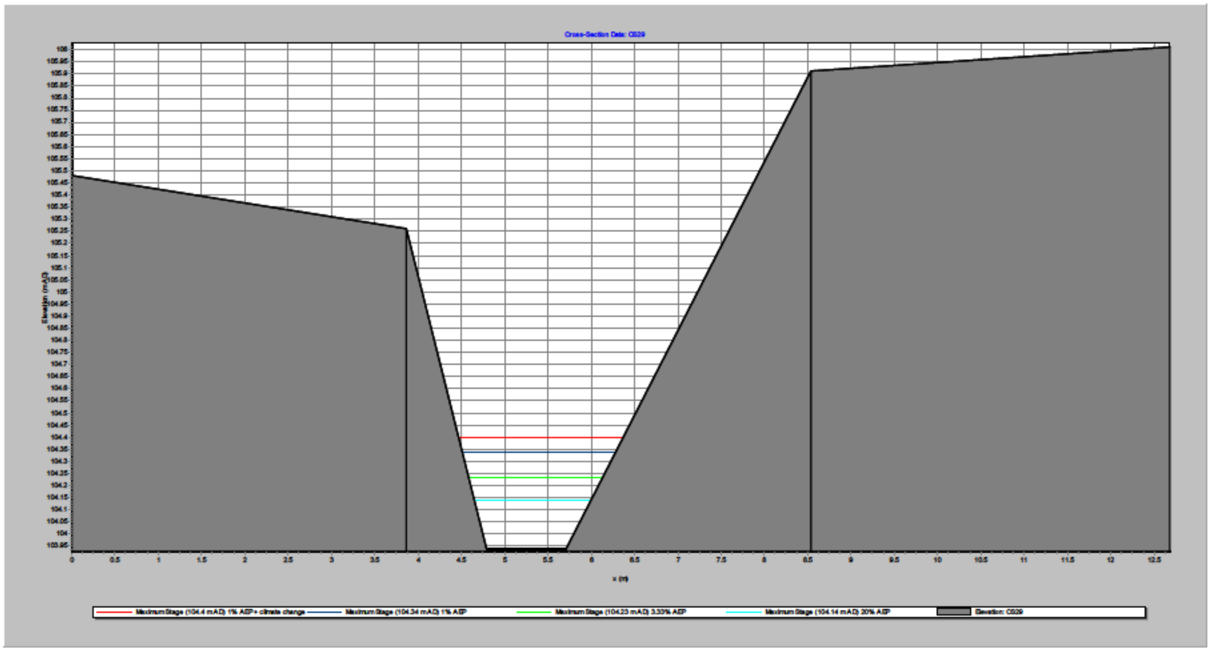

Figure E.27 Peak levels at cross section CS29

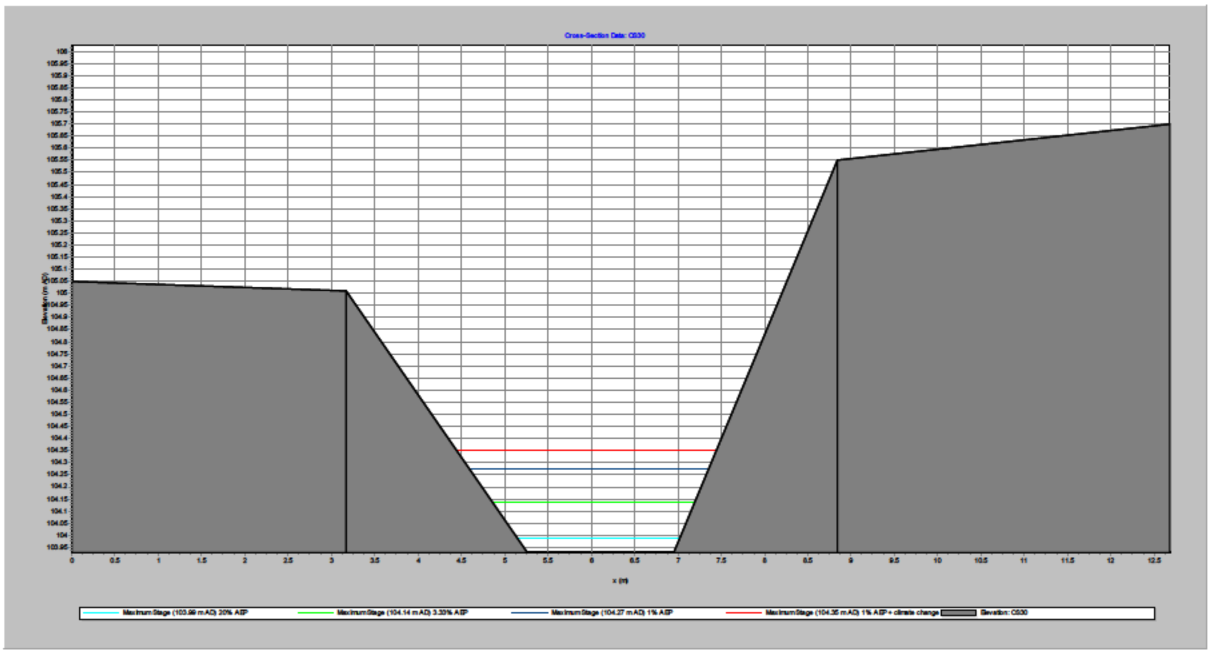

Figure E.28 Peak levels at cross section CS30

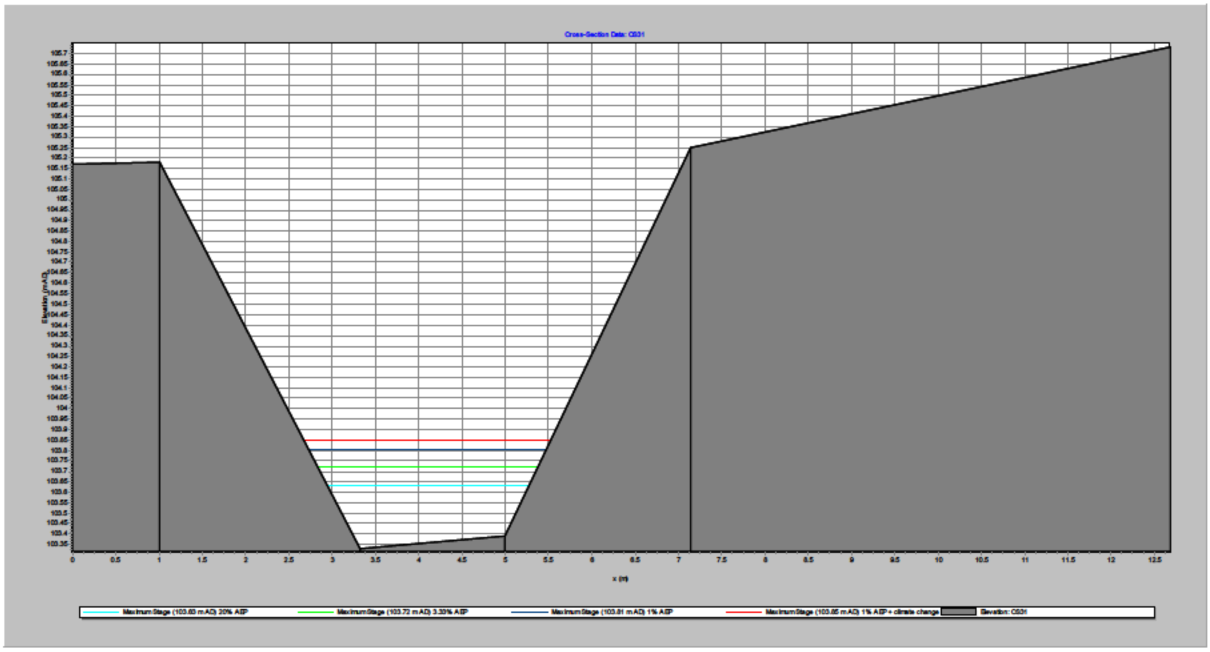

Figure E.29 Peak levels at cross section CS31

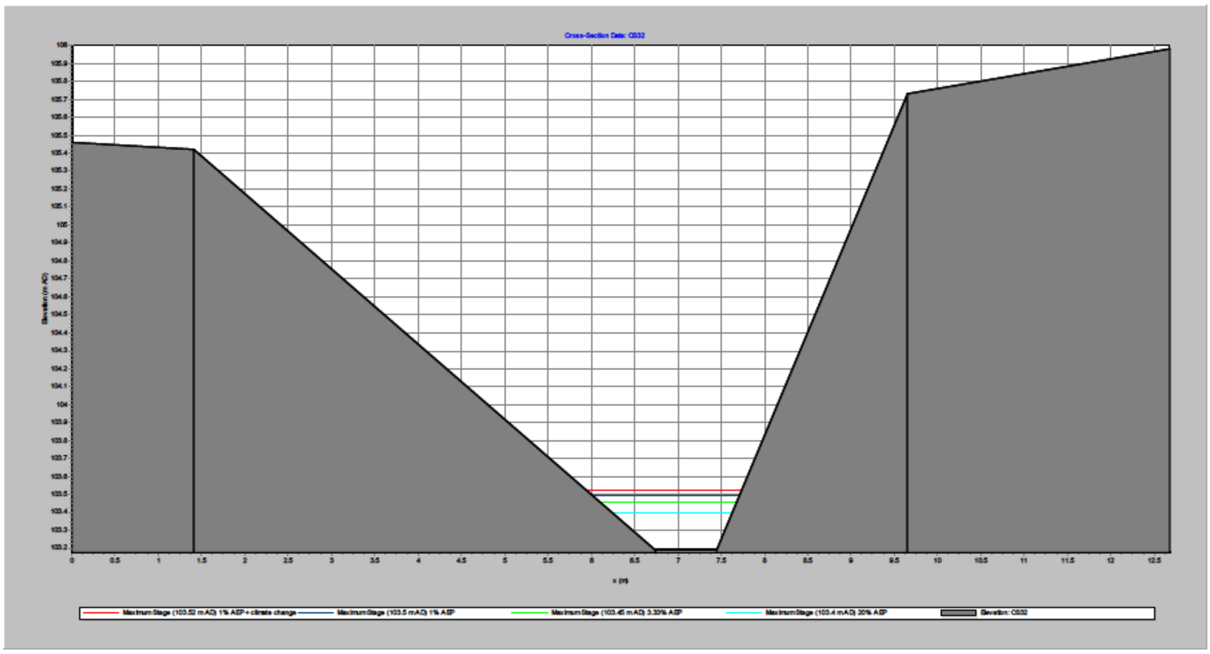

Figure E.30 Peak levels at cross section CS32

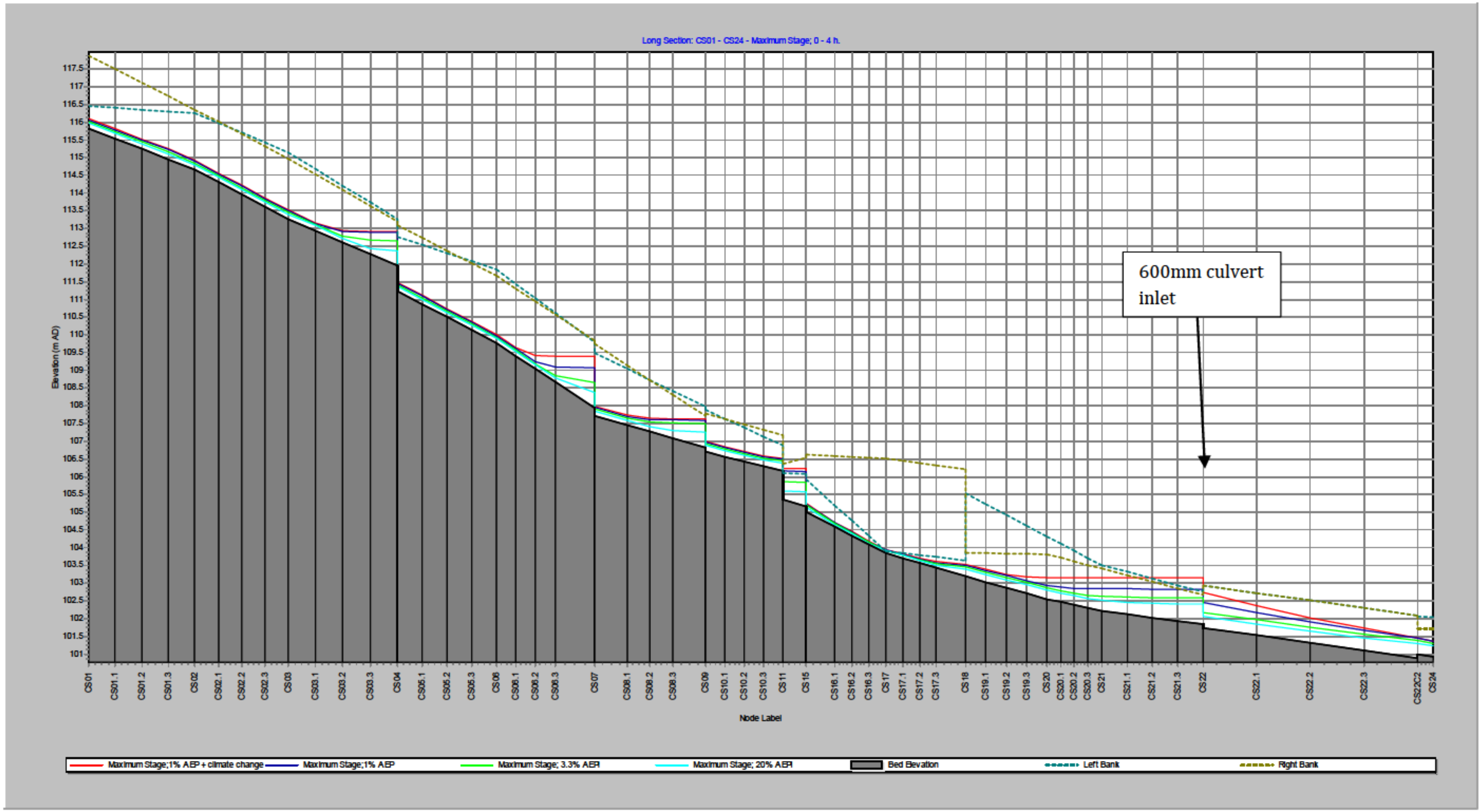

Figure E.15 Long section CS01 to CS24

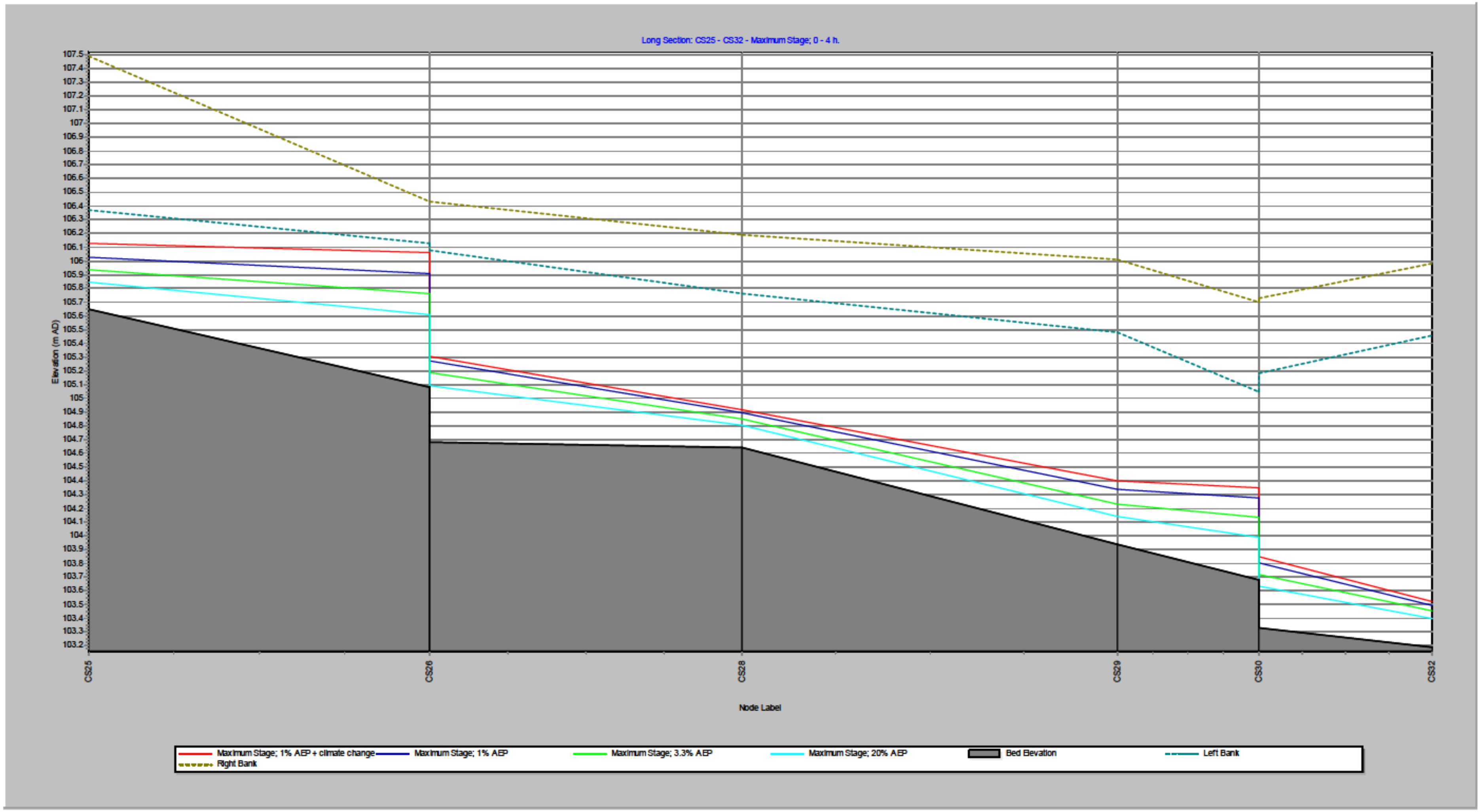

Figure E.15 Long section CS25 to CS32

APPENDIX F: ISIS OUTPUTS: PROPOSED SCENARIO SCHEMATIC, LONG-SECTION AND CROSS-SECTIONS

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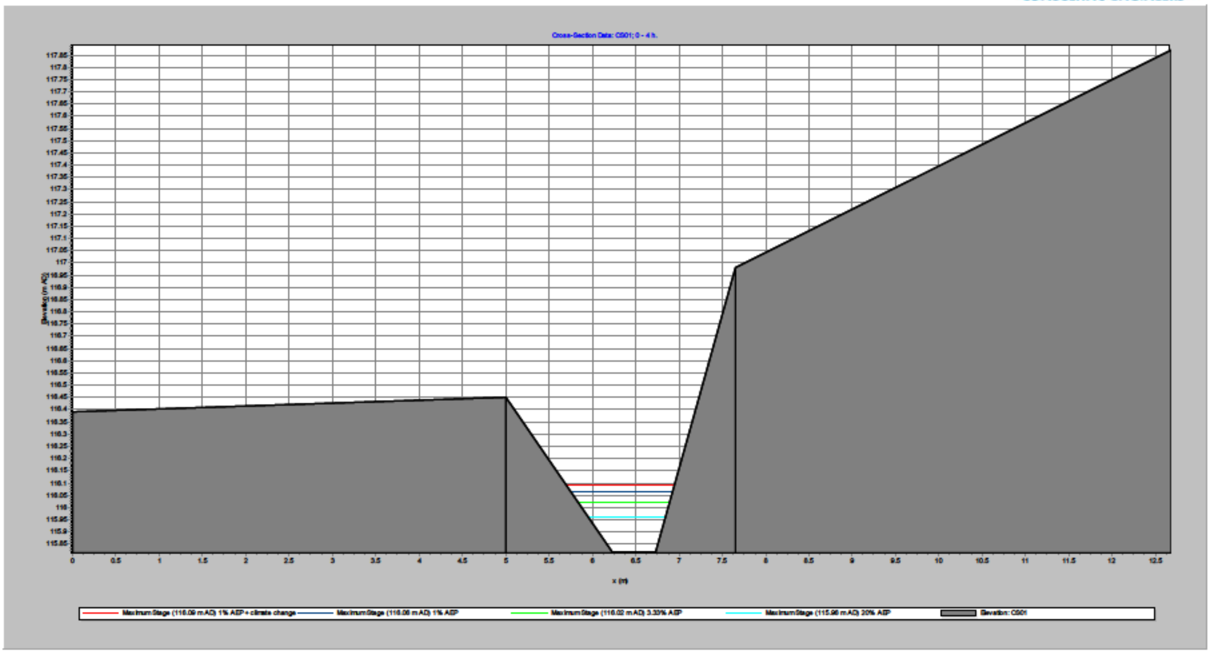

Figure F.1 Peak levels at cross section CS01

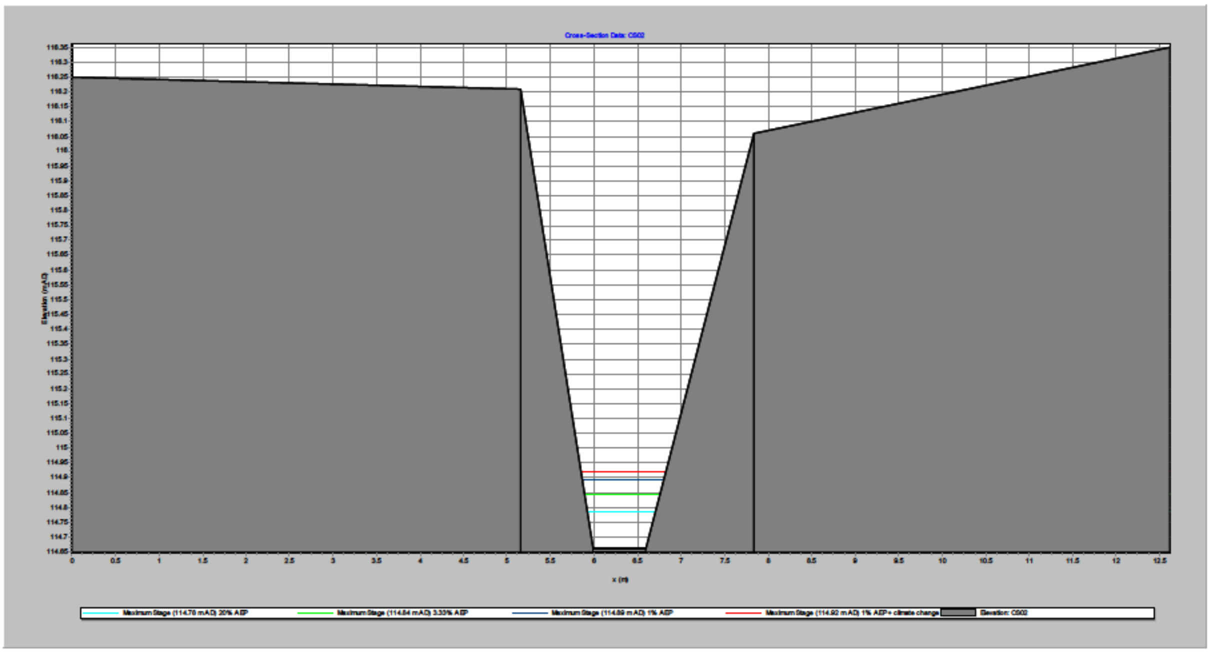

Figure F.2 Peak levels at cross section CS02

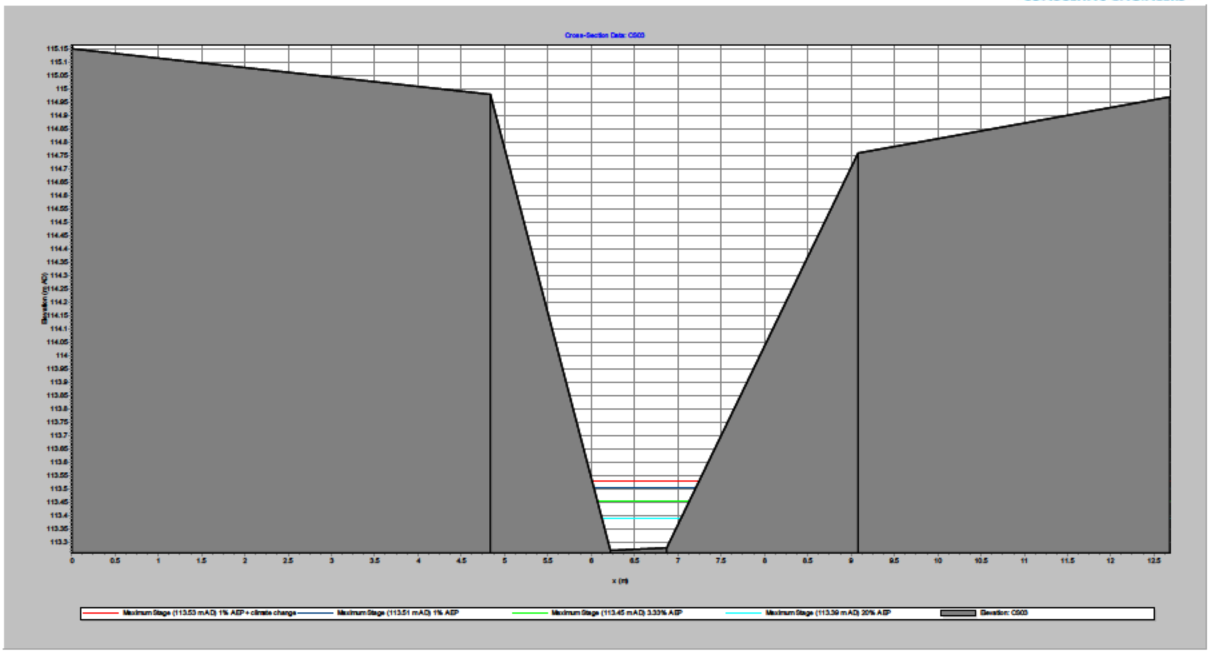

Figure F.3 Peak levels at cross section CS03

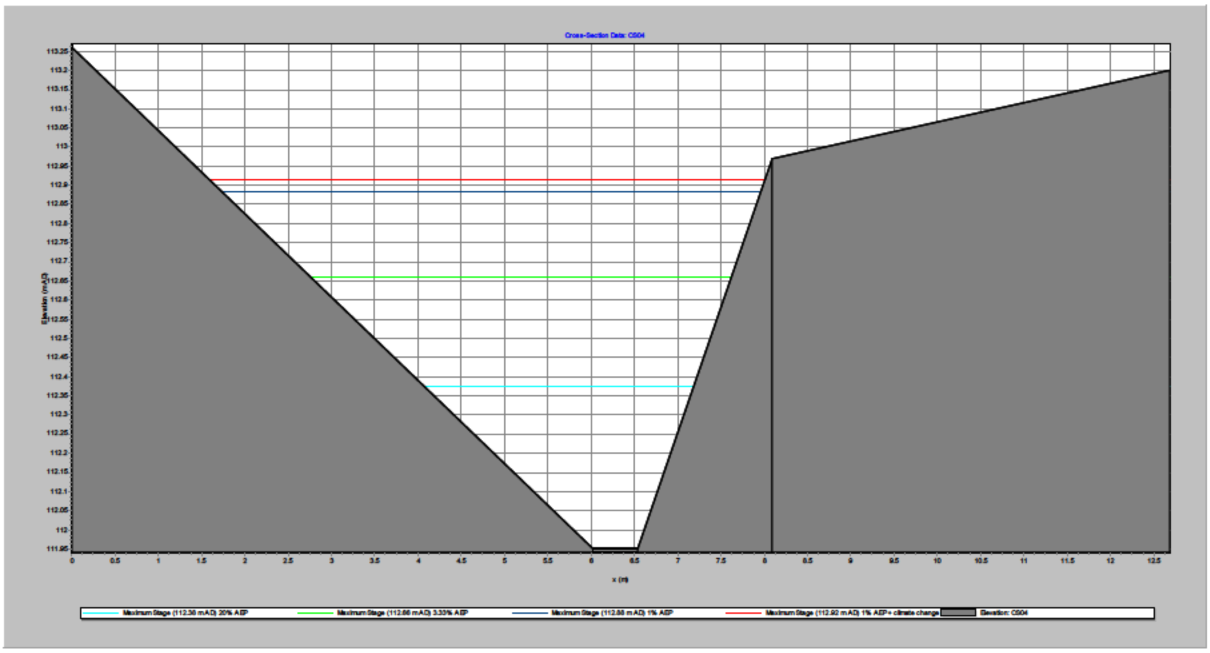

Figure F.4 Peak levels at cross section CS04

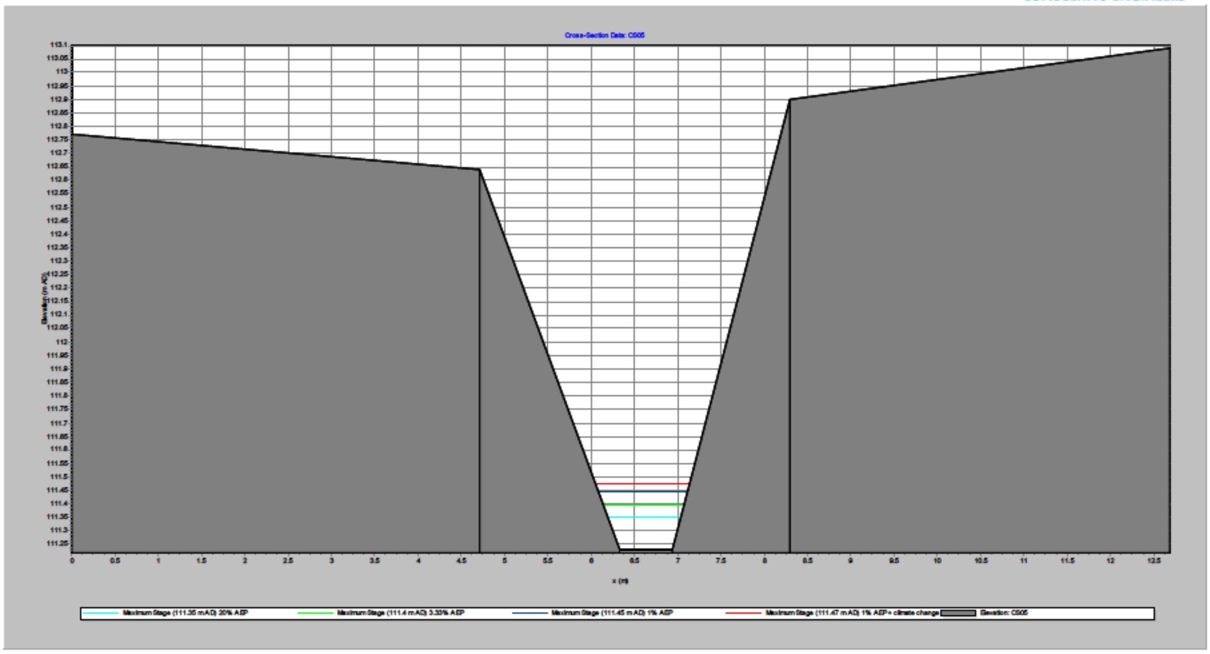

Figure F.5 Peak levels at cross section CS05

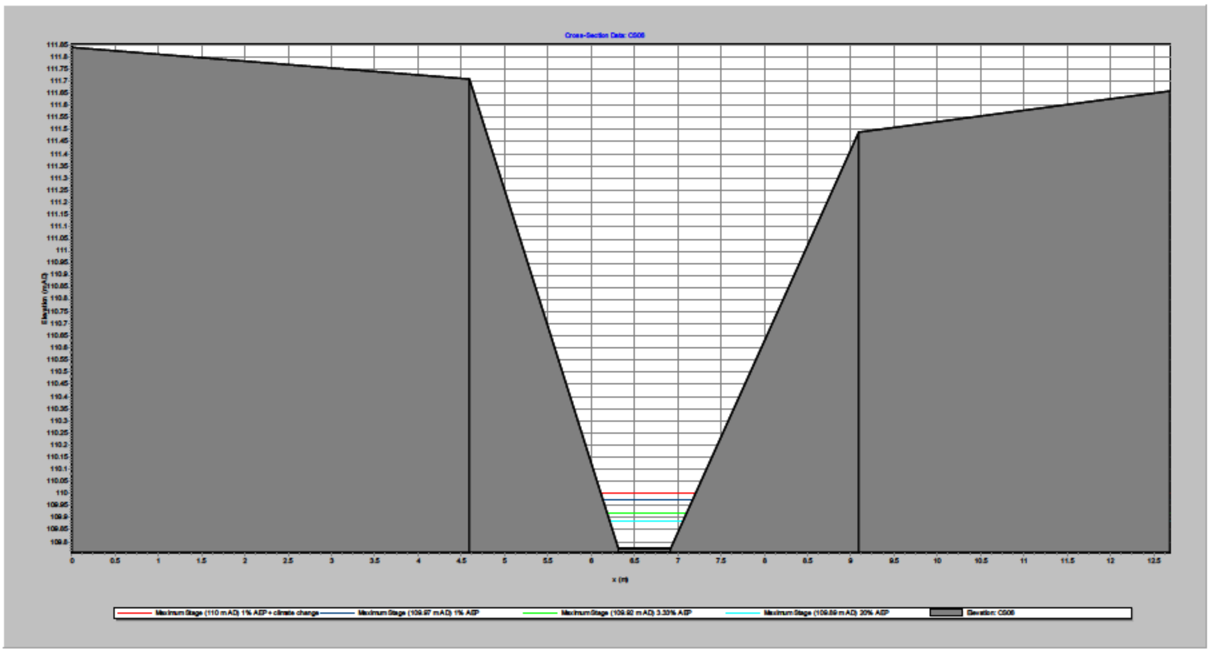

Figure F.6 Peak levels at cross section CS06

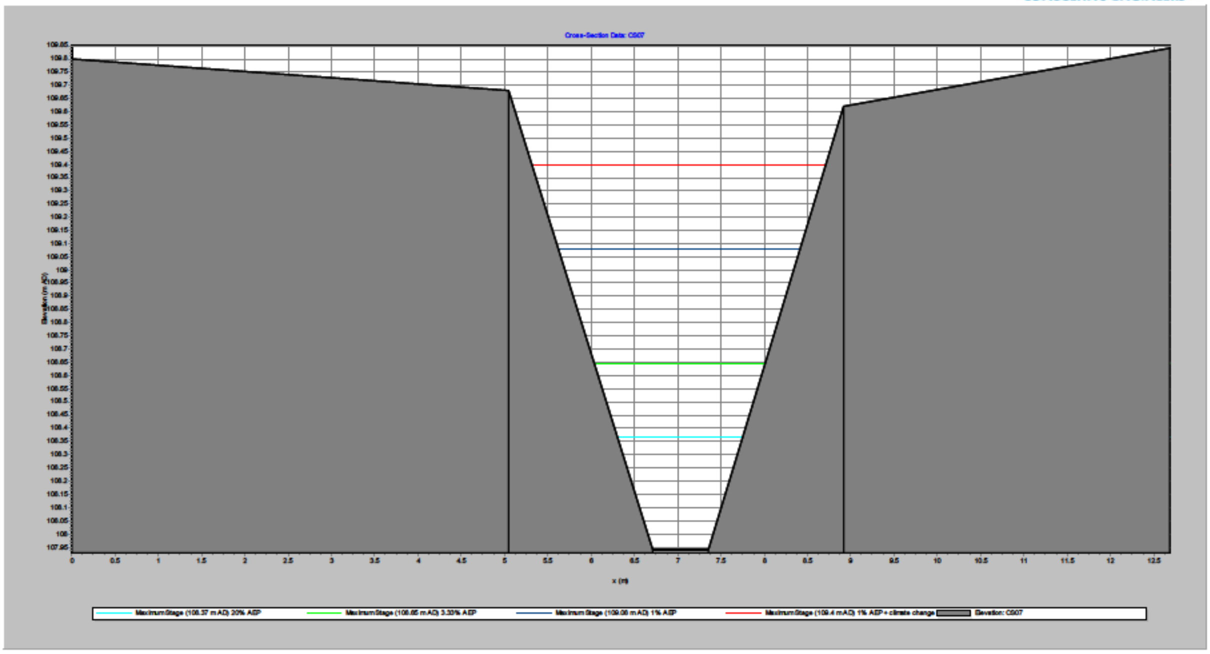

Figure F.7 Peak levels at cross section CS07

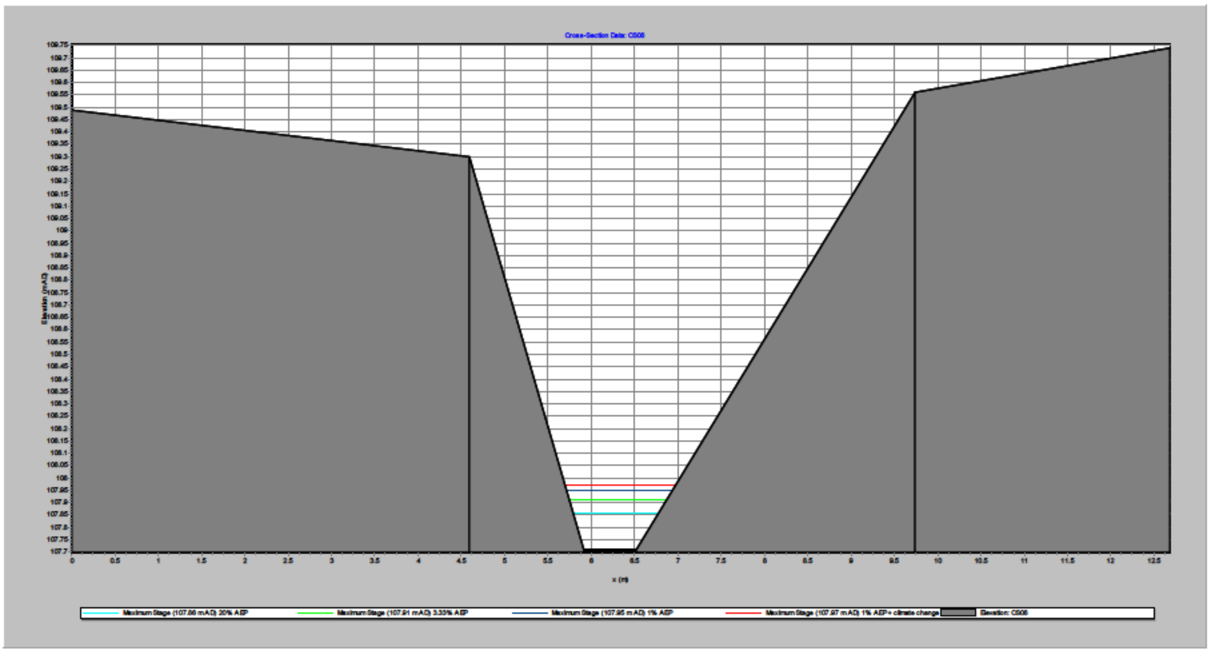

Figure F.8 Peak levels at cross section CS08

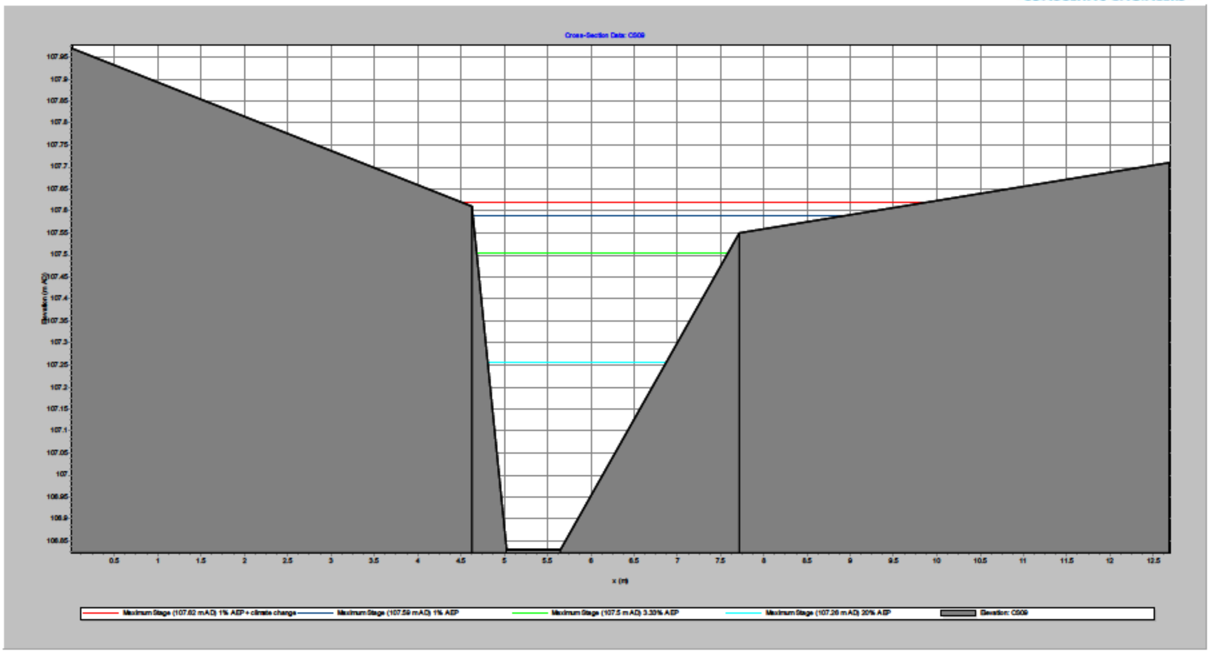

Figure F.9 Peak levels at cross section CS09

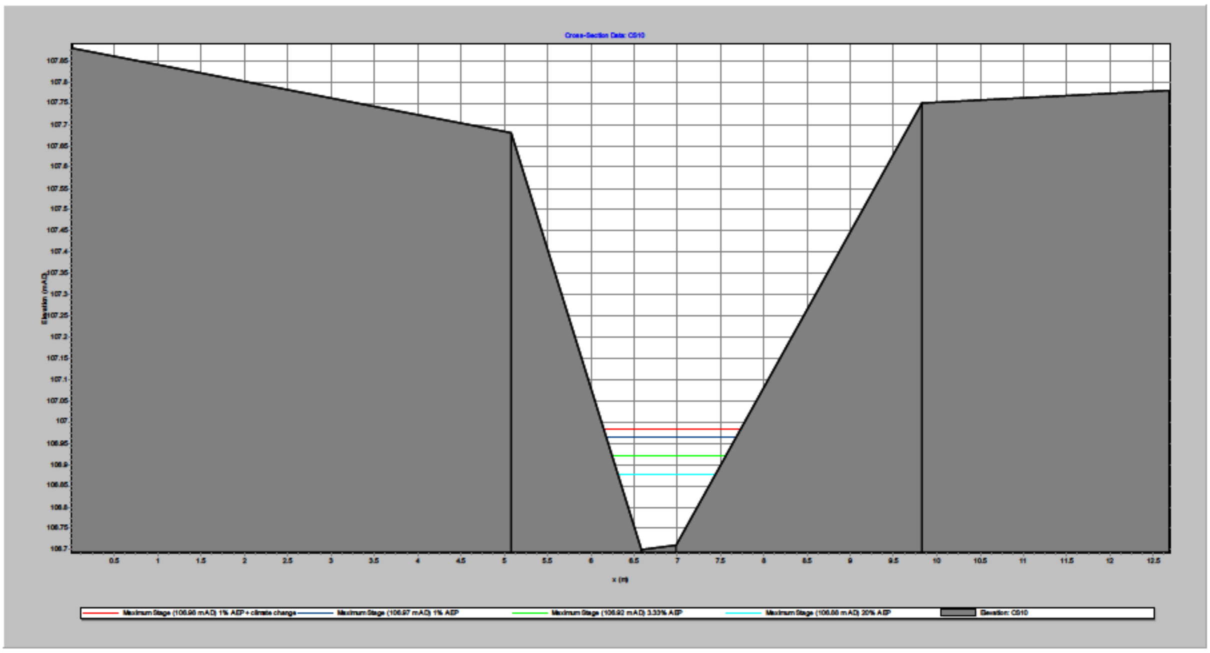

Figure F.10 Peak levels at cross section CS101

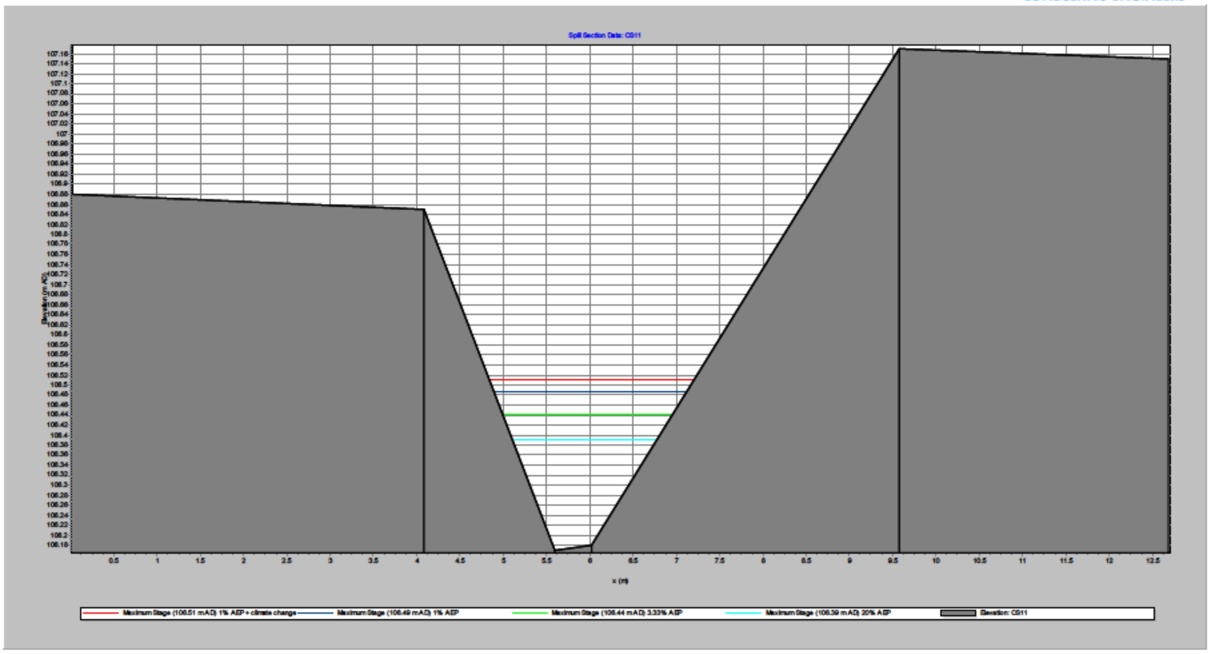

Figure F.11 Peak levels at cross section CS11

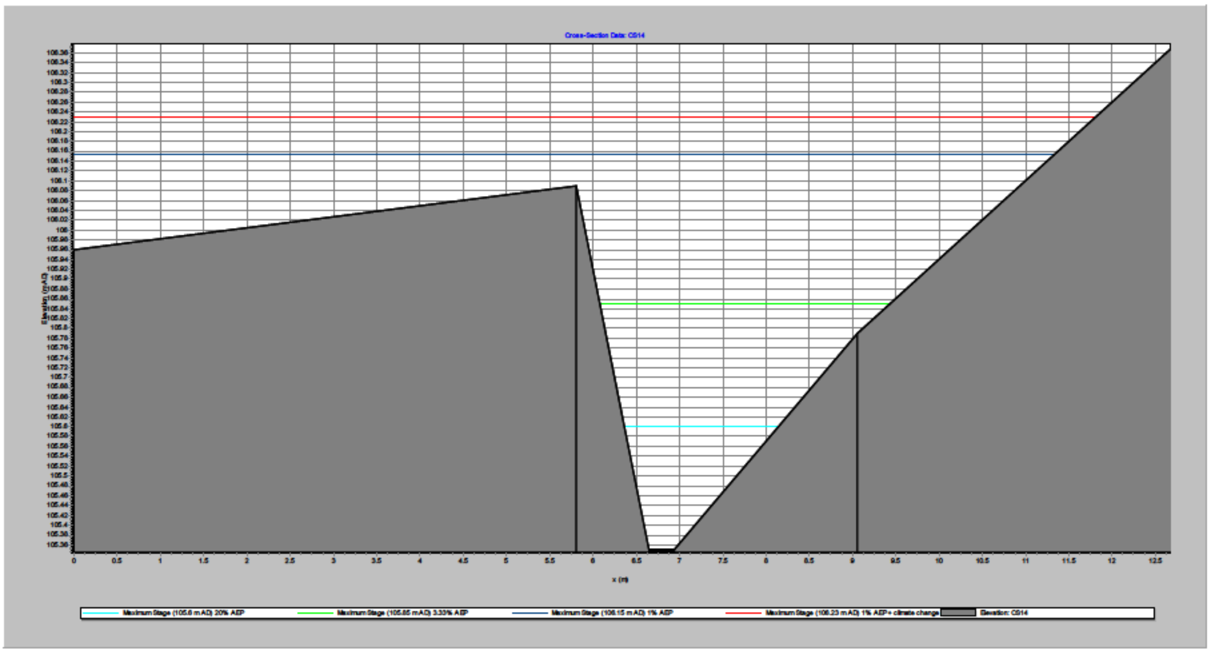

Figure F.12 Peak levels at cross section CS14

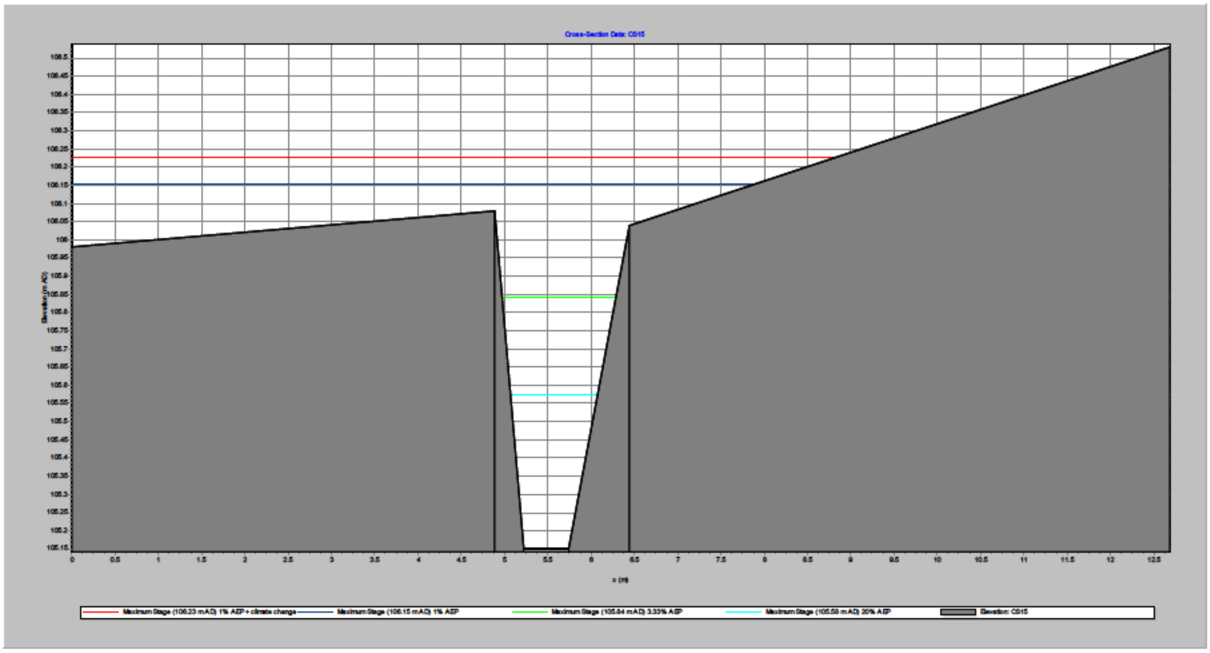

Figure F.13 Peak levels at cross section CS15

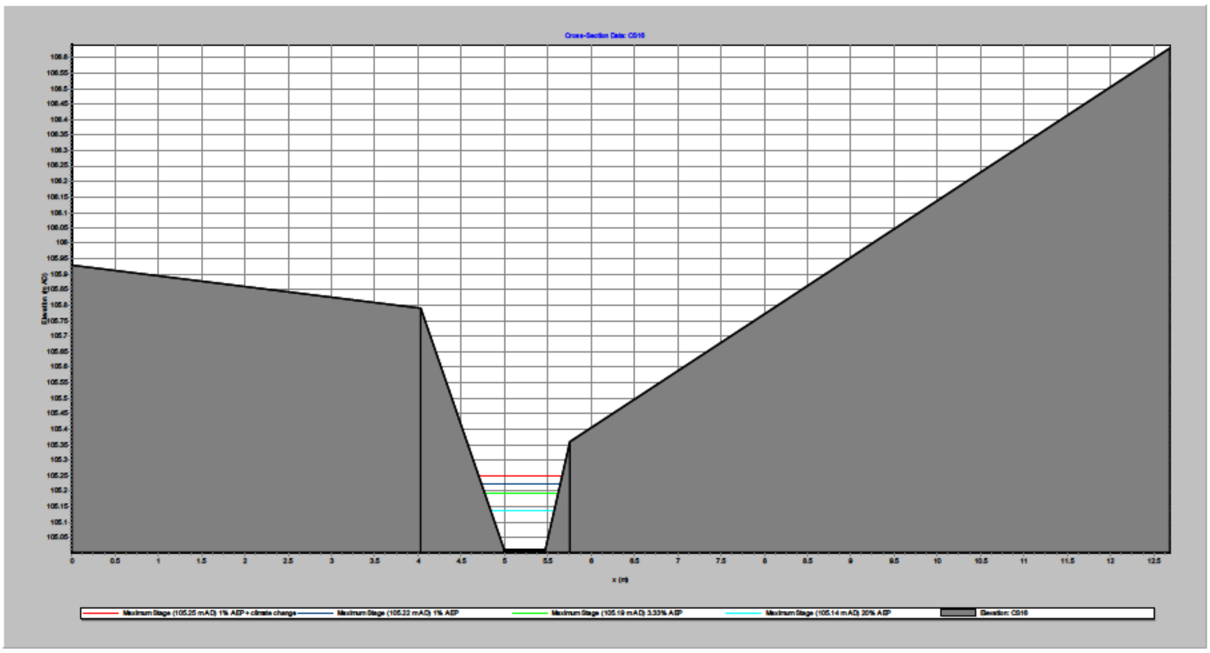

Figure F.14 Peak levels at cross section CS16

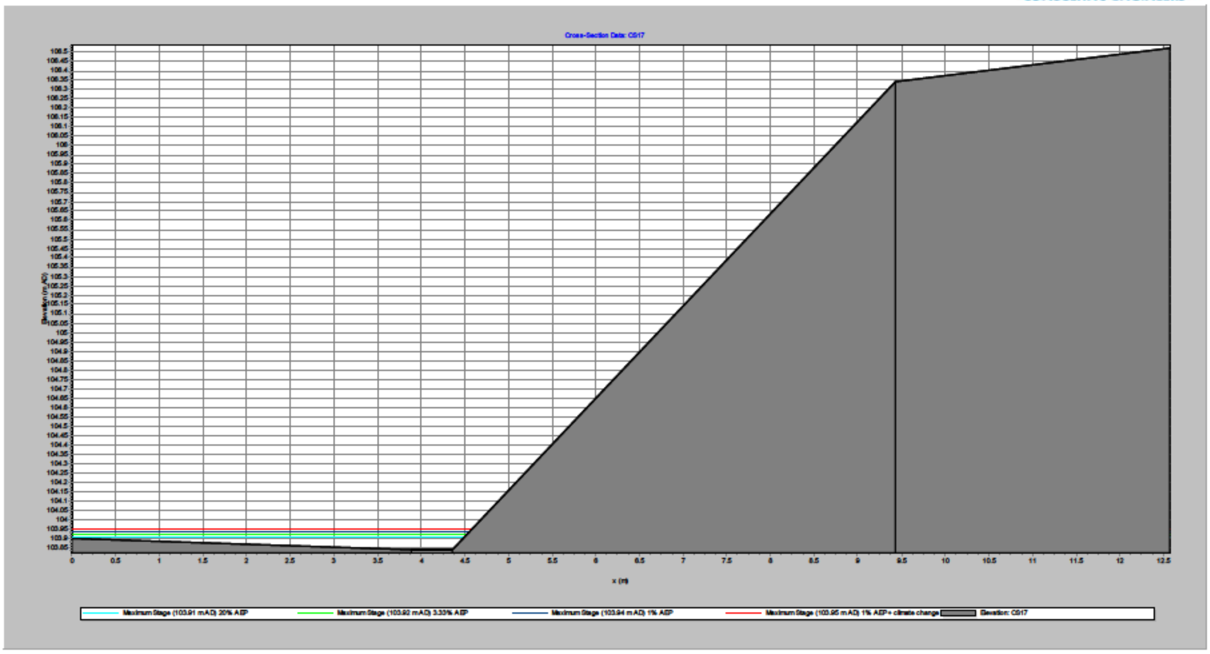

Figure F.15 Peak levels at cross section CS17

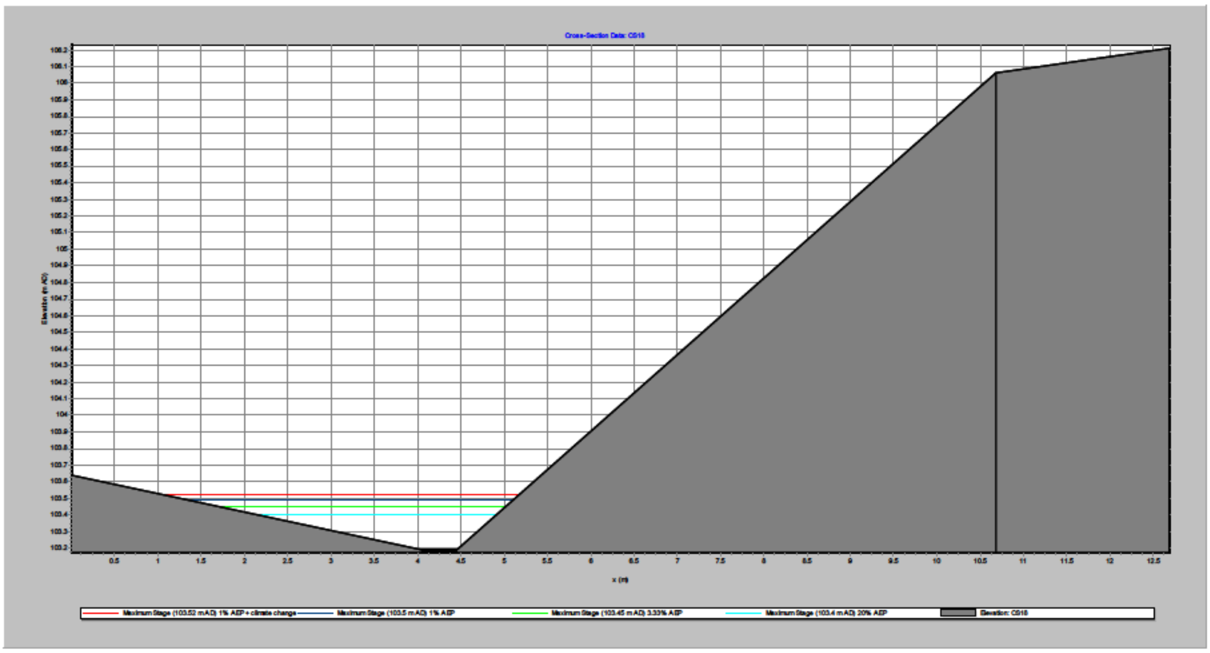

Figure F.16 Peak levels at cross section CS18

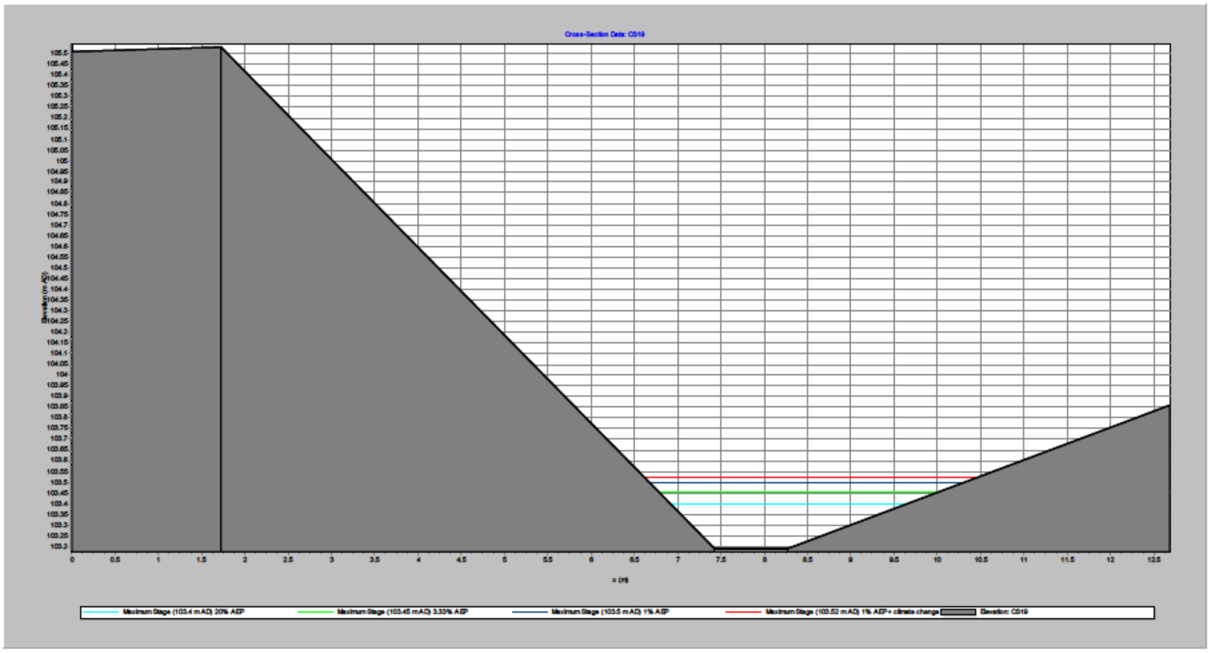

Figure F.17 Peak levels at cross section CS19

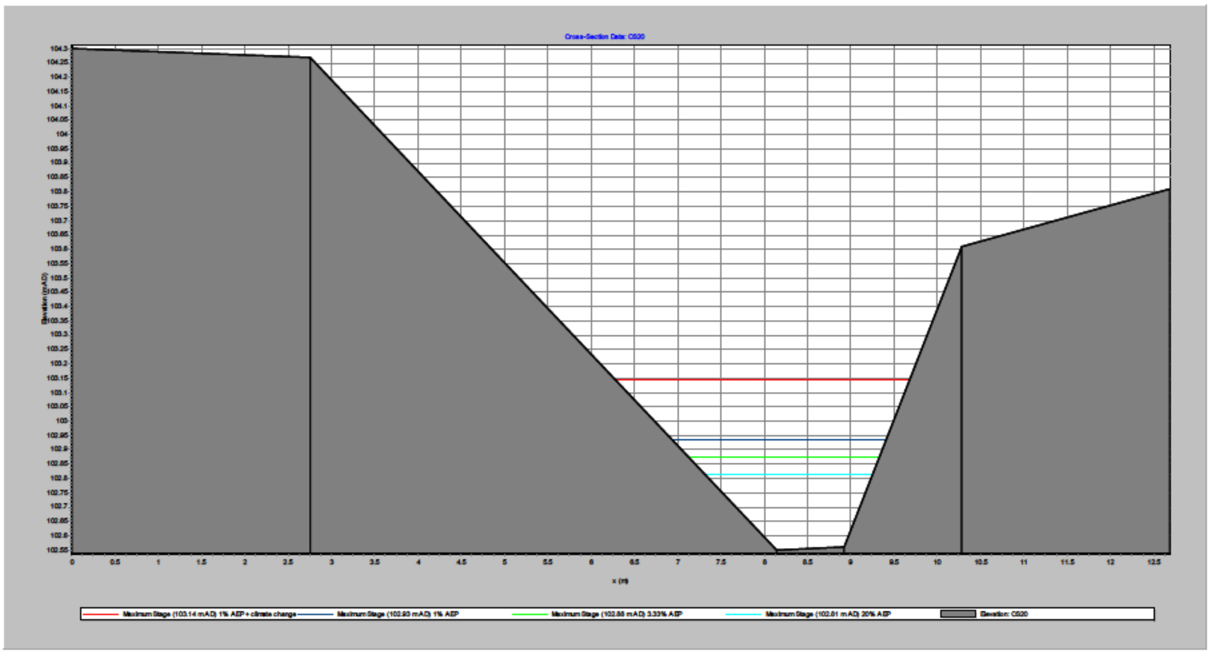

Figure F.18 Peak levels at cross section CS20

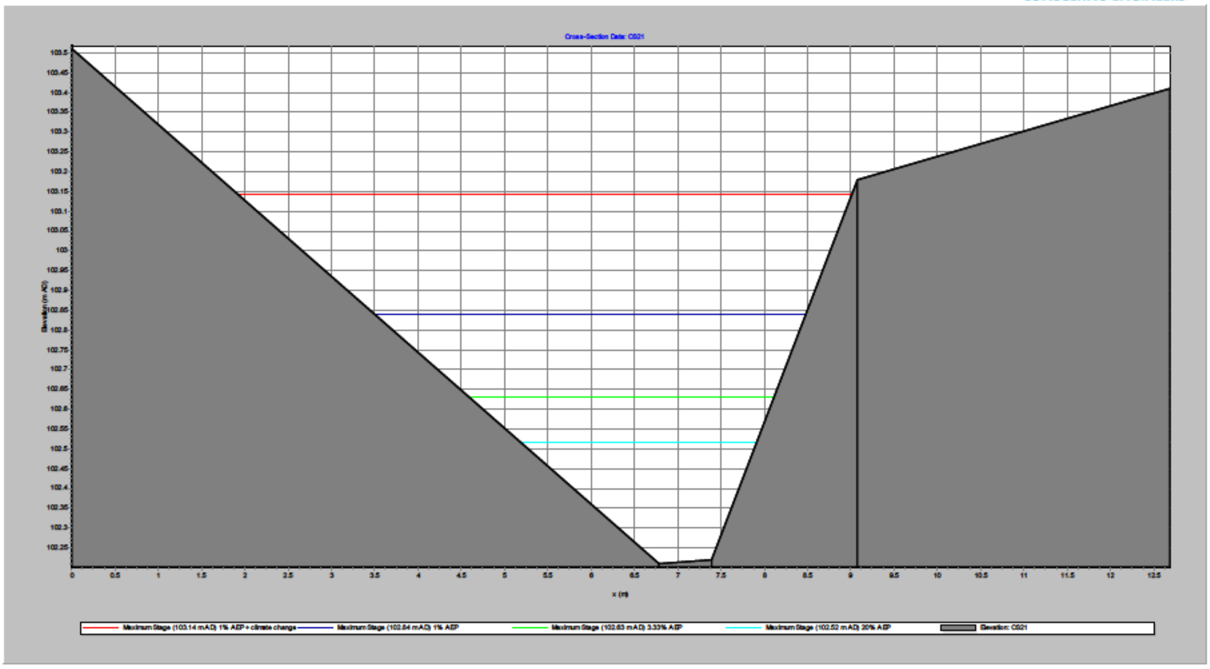

Figure F.19 Peak levels at cross section CS21

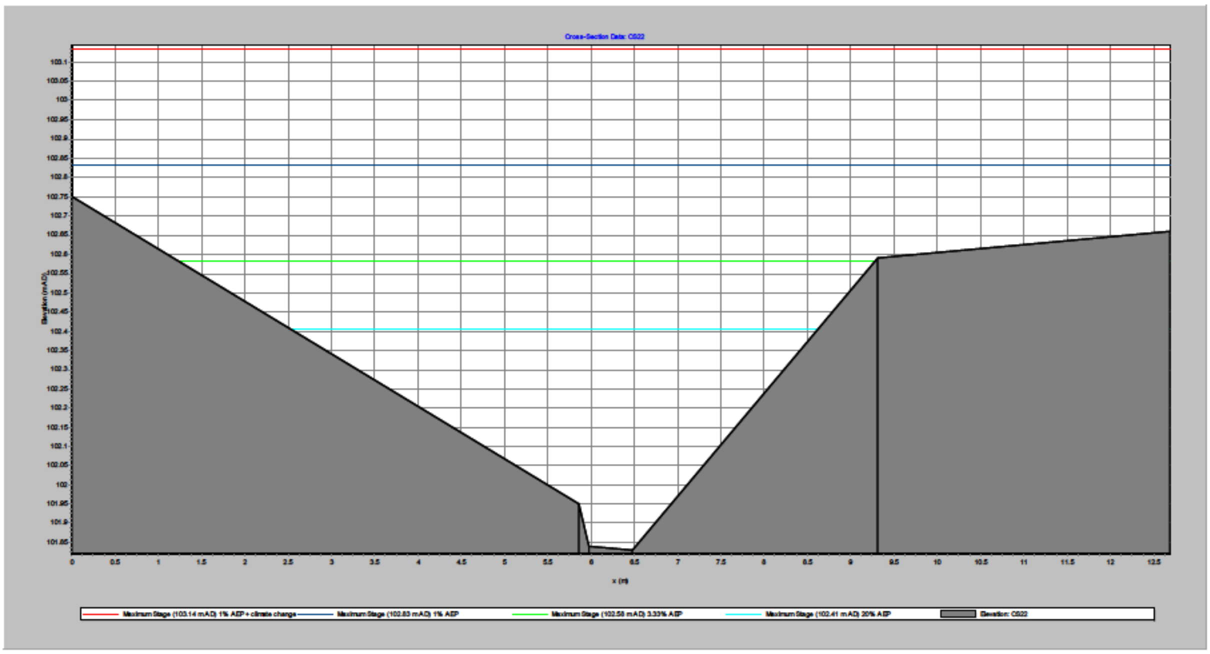

Figure F.20 Peak levels at cross section CS22

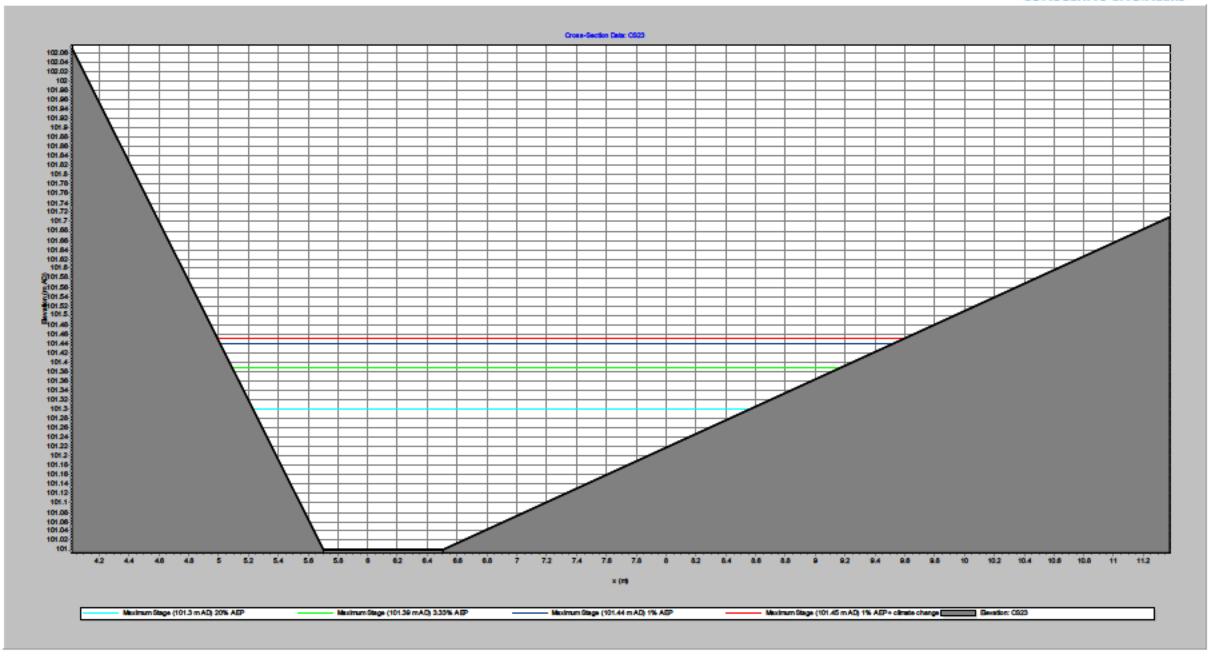

Figure F.21 Peak levels at cross section CS23

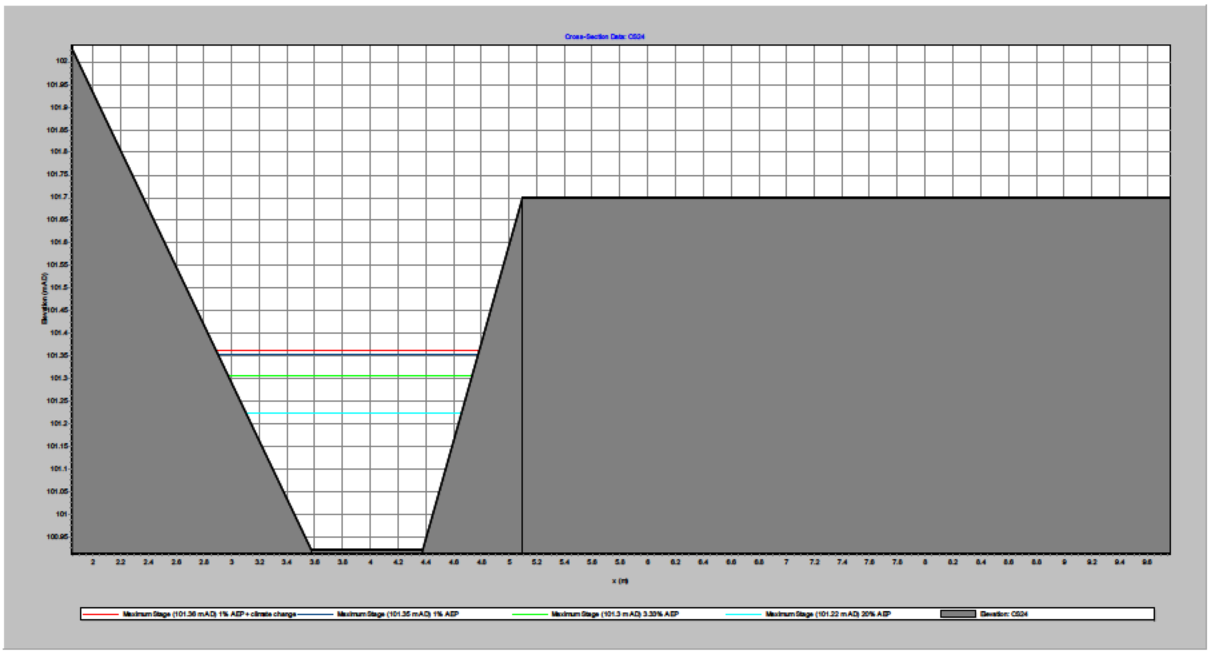

Figure F.22 Peak levels at cross section CS24

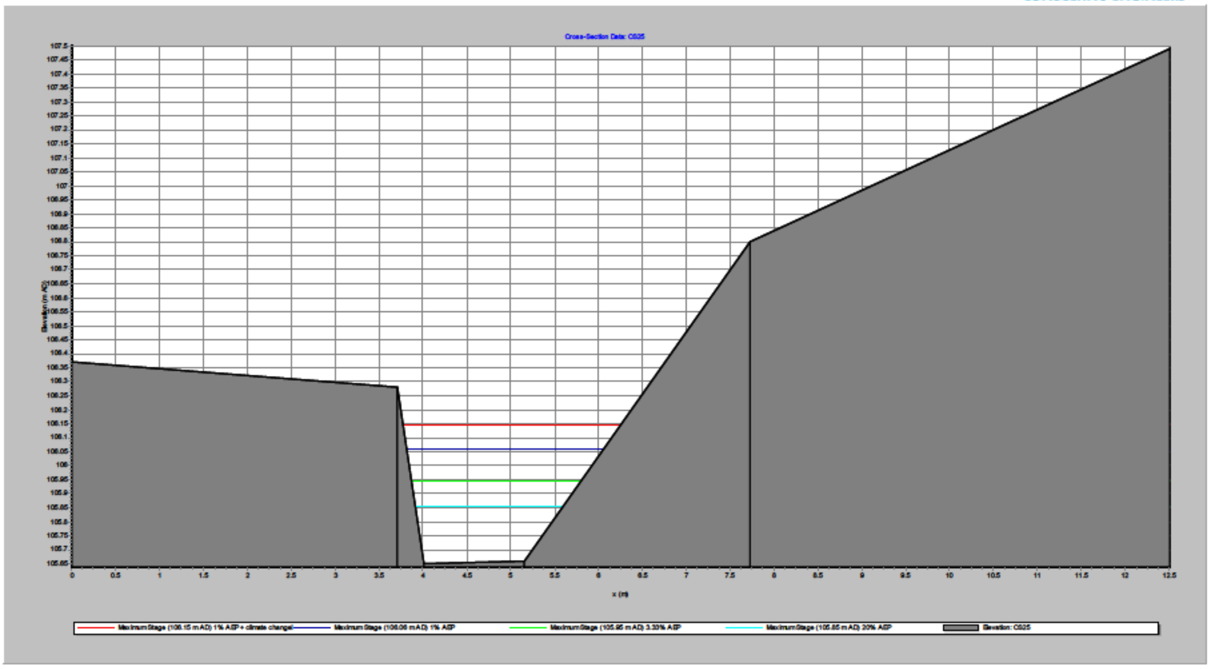

Figure F.23 Peak levels at cross section CS25

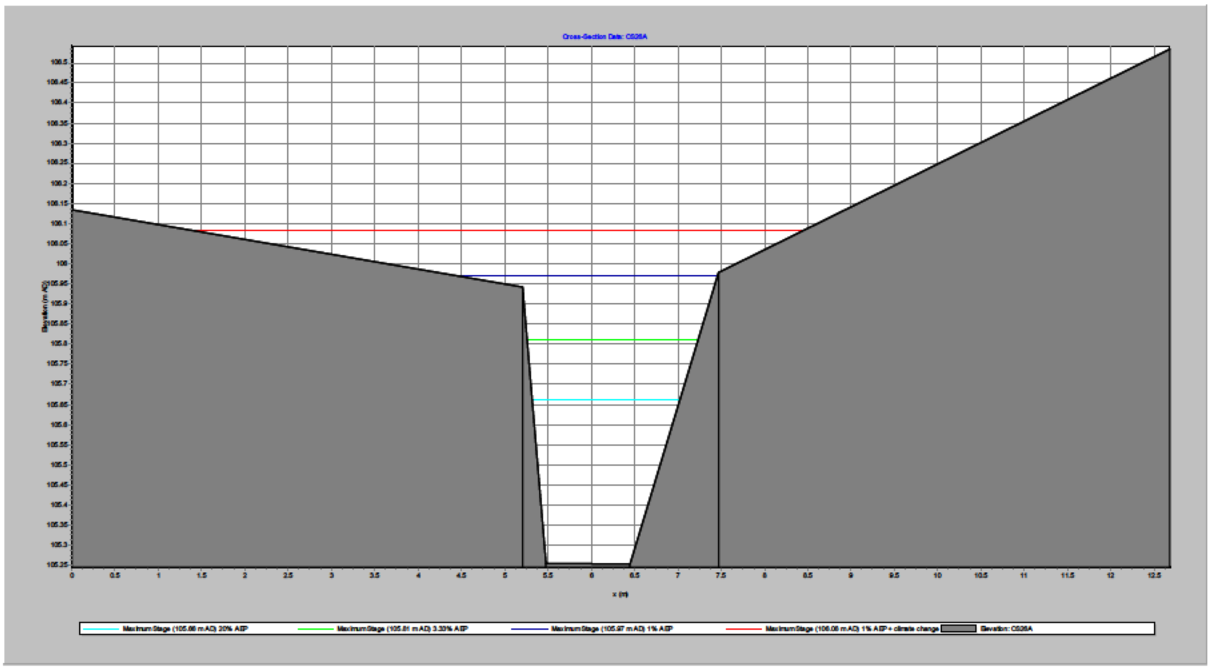

Figure F.24 Peak levels at cross section CS26

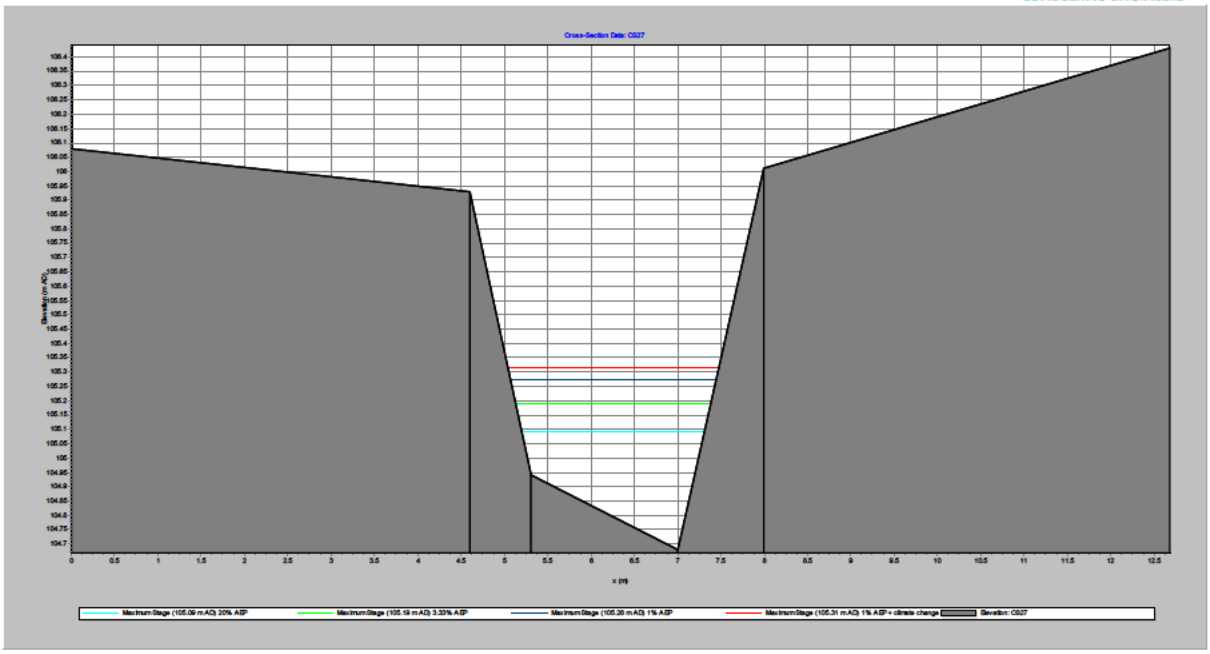

Figure F.25 Peak levels at cross section CS27

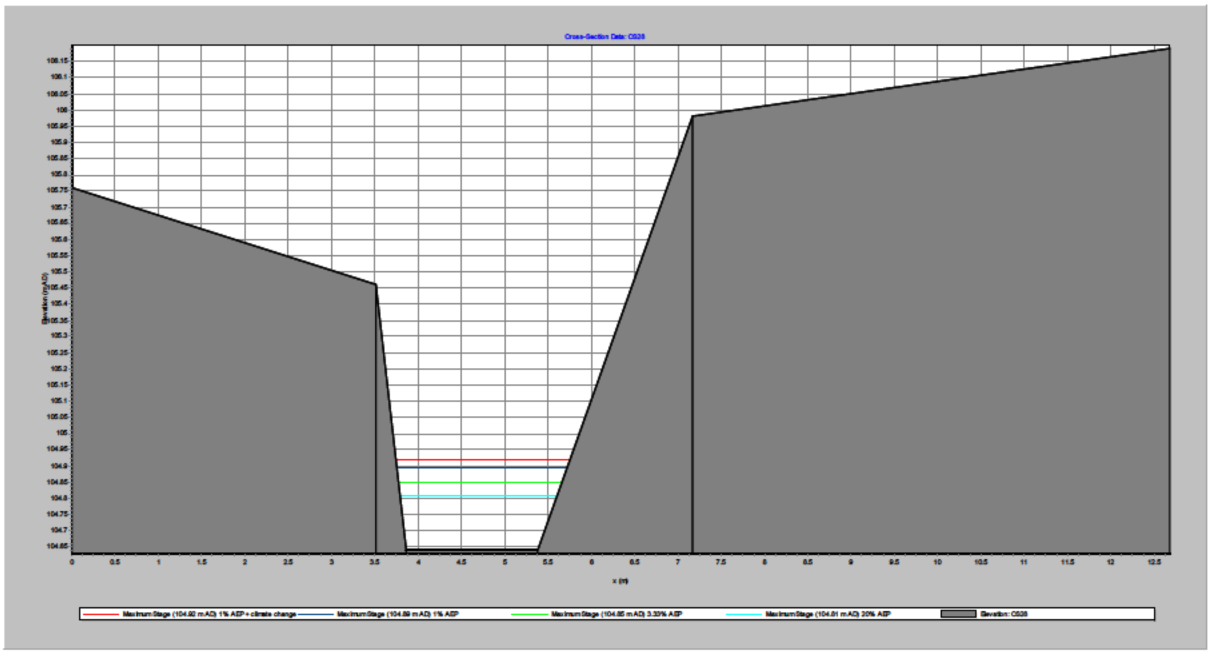

Figure F.26 Peak levels at cross section CS28

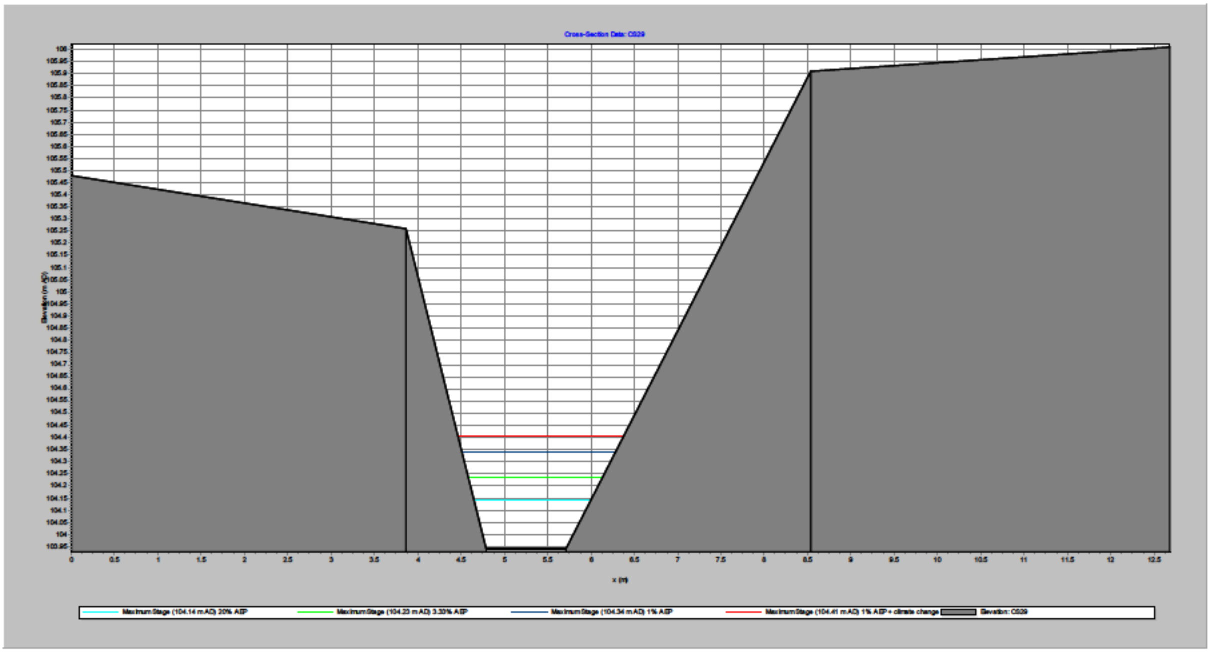

Figure F.27 Peak levels at cross section CS29

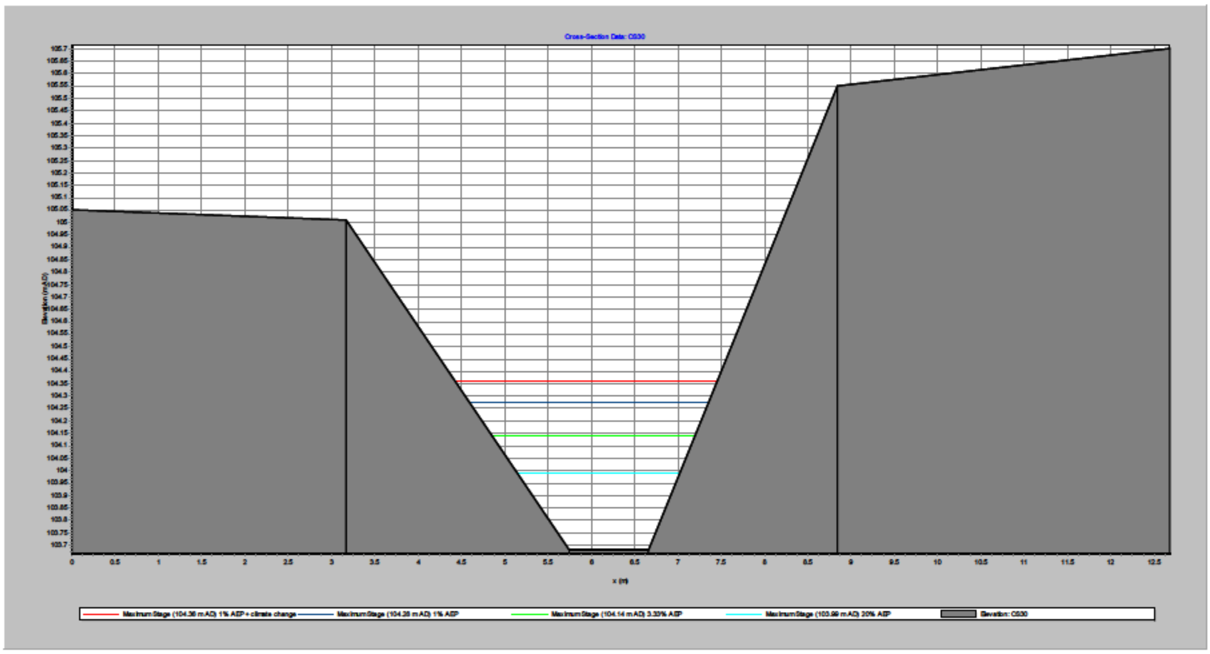

Figure F.28 Peak levels at cross section CS30

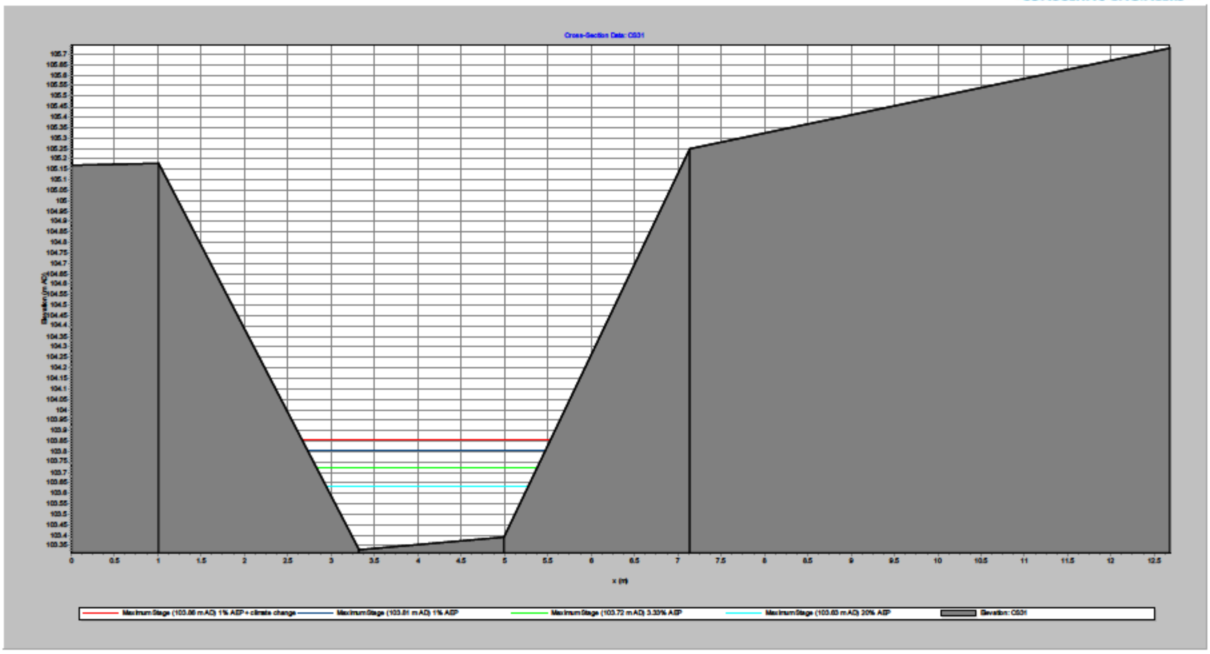

Figure F.29 Peak levels at cross section CS31

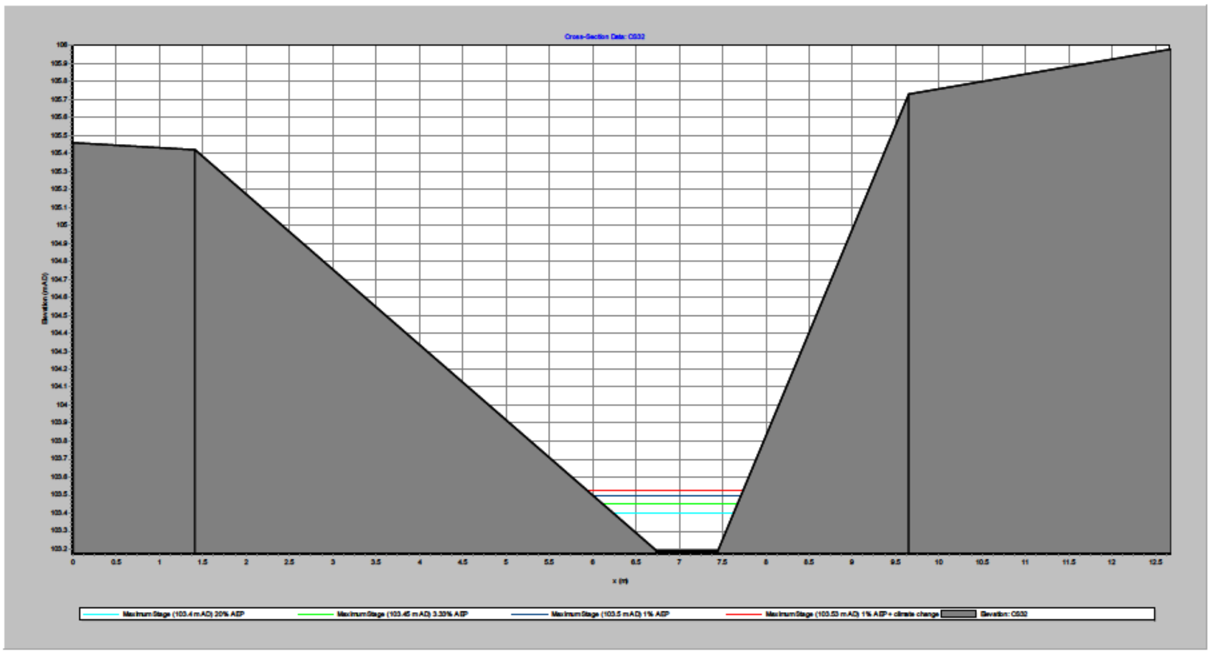

Figure F.30 Peak levels at cross section CS32

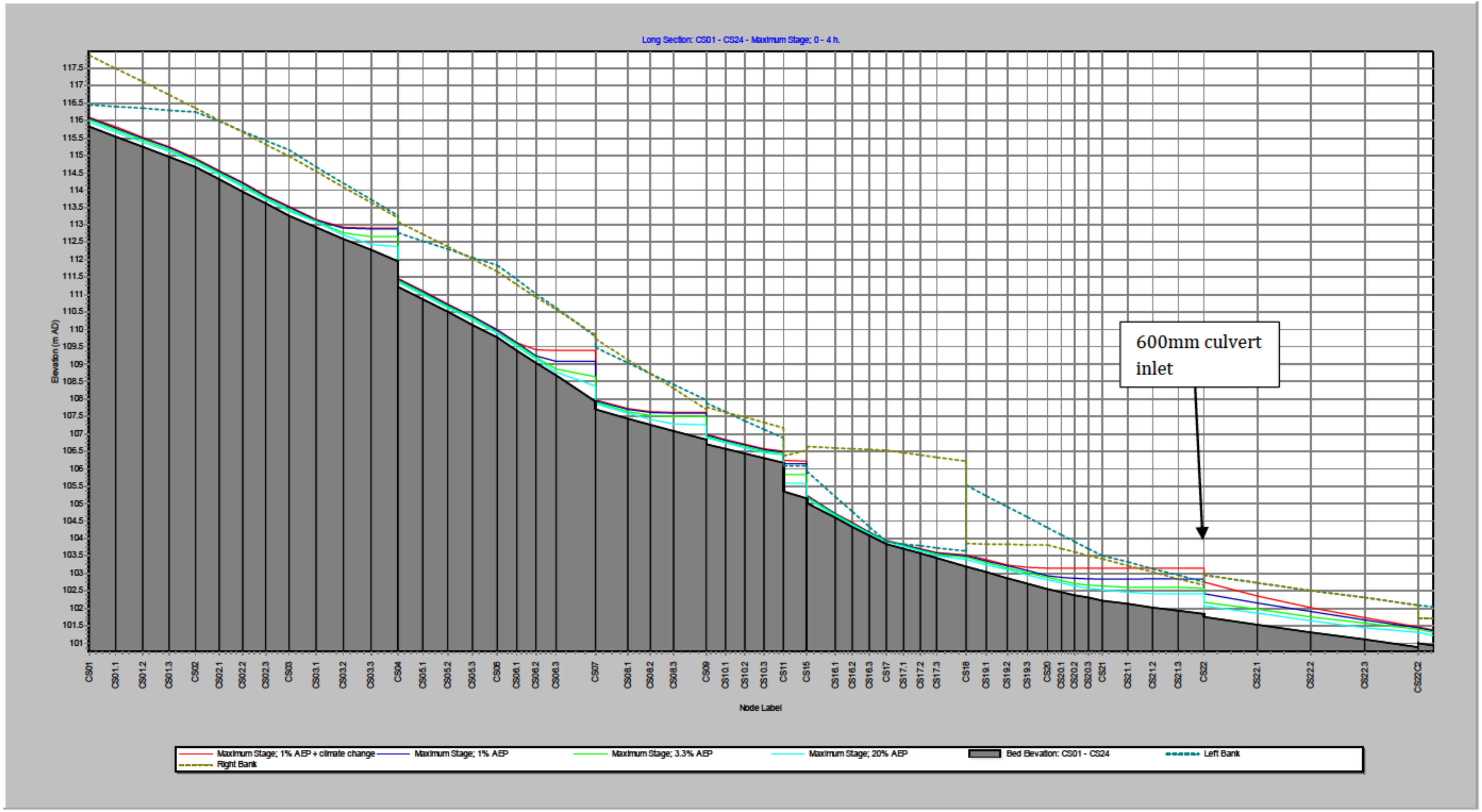

Figure F.31 Long section CS01 to CS24

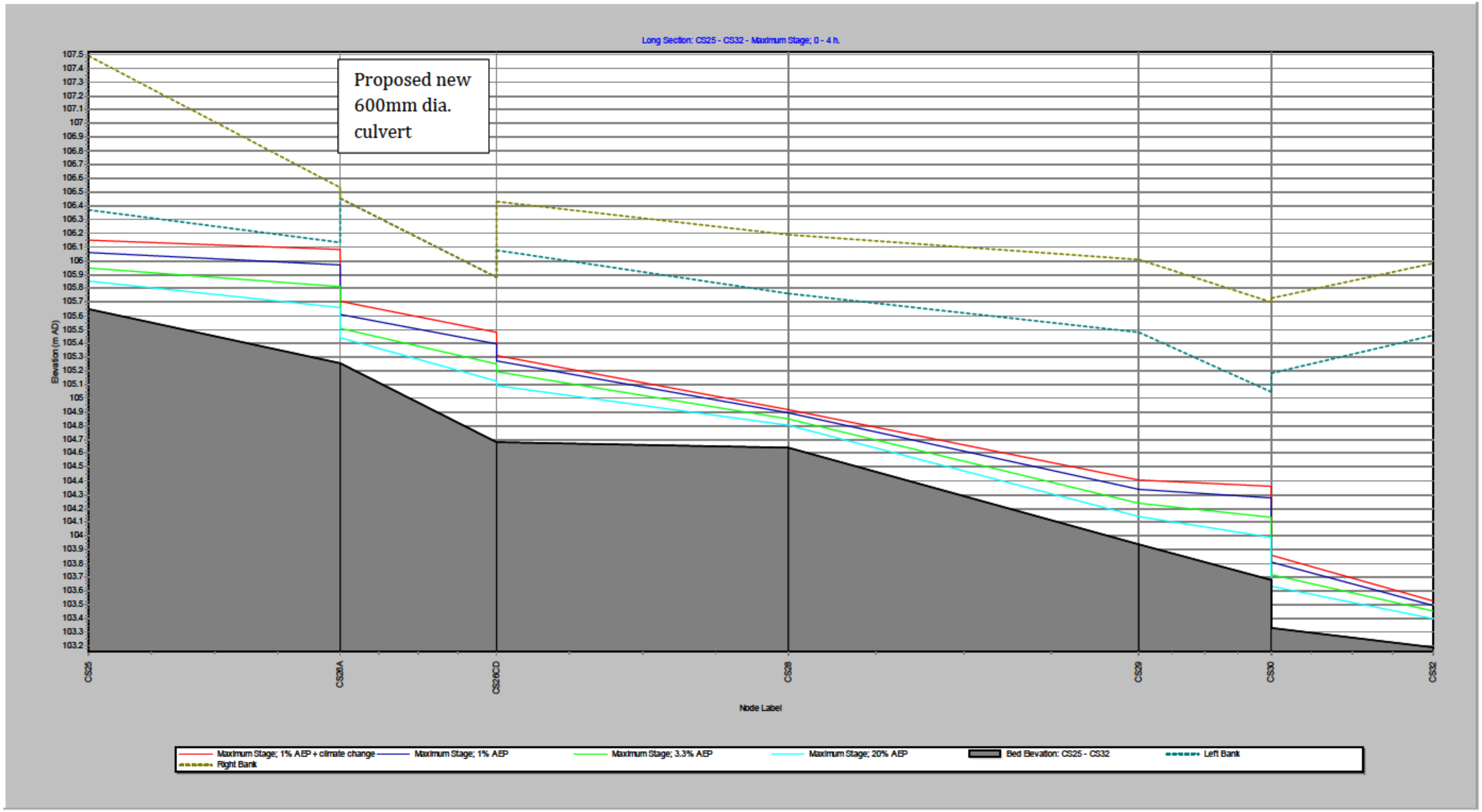

Figure F.32 Long section CS25 to CS32

APPENDIX G: FLOOD MODELLER OUTPUTS: SENSITIVITY TESTING

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Cross section	1% AEP level (mAOD)	Manning's roughness n+20% (mAOD)	Difference (m)	Manning's roughness n-20% (mAOD)	Difference (m)	1% AEP Flow + 20% level (mAOD)	Difference (m)
CS01	116.064	116.095	0.031	116.033	-0.031	116.095	0.031
CS02	114.892	114.920	0.028	114.858	-0.034	114.920	0.028
CS03	113.506	113.530	0.024	113.471	-0.035	113.528	0.022
CS04	112.883	112.884	0.001	112.883	0.000	112.917	0.034
CS05	111.444	111.478	0.034	111.421	-0.023	111.474	0.030
CS06	109.972	109.996	0.024	109.942	-0.030	110.001	0.029
CS07	109.077	109.080	0.003	109.069	-0.008	109.400	0.323
CS08	107.949	107.980	0.031	107.919	-0.030	107.973	0.024
CS09	107.590	107.591	0.001	107.589	-0.001	107.621	0.031
CS10	106.966	106.989	0.023	106.935	-0.031	106.985	0.019
CS11	106.487	106.487	0.000	106.485	-0.002	106.509	0.022
CS14	106.154	106.158	0.004	106.152	-0.002	106.229	0.075
CS15	106.152	106.155	0.003	106.150	-0.002	106.228	0.076
CS16	105.222	105.249	0.027	105.195	-0.027	105.249	0.027
CS17	103.936	103.947	0.011	103.925	-0.011	103.947	0.011
CS18	103.496	103.524	0.028	103.467	-0.029	103.523	0.027
CS19	103.496	103.524	0.028	103.467	-0.029	103.523	0.027
CS20	102.933	102.974	0.041	102.893	-0.040	103.143	0.210
CS21	102.837	102.877	0.040	102.833	-0.004	103.137	0.300
CS22	102.827	102.866	0.039	102.829	0.002	103.136	0.309
CS23	101.440	101.468	0.028	101.405	-0.035	101.450	0.010
CS24	101.352	101.389	0.037	101.304	-0.048	101.361	0.009
CS25	106.028	106.052	0.024	106.000	-0.028	106.125	0.097
CS26	105.911	105.911	0.000	105.911	0.000	106.059	0.148
CS27	105.274	105.288	0.014	105.267	-0.007	105.309	0.035
CS28	104.893	104.929	0.036	104.852	-0.041	104.917	0.024
CS29	104.336	104.358	0.022	104.312	-0.024	104.399	0.063
CS30	104.274	104.275	0.001	104.274	0.000	104.352	0.078
CS31	103.806	103.849	0.043	103.749	-0.057	103.851	0.045
CS32	103.496	103.524	0.028	103.467	-0.029	103.523	0.027
Maximum			0.043		-0.057		0.323
Mean			0.022		-0.021		0.073

Table G.1 Sensitivity analysis on 1 in 100 year peak water level

APPENDIX H: NOTES OF LIMITATIONS

The data essentially comprised a study of available documented information from various sources together with discussions with relevant authorities and other interested parties. There may also be circumstances at the site that are not documented. The information reviewed is not exhaustive and has been accepted in good faith as providing representative and true data pertaining to site conditions. If additional information becomes available which might impact our l conclusions, we request the opportunity to review the information, reassess the potential concerns and modify our opinion if warranted.

It should be noted that any risks identified in this report are perceived risks based on the available information.

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