Newton Stewart
FLOOD PROTECTION SCHEME

NEWTON STEWART FLOOD PROTECTION SCHEME – SUPPORTING DOCUMENT
SEEPAGE ANALYSIS REPORT

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10 December 2018
Sweco UK Limited

Dumfries & Galloway COUNCIL

SWECO

Change list

VER.	DATE	CHANGE CONCERNS	ORIGINATOR	REVIEWED	APPROVED
0	07/08/17	DRAFT FOR COMMENT	DK	SMCL	NT
1	10/12/18	UPDATED FOLLOWING COMMENTS	ARW	SMCL	NT
2	12/05/20	UPDATED FOLLOWING COMMENTS	ARW	SMCL	NT

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1 Introduction

An outline proposal has been made for the implementation of flood alleviation works under terms of the Flood Protection (Scotland) Act 1961 and Flood Prevention and Land Drainage (Scotland) Act 1997 and Flood Risk Management Act 2009, in order to protect the properties of Newton Stewart, Dumfries and Galloway.

Sweco was appointed on the 7th August 2017 by Dumfries and Galloway Council (DGC) to undertake ground investigation, environmental assessments and other works necessary to complete detailed design development for the Newton Stewart Flood Protection Scheme.

The outline design phase has identified areas where flood protection structures are required. The current proposed type of structure is based on local topographical features and available space and may be subject to limited revision.

The aim of the flood protection structures is to prevent peak flood levels overtopping the structure in the 200-year return period flood. This Technical Note addresses potential seepage of ground water from the wet, to the dry side of the flood protection structures during this event. Depending on whether the flood structure is permeable to some extent (earthen embankment), or includes an impermeable cut-off wall to some depth, seepage may occur through or under the structure. The serviceability criterion, as advised by the client as a first approach, is to prevent the water table rising above ground level on the defended side of the structure. This is assessed using the SEEP/W program with the results presented in this Technical Note.

1.1 Scope – Seepage Modelling

The scope of this Technical Note is:

1. To analyse the suitability of the proposed flood protection structures with the aim to prevent seepage flow rising above ground level on the defended side of the flood wall.
2. Undertake a sensitivity analysis based on structure seepage cut-off depths and soil permeability parameters, as appropriate.
3. Propose preliminary embedment depths for seepage cut-off walls.

2 Seepage Analysis Methodology

To assess the above serviceability criterion, transient seepage analyses were undertaken for the 200-year return period time-stage hydrograph provided for each location. This was undertaken at each of the proposed flood protection structures, as necessary, with models based on the most onerous combination of:

1. Soil permeability.
2. The maximum water head difference between peak flood level (wet side) and existing ground level (dry side).
3. Flow path length – this is affected by ground level difference between wet and dry face of flood structure.

2.1 Current Analyses - Considerations

The current analyses are sensitive to the following:

- Type of flood protection structure: the structures were modelled as cantilever walls with spread footings, or as sheet piles where embedded within an embankment structure, to determine the required embedment depths. The geometry of the structure affects the seepage flow path (length) and the soil type (permeability) it travels through. This is crucial to the outcome of the analyses.
- Position of flood protection structure: The flood height acting on the face of the proposed flood protection structures is dependent on the final positioning of the structure (i.e. upslope or downslope of the proposed position) and has a major influence on the results of the analyses.

It is important that the analyses be reassessed if these details change. Additionally, the following is recommended as part of the detailed design stage:

- Ground investigations: Supplementary information might allow for refinement, allowing for more economical embedment depths, or increase as appropriate. This might involve hand pits or trial pits, as required.
- Detailed assessment of the man-made structures and topography on the dry and wet sides of the flood prevention structure should be undertaken when the position of the wall is finalised. The presence of relatively impermeable structures such as pavements and foundations have the potential to affect seepage flows.

2.2 Risk Acceptance

The seepage design criterion is to prevent the water table rising above the ground level on the dry side of the flood prevention structure with the aim of providing economical flood structures with minimum cut-off embedment depths. This is an unconservative approach and attracts an element of risk that should be appreciated.

Additionally, the analyses make no allowance for rainfall events affecting water table levels on the dry side of the flood prevention structure. This cumulative effect of rainfall and seepage may result in groundwater rising above ground level.

2.3 Scope – Seepage Modelling

The proposed flood protection measures include earth embankments, cantilever walls, and the modification of existing structures. Multiple cross-sections through the existing/proposed flood protection structures were assessed to determine the most onerous geometries in relation to seepage potential, in terms of:

- flood heights acting on the face of the flood prevention structure (Maximum height difference between existing ground level and peak flood level acting on structure)

- geometry of existing topography in relation to the proposed structure (steep slopes adjacent to structure on wet side being most onerous based on reduced seepage flow path)

The flood prevention structure and location may be subject to change and any changes should be re-analysed for seepage if the new structure is determined to be more onerous. A summary of the section locations and associated structures is provided in **Table 1**, with a plan provided in **Appendix A**. The flood heights acting on the flood prevention structure, and applied in the seepage modelling, are also provided in **Table 1**. Sections 14 and 34 are existing structures with the intention that these be modified by increasing the freeboard. Section 59 is a proposed new embankment structure.

Table 1: *Flood protection structures and flood heights acting on structures*

STRUCTURE NO. (BASED ON SECTION NO.)	LOCATION	STRUCTURE CHOSEN BASED ON MOST ONEROUS GEOMETRIES	FLOOD PREVENTION STRUCTURE	FLOOD HEIGHT ACTING ON FACE OF STRUCTURE (APPLIED IN SEEPAGE ANALYSES)
SECTION 14	EAST BANK OF RIVER CREE	SECTION 1 TO 16	CANTILEVER WALL (existing – embedment depth and footing details to be confirmed)	1.8
SECTION 34	WEST BANK OF RIVER CREE	SECTION 25 TO 50	CANTILEVER WALL (existing – embedment depth and footing details to be confirmed)	1.7
SECTION 59	WEST BANK OF RIVER CREE	SECTION 50 – 70	EMBANKMENT (proposed- new embankment)	1.0

2.4 Flood Data

The 200-year return period flood level data for the relevant sections supplied by Kaya Consulting, is presented in **Figure 1**. These assume the construction of defences in all locations through the town (*except* Minnigaff), and the construction of a two-stage channel between the new Sparling Bridge and the A75. Note that the post-peak flood level data is estimated since 17 hrs of data were supplied only.

These flood levels were applied to the most onerous structure geometry as discussed earlier. It should be noted that the 200-year return period may not be the most onerous flood event. For example, an event where peak flood levels are lower but act against the flood wall for a greater duration may be more onerous, and should be considered in the detailed design stage.

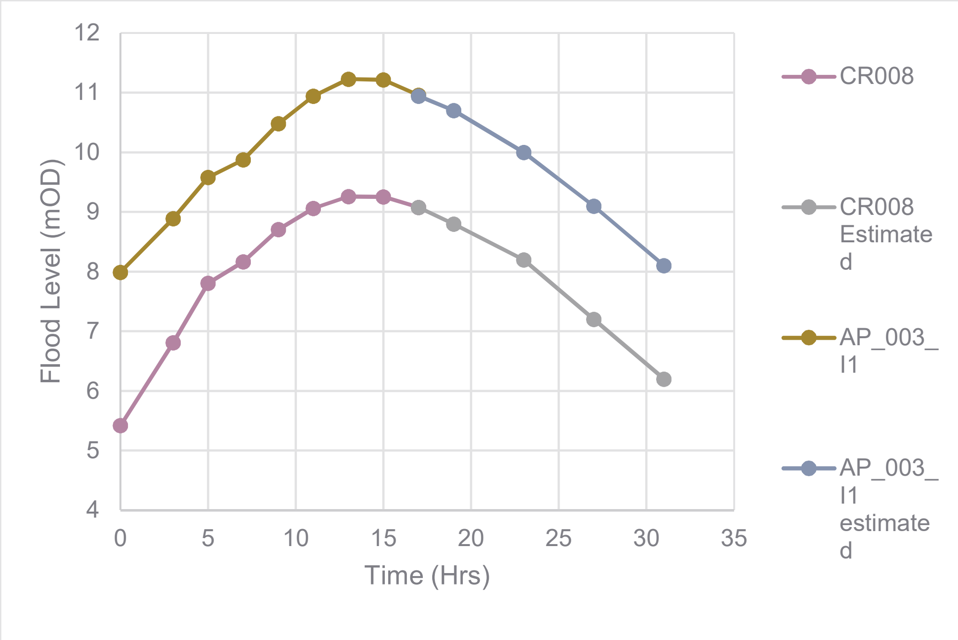


Figure 1: *Flood level with time (200-year storm return period) provided by Kaya Consulting. (Note post peak flood data is estimated)*

Figure 1 shows the flood level section data applied to each of the structures analysed in SEEP/W. The peak flood level in each data set was matched to the peak flood level anticipated at the structure, where the flood section was not directly adjacent the structure being analysed.

Table 2: *Flood Level data applied to flood protection structures*

STRUCTURE NO. (BASED ON SECTION NO.)	FLOOD LEVEL SECTION APPLIED
Section 14	CR008
Section 34	CR008
Section 59	AP_003_I1

A plan showing the flood section locations is provided in **Appendix B**.

2.4.1 Ground Water Levels

Groundwater monitoring was undertaken by installation of groundwater standpipes in 16 no. exploratory holes and is presented in **Table 3**. These levels are typically lower than that based on the initial water level in the 200-year return-period flood data presented earlier. Therefore, the flood data is considered appropriate with flood level at flood commencement used as the initial water table level in the analyses. The GI location plan is available in **Appendix C**.

__Table 3:__ Summary of ground water monitoring (Holequest GI)

Exploratory Hole No.	Groundwater monitoring depth to water (m bgl)								
	18.01.18	19.01.18	22.01.18	24.01.18	01.02.18	21.02.18	23.04.18	24.04.18	25.04.18
BH1-OP6	-	1.85	1.50	1.05	1.80	4.62	4.80	-	-
BH2A-OP6	-	-	-	-	3.60	3.63	3.80	-	-
BH3-OP6	-	-	-	-	2.60	2.83	-	2.80	-
BH4-OP6	-	-	-	-	-	1.42	-	-	-
BH5-OP6	-	-	-	-	-	-	-	2.10	-
BH7-OP6	-	1.85	1.50	1.05	1.80	2.01	2.40	-	-
BH8-OP6	-	-	-	-	-	3.80	3.90	-	-
BH9-OP6	-	-	-	-	-	3.00	3.25	-	-
BH11-OP6	-	-	-	-	-	1.59	-	-	2.10
BH12-OP6	-	-	-	-	-	2.50	-	-	3.10
BH13-OP6	-	-	-	-	-	2.00	-	-	2.20
BH14-OP6	-	-	-	-	-	2.95	-	-	1.90
TP9-OP6	-	-	-	-	-	2.05	-	-	-
BH1-OP7	-	-	-	-	0.50	0.87	-	1.10	-
BH1-SP	3.70	3.10	2.94	2.56	3.06	3.87	3.50	-	-
BH2-SP	1.26	1.25	1.07	0.54	1.30	1.55	-	1.60	-

2.5 Ground Investigation Data

A summary of the ground investigation (GI) borehole log soil descriptions for each section, and associated flood prevention structure, is presented in

Table 4. These informed the ground models for each section in the seepage analysis. The GI location plan is available in **Appendix C**.

Table 4: *Ground Investigation soil description summary*

SECTION NO.	**RELEVANT GI**	**SUMMARY OF BOREHOLE SOIL DESCRIPTIONS** **(dimensions in mBGL)**
SECTION 14	TP9-OP6, BH11-OP6, BH12-OP6, HP9-OP6, HP10-OP6.	**TP9-OP6 (borehole):** 0.0 Topsoil: silty sandy gravelly, 0.7 slightly sandy gravelly CLAY, 0.8 silty to very silty gravelly SAND, 10.7 slightly sandy silty CLAY, silty sandy GRAVEL, 12.7 SANDSTONE/SILTSTONE, BH termination at 17.9. **BH11-OP6:** 0.0 Topsoil: clayey very sandy gravelly, 0.9 very clayey gravelly SAND, 1.2 very silty gravelly SAND, 3.1 slightly sandy slightly gravelly silty CLAY, 3.7 clayey SAND/GRAVEL, 6.2 silty sandy GRAVEL, 12.4 Sandstone, 17.8 BH termination. **BH12-OP6:** 0.0 silty sandy Topsoil, 0.2 clayey sandy GRAVEL, 1.2 silty sandy GRAVEL, 7.8 slightly sandy slightly gravelly silty CLAY, silty sandy GRAVEL, 13.5 SANDSTONE. **HP9-OP6:** 0.0 sandy gravelly Topsoil, 0.3 silty gravelly SAND, 0.5 very clayey sandy GRAVEL, 1.1 HP termination. **HP10-OP6:** 0.0 Made Ground: silty sandy GRAVEL, 1.0 HP termination.
SECTION 34	HP8-OP6, BH7-OP6, TP5-OP6, TP1- SP, TP2-SP, BH1-SP.	**HP8-OP6:** 0.0 Made Ground: silty sandy GRAVEL, 0.8m HP termination. **BH7-OP6:** 0.0 Made Ground: silty sandy GRAVEL, 2.4m silty gravelly CLAY, 4.1 silty sandy GRAVEL, 8.2 CLAY, 10.65 silty sandy GRAVEL, 11.6 SANDSTONE. **TP5-OP6:** 0.0 silty SAND/GRAVEL, 1.2 TP termination. **TP1- SP:** 0.0 Silty SAND/GRAVEL, 2.0 TP termination. **TP2-SP:** 0.0 Silty SAND/GRAVEL, 1.85 TP termination. **BH1-SP:** 0.0 Made Ground: clayey gravelly SAND, 4.3 silty gravelly SAND, 5.6 silty SAND/GRAVEL, 12.4 SANDSTONE.

SECTION NO.	RELEVANT GI	SUMMARY OF BOREHOLE SOIL DESCRIPTIONS (dimensions in mBGL)
SECTION 59	TP2-OP6, HP1-OP6, BH3-OP6, TP3-OP6, TP4-OP6, HP2-OP6, BH4-OP6.	**TP2-OP6:** 0.0 slightly silty to silty sandy GRAVEL. Clayey from 1.8. 2.3 silty to very silty SAND, 2.4 TP termination. **HP1-OP6:** 0.0 silty very gravelly SAND, 0.5 HP termination. **BH3-OP6:** 0.0 Made Ground: Silty SAND/GRAVEL, 1.8 slightly silty to silty sandy GRAVEL, 5.1 Metasandstone **TP3-OP6:** 0.0 MADE GROUND: 0.0 silty SAND/GRAVEL, 2.0 TP termination. **TP4-OP6:** 0.0 Made Ground: silty clayey SAND/GRAVEL, 0.9 silty CLAY, 1.8 silty sandy GRAVEL, 1.9 TP termination. **HP2-OP6:** 0.0 silty SAND/GRAVEL, 1.2 HP termination. **BH4-OP6:** 0.0 Made Ground: silty sandy GRAVEL, 0.8 CLAY, silty sandy GRAVEL.

2.5.1 In-situ Constant Flow Permeability Tests

The results of the in-situ constant flow permeability tests are shown in **Figure 2**. Each test shows the average permeability of the soil over the length of test section with respect to depth tested.

In general, the results of the permeability testing agree with that expected for sands and gravels with low fines content (5E-02 – 5E04 m/s). However, these are average permeabilities over the length of the test section. Permeability values (k-values) may decrease or increase with depth as fines contents and densities increase or decrease.

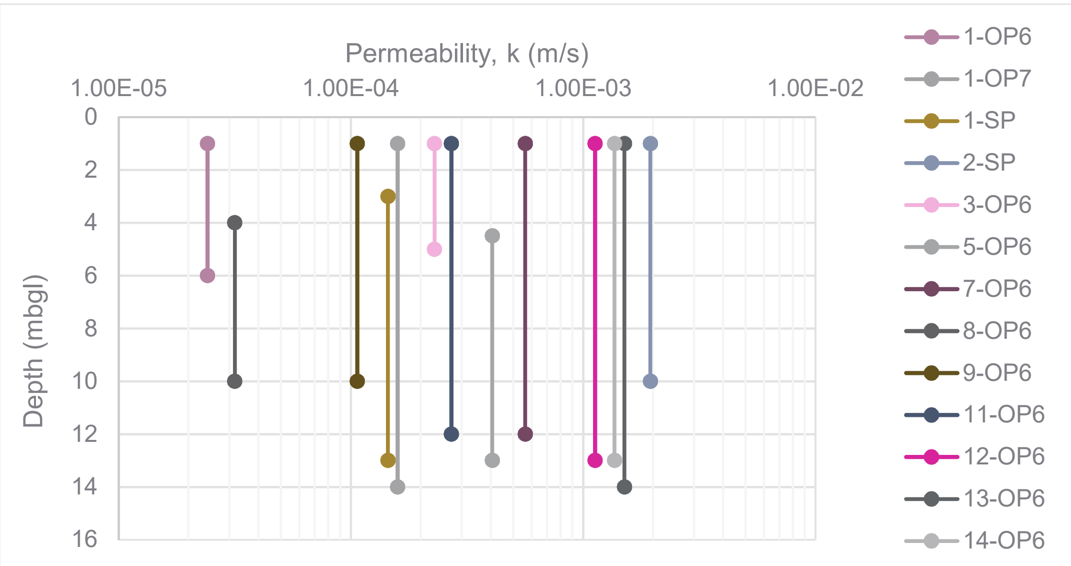


Figure 2: *Constant flow permeability results – average permeability over test section*

2.5.2 Permeability based on Particle Size Distribution

The permeability of the soil has been estimated based on the grading characteristics of the soil obtained from particle size distribution (PSD) tests. The following relation can be used to estimate the hydraulic permeability of soil (Carrier, 2003):

$$k = 1.99 \times 10^{4} \left[\frac{100\%}{\sum \frac{f_i}{D_{li}^{0.404} \times D_{si}^{0.595}}} \right]^{2} \left(\frac{1}{SF^2} \right) \left(\frac{e^3}{1+e} \right) \quad \textit{Equation 2-1}$$

where,

f_i = fraction of particles between two sieve sizes, (%)

D_{li} = Diameter of the larger sieve size (cm)

D_{si} = Diameter of the smaller sieve size (cm)

e = void ratio

SF = shape factor, [range of 6 (rounded) to 8 (angular)].

An SF of 7 was applied to account for the typical soil description of sub-rounded to sub-angular.

The void ratio ranges for a variety of soil types similar to those encountered on site are shown in **Table** . These allow the selection of appropriate void ratios for the soils encountered during the ground investigation.

Table 5: *Void ratio selected based on grading and density*

Soil Type	Description	Void ratio		Reference	Selected void ratio for permeability calculation
		min	max		
1	Silty gravel, silty sandy gravel	0.18	0.28	[1]	0.28
2	Well graded gravel, sandy gravel, with little or no fines	0.26	0.46	[1]	0.36
3	Poorly graded gravel, sandy gravel, with little or no fines	0.26	0.46	[1]	0.36

References:

(Swiss Standard SN 670 010b, 1999)

Based on the soil types described in the logs a conservative void ratio of 0.28 for silty sands and gravels, and 0.36 for slight to no-fines content sand and gravel, was selected for use in the k-value relation.

For soil type 1, the max void ratio was chosen to be conservative (based on the k-value relation presented, the max void ratio computes the maximum k-value). For soil types 2 and 3, an intermediate void ratio was chosen based on the typical fines content of between 5 and 10%. Furthermore, the soil was typically described as dense. Hence the applied void ratio is likely to be conservative.

Figure 3 presents the k-values derived using this relation. The k-values cover a broader range of values than those calculated from constant head tests. This may be due to the discrete (selected disturbed soil sample) versus global (undisturbed in-situ soil) effects. Therefore, the in-situ permeability tests are deemed more representative than the k-values derived from PSDs.

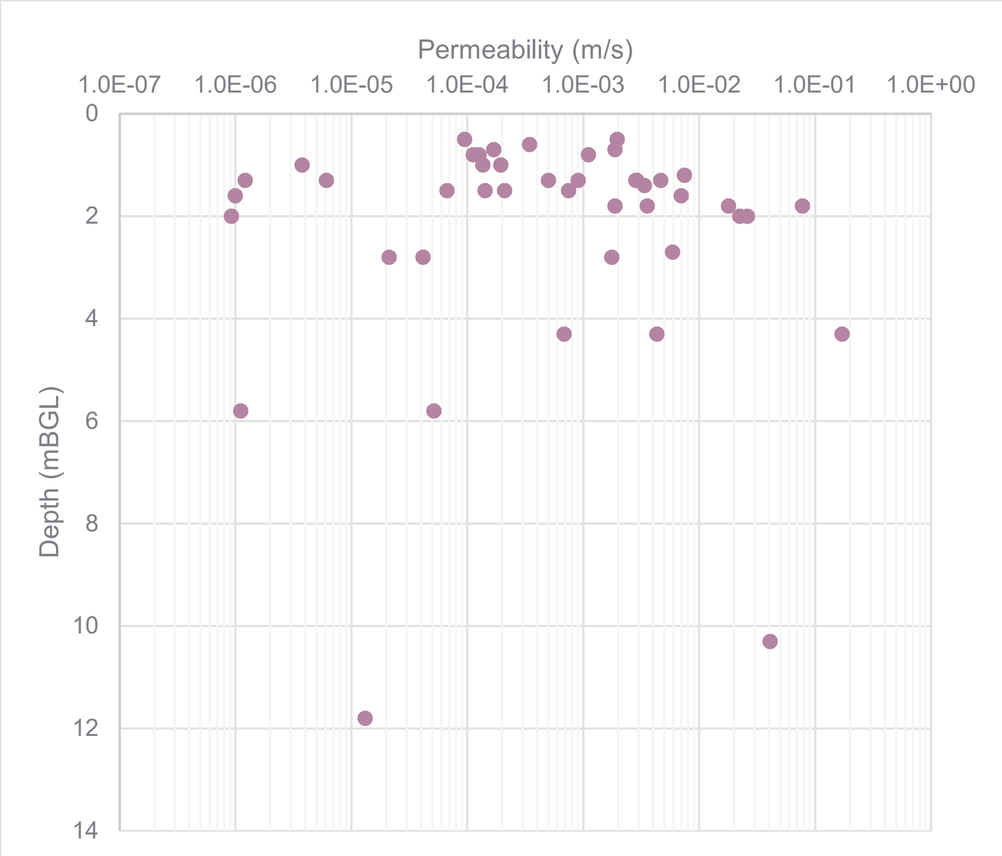


Figure 3: *k-values derived from particle size distributions after Carrier, 2003*

2.5.3 k-values at Each Section of Flood Protection Structure

The k-values from in-situ tests and derived from PSDs for each section of flood protection structure informed the selection of the k-values for application in the seepage analyses.

2.5.4 SEEP/W Modelling

A transient seepage analysis was performed in SEEP/W for the 200-year return-period flood.

The SEEP/W models are based on the assumption that the ground profile is laterally continuous. This allows the water seeping underneath the structure to flow within the more permeable strata typically found at, or near, the ground surface on the defended side since this will have a capacity for storage. This means that seepage flows accumulate within this stratum and may not rise above ground level. If less permeable ground, or an obstruction, is present within 5 to 10m of the wall on the defended side the water table may rise to above ground level. The influence of this assumption is observed in the seep/w outputs presented later.

To be conservative, vertical permeability is assumed to be equivalent to horizontal permeability. It is usual for the vertical permeability to be less due to soil depositional processes.

3 Seepage Analyses Output Summary

A summary of the SEEP/W analyses is presented in **Table** . This should be viewed in conjunction with the graphical seepage outputs in **Appendix D**.

Table 6: *k-values applied in seepage analyses and proposed embedment depth*

SECTION NO.	k-values and embedment depth applied in SEEP/W seepage analyses	Results and Commentary	Required Cut-off Embedment Depth (mbegl)
Section 14	Modelled as cantilever wall with embedment 1.5mbgl on wet side of structure. G.L. 0.3m higher on dry side. Made Ground layer extends to river channel. k-value applied to: “Made Ground: silty clayey sandy GRAVEL”: 1E-04m/s “silty sandy GRAVEL”: 1E-03m/s.	Water table is: 0.6mbgl on dry side at peak flood 0.4mbgl on dry side at 9hrs post peak flood	0.5mbgl on wet side
	As above with embedment of 1.0mbgl.	Water table is: 0.5mbgl on dry side at peak flood 0.3mbgl on dry side at 9hrs post peak flood	
	As above with embedment of 0.5mbgl.	Water table is: 0.3mbgl on dry side at peak flood 0.1mbgl on dry side at 9hrs post peak flood	
Section 34	Modelled as cantilever wall with embedment 1.5mbgl on wet side of structure. G.L. 1.4m higher on dry side. Made Ground layer extends to river channel. k-values applied: “Made Ground: silty clayey sandy GRAVEL”: 1E-04m/s “silty sandy GRAVEL”: 6E-04m/s.	Water table is: 0.8mbgl on dry side at peak flood 0.6mbg on dry side at 9hrs post peak flood	0.6mbgl on wet side

SECTION NO.	k-values and embedment depth applied in SEEP/W seepage analyses	Results and Commentary	Required Cut-off Embedment Depth (mbegl)
Section 59	Modelled as embankment with cut-off embedment of 1.5mbgl. k-value applied to: “silty sandy GRAVEL”: 2E-04m/s. “embankment CLAY: 1E-06m/s	Water table is: 2.0mbgl on dry side at peak flood 1.8mbg on dry side at 9hrs post peak flood	No cut-off below proposed embankment. However, impermeable barrier to be included within core.
	Modelled as embankment with no cut-off. k-value applied to: “silty sandy GRAVEL”: 2E-04m/s. “embankment CLAY: 1E-06m/s	Water table is: 2.0mbgl on dry side at peak flood 1.3mbg on dry side at 9hrs post peak flood	

Note that the embankment soil has been modelled with a k-value of 1E-06m/s. If a soil of greater permeability is to be used in construction, the seepage analyses will need to be re-run with the alternative permeability. Alternatively, if a different type of structure is proposed the analysis will need to be run again to determine required cut-off embedment. Embankments are effective by increasing the seepage flow paths and reduce the embedment depth required.

3.1 Results Discussion

It should be noted that the position, geometry, and type of structure affects the validity of the required embedment depths, as discussed earlier. There are risks associated with the unconservative design criterion on which the analyses are based, namely preventing the water table rising above ground level on the dry side of the flood protection structure. For example, the analyses do not take account of a rising water table on the dry side due to rainfall events, and cannot account for surface ponding of rainwater.

However, in terms of seepage from the wet to dry sides, the analyses show the modelled structures to be sufficient in satisfying the design criterion. A discussion of each of the chosen sections is presented below:

3.1.1 Section 14

An embedment depth of 0.5mbgl on the wet side of the existing flood prevention structure is required to prevent the water table rising above ground level on the dry side. A limited number of hand dug trial pits dug at the existing structures extended to at least 0.5m below EGL (HP9- OP6 and HP10-OP6). The future design should therefore incorporate sufficient embedment, as noted above.

3.1.2 Section 34

An embedment depth of 0.6mbgl on the wet side of the existing flood prevention structure is required to prevent the water table rising above ground level on the dry side. A limited number of hand dug trial pits dug at the existing structures terminated at between 0.5 and 1.2m below EGL (HP5- OP6 and HP8-OP6). The future design should therefore incorporate sufficient embedment, as noted above.

3.1.3 Section 59

No embedment depth of the cut-off below existing ground level is required for the proposed embankment. However, the embankment is modelled as having a permeability of 1E-07m/s with an integrated impermeable cut-off. Further, the footprint of the embankment from wet to dry sides is 8.5m. Any reduction in this dimension, increase in permeability of the soil used to construct the structure, or exclusion of the internal cut-off, will require that the structure be re-analysed for seepage flows.

4 Summary

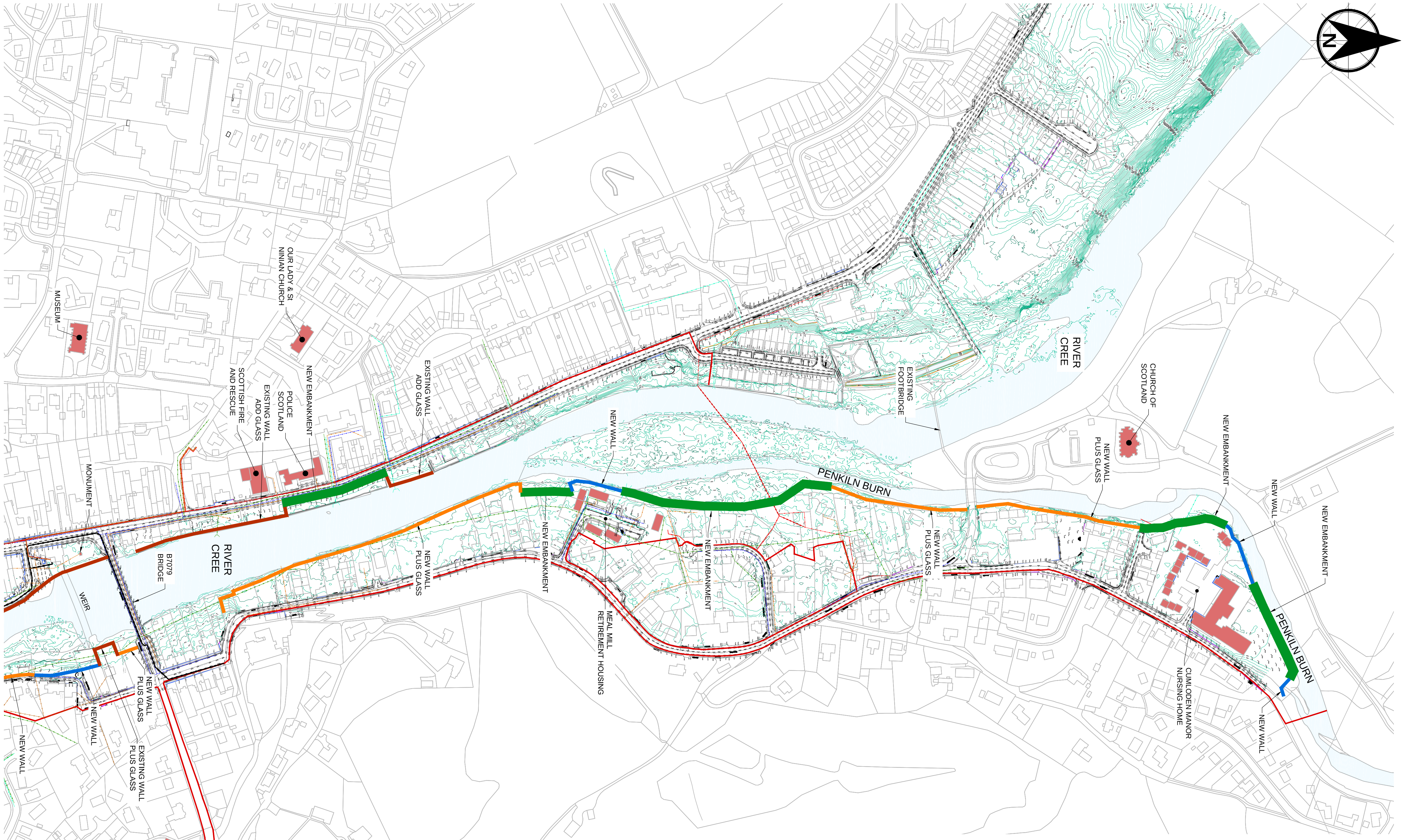
Seepage analyses have been performed for the flood protection structures proposed to protect Newton Stewart from the 200-year return-period flood. The structure geometry, flood data, and GI information were assessed for each section of structure to develop models for seepage analysis.

Sections 14, 34 and 59 were identified as having the most onerous combination of structure geometry and flood levels. Transient analyses were performed using the SEEP/W program to assess the potential seepage below the structures during the flood event. The design criterion was to prevent the water table rising above ground level on the dry side. The analyses also sought to determine the most economical cut-off embedment depths. Minimum cut-off embedment depths below existing ground level have been proposed.

It was highlighted that water may rise above ground level, or surface ponding may occur, due to secondary effects such as rainfall events.

The structure type and position will have a major influence on seepage flows and the analyses will need to re-run to take account of any changes that present more onerous conditions.

Appendix A – Flood Protection Structure Layout Plans (Edited to Show Locations of Modelled Flood Prevention Sections 14, 34 & 59)



EXAMPLE OF EXISTING STONE WALL WITH TOP MOUNTED GLASS AND STAINLESS STEEL FLOOD PROTECTION
(RIVER GRETA, KESWICK)

TYPICAL EXAMPLE OF BRICK FACED WALL
(WATER OF LEITH, EDINBURGH)

TYPICAL EXAMPLE OF EMBANKMENT

NOTES

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2. LEVELS AND HEIGHTS IN M.

PUBLIC UTILITIES KEY

- EXISTING SURFACE WATER SEWER
- EXISTING WASTE WATER NETWORK
- EXISTING LP GAS MAIN
- EXISTING MP GAS MAIN
- EXISTING WATER MAIN
- EXISTING TRUNK WATER MAIN
- EXISTING UNDERGROUND LV ELECTRIC
- EXISTING UNDERGROUND HV ELECTRIC
- EXISTING UNDERGROUND BT
- EXISTING VIRGIN MEDIA
- EXISTING OVERHEAD POWER LINE

FLOOD PROTECTION KEY

- INDICATIVE LOCATION OF EXISTING FLOOD WALLS
- INDICATIVE LOCATION OF EXISTING FLOOD WALLS, ADD GLASS
- INDICATIVE LOCATION OF NEW FLOOD WALLS
- INDICATIVE LOCATION OF NEW FLOOD WALLS PLUS GLASS
- INDICATIVE LOCATION OF FLOOD EMBANKMENT
- INDICATIVE LOCATION OF RE-PROFILED CHANNEL
- RED LINE BOUNDARY
- IDENTIFIED LOCATION OF POTENTIAL CLASH WITH UTILITIES (NOT EXHAUSTIVE)
- LOCATION OF PROPOSED SECONDARY FLOODINGS MITIGATION

INVASIVE WEEDS KEY

- SURVEYED LOCATION OF JAPANESE KNOTWEED *(FALLOPIA JAPONICA)*

Rev.	Date	Amendment Details	Drw'n	Chk'd	App'd
0	05/06/18	FOR INFORMATION	NM	JJ	DCE

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Drawing Status
FOR INFORMATION

Project Title
Newton Stewart Flood Protection Scheme

Drawing Title
NEW FLOOD DEFENCES CONSTRAINTS SHEET 1 OF 2

Scale	Designed	Drawn	Checked	Approved
1:2000	JJ	BBMD	DE	DL
Original Size: A1	Date: 18/04/18	Date: 02/04/18	Date: 18/04/18	Date: 18/04/18

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Revision: 0

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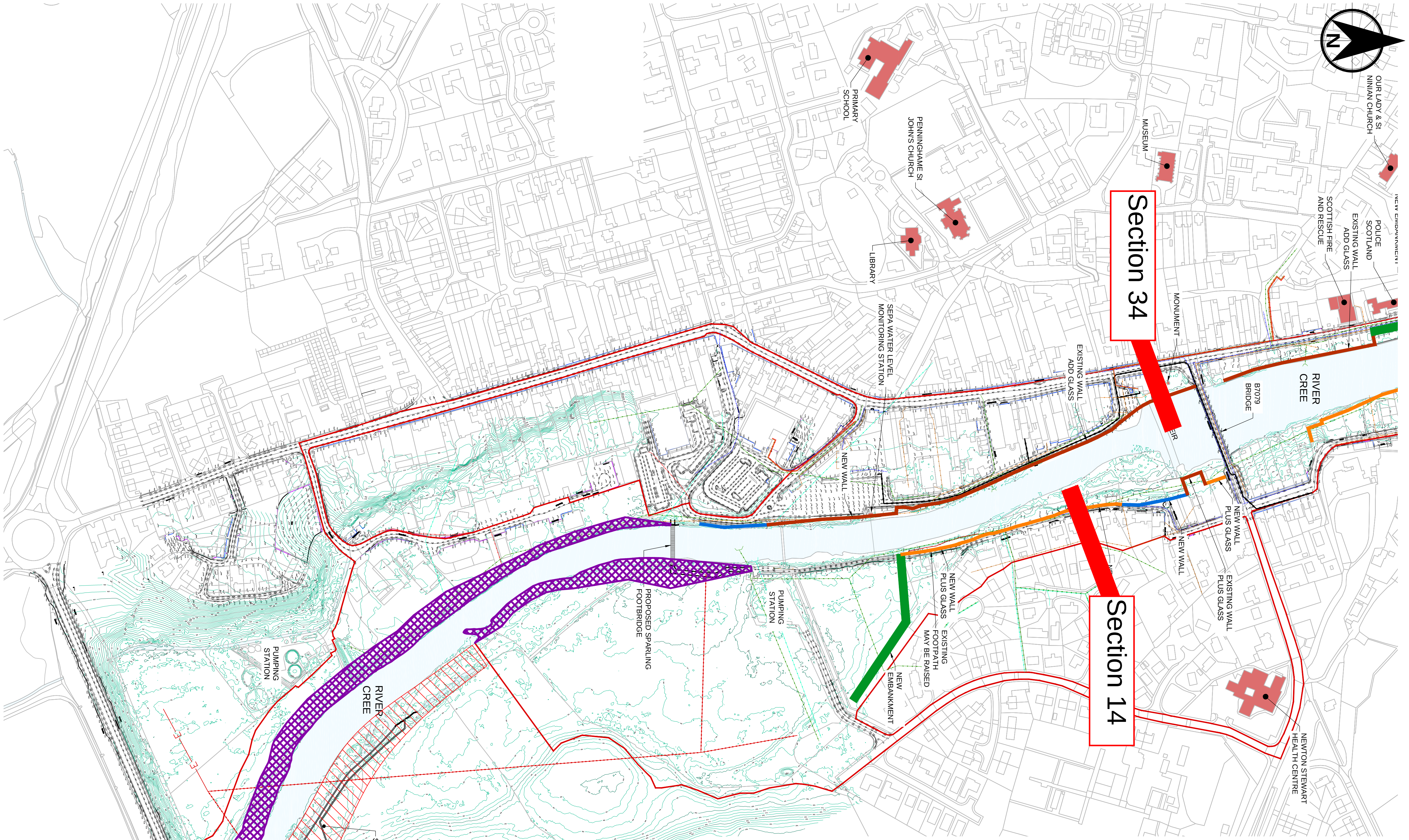
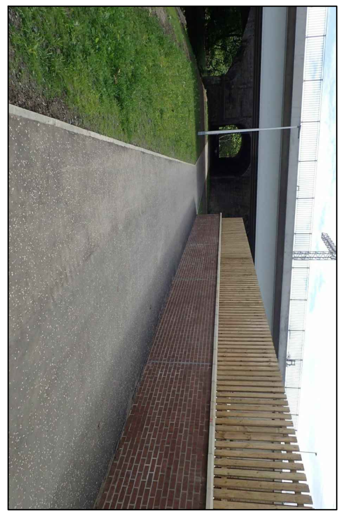



TYPICAL EXAMPLE OF GLASS WALL FLOOD BARRIER


TYPICAL EXAMPLE OF BRICK FACED WALL
(WATER OF LEITH, EDINBURGH)


TYPICAL EXAMPLE OF EMBANKMENT

NOTES

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2. LEVELS AND HEIGHTS IN M.

PUBLIC UTILITIES KEY

- EXISTING SURFACE WATER SEWER
- EXISTING WASTE WATER NETWORK
- EXISTING LP GAS MAIN
- EXISTING MP GAS MAIN
- EXISTING WATER MAIN
- EXISTING TRUNK WATER MAIN
- EXISTING UNDERGROUND LV ELECTRIC
- EXISTING UNDERGROUND HV ELECTRIC
- EXISTING UNDERGROUND BT
- EXISTING VIRGIN MEDIA
- EXISTING OVERHEAD POWER LINE

FLOOD PROTECTION KEY

- INDICATIVE LOCATION OF EXISTING FLOOD WALLS
- INDICATIVE LOCATION OF EXISTING FLOOD WALLS, ADD GLASS
- INDICATIVE LOCATION OF NEW FLOOD WALLS
- INDICATIVE LOCATION OF NEW FLOOD WALLS PLUS GLASS
- INDICATIVE LOCATION OF FLOOD EMBANKMENT
- INDICATIVE LOCATION OF RE-PROFILED CHANNEL
- RED LINE BOUNDARY
- IDENTIFIED LOCATION OF POTENTIAL CLASH WITH UTILITIES (NOT EXHAUSTIVE)
- LOCATION OF PROPOSED SECONDARY FLOODINGS MITIGATION

INVASIVE WEEDS KEY

- SURVEYED LOCATION OF JAPANESE KNOTWEED *(FALLOPIA JAPONICA)*

Rev.	Date	Amendment Details	Drw'n	Chk'd	App'd
0	05/06/18	FOR INFORMATION	NM	JJ	DCE

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SWECO

Client
Dumfries & Galloway Council

Drawing Status
FOR INFORMATION

Project Title
Newton Stewart
Flood Protection Scheme

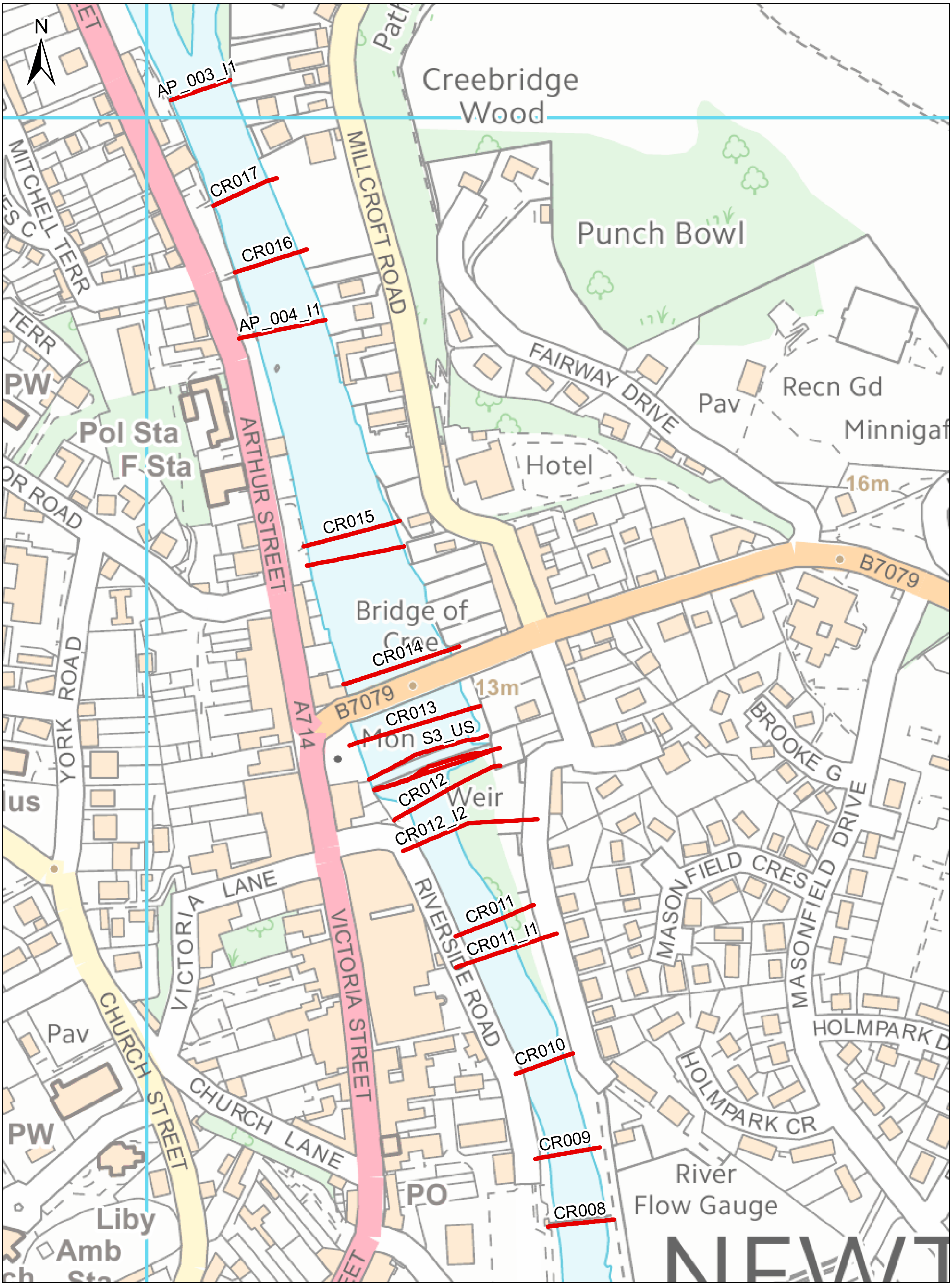
Drawing Title
NEW FLOOD DEFENCES
CONSTRAINTS SHEET 2 OF 2

Scale	Designed	Drawn	Checked	Approved
1:2000	JJ	BBMD	DE	DL
Original Size: A1	Date: 05/06/18	Date: 05/06/18	Date: 05/06/18	Date: 05/06/18

Drawing Number	Revision
118908 - SWECO - SK127	0

F:\U2011\proj\118908 Newton Stewart Flood\09 Drawings\Structures\ 118908-SWECO-SK126_0 & SK127_0.dwg

Appendix B – Flood Data Section Plan



0 12.5 25 50 75 100
Meters

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Newton Stewart Flood Protection Scheme

River Sections

SWECO

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Appendix C – GI Location Plan

Notes

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2. ENVIRONMENTAL CONSTRAINTS, NOTABLY "SSSI" IN VICINITY OF WORKS NO ACCESS AT ALL DURING WORKS WITHOUT PRIOR AUTHORIZATION.

3. ALL LOCATIONS ARE INDICATIVE, FINAL LOCATIONS TO SUIT ACCESS, ENVIRONMENTAL & STRUCTURAL CONSTRAINTS. SERVICES ALSO TO BE TAKEN INTO CONSIDERATION.

KEY

- MECHANICALLY EXCAVATED TRIAL PIT
- HAND DUG TRIAL PIT
- APPROXIMATE EXTENT OF SSSI
- BOREHOLE LOCATION

Rev	Date	Amendment Details	Orig	Chk'd	App'd
X1	11/04/18	AS BUILT	SC	SMC	NT
X0	16/03/18	AS BUILT	SC	SMC	NT

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SWECO

Client

Dumfries & Galloway COUNCIL

Drawing Status: AS BUILT

Suitability: S0

Project Title

Newton Stewart
Flood Protection Scheme

Drawing Title

PROPOSED GROUND INVESTIGATION
TESTING LOCATIONS
OPTION 6 - CONSTRUCTION OF DIRECT
DEFENCES + SPARLING BRIDGE

Scale	Designed	Drawn	Checked	Approved
1:2000	SMC	SC	SMC	NT
Original Size	Date	Date	Date	Date
A1	17/10/18	16/03/18	16/03/18	16/03/18

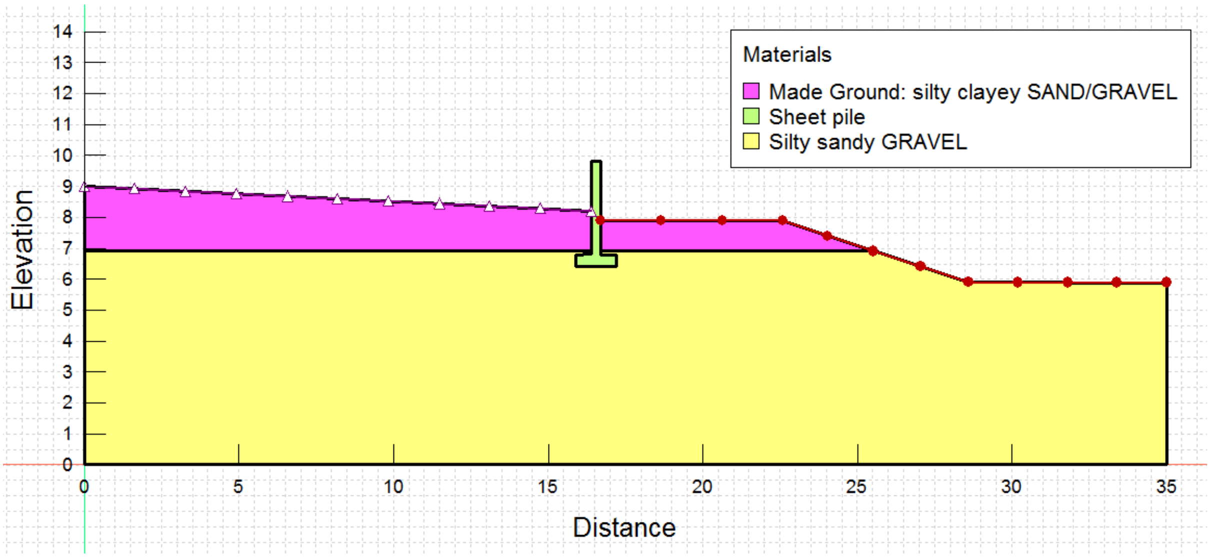
Drawing Number: 118908- SWECO - - - - - SK02

Project | Originator | Volume | Location | Type | Role | Number

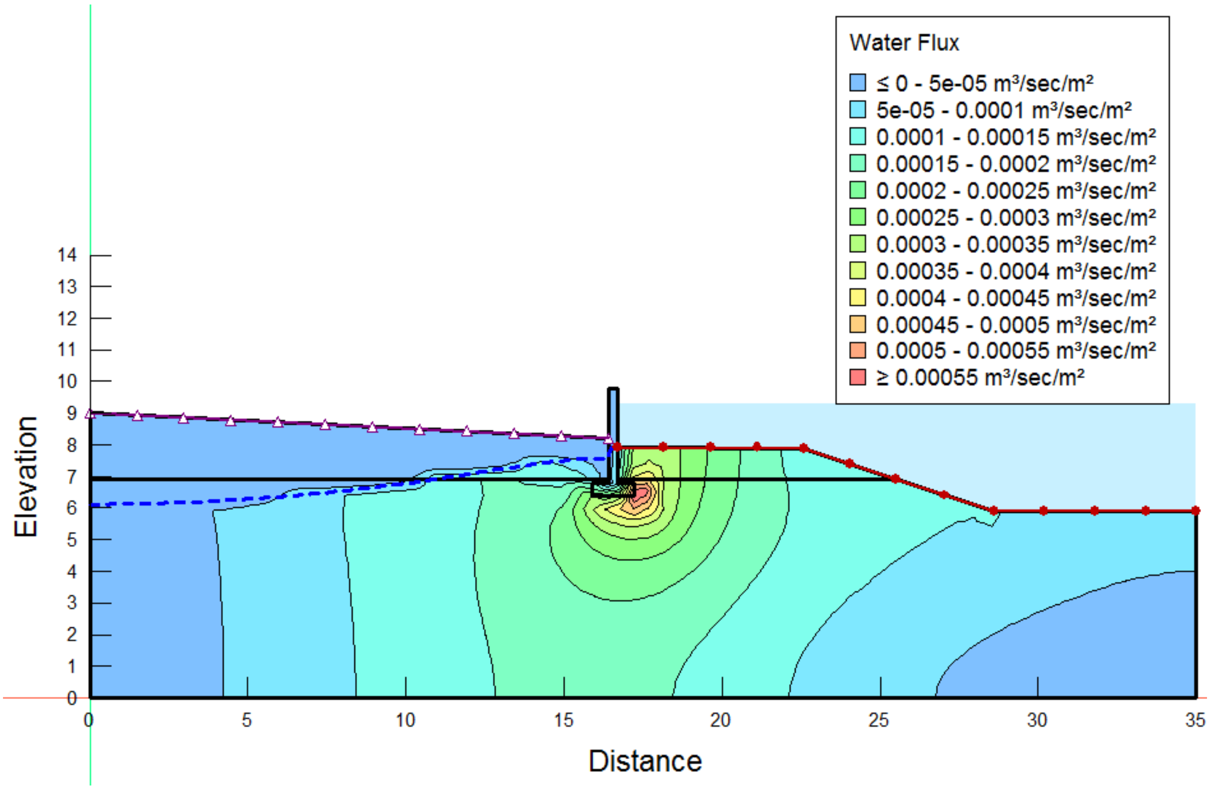
Project Ref. No.: 118908

Revision: X1

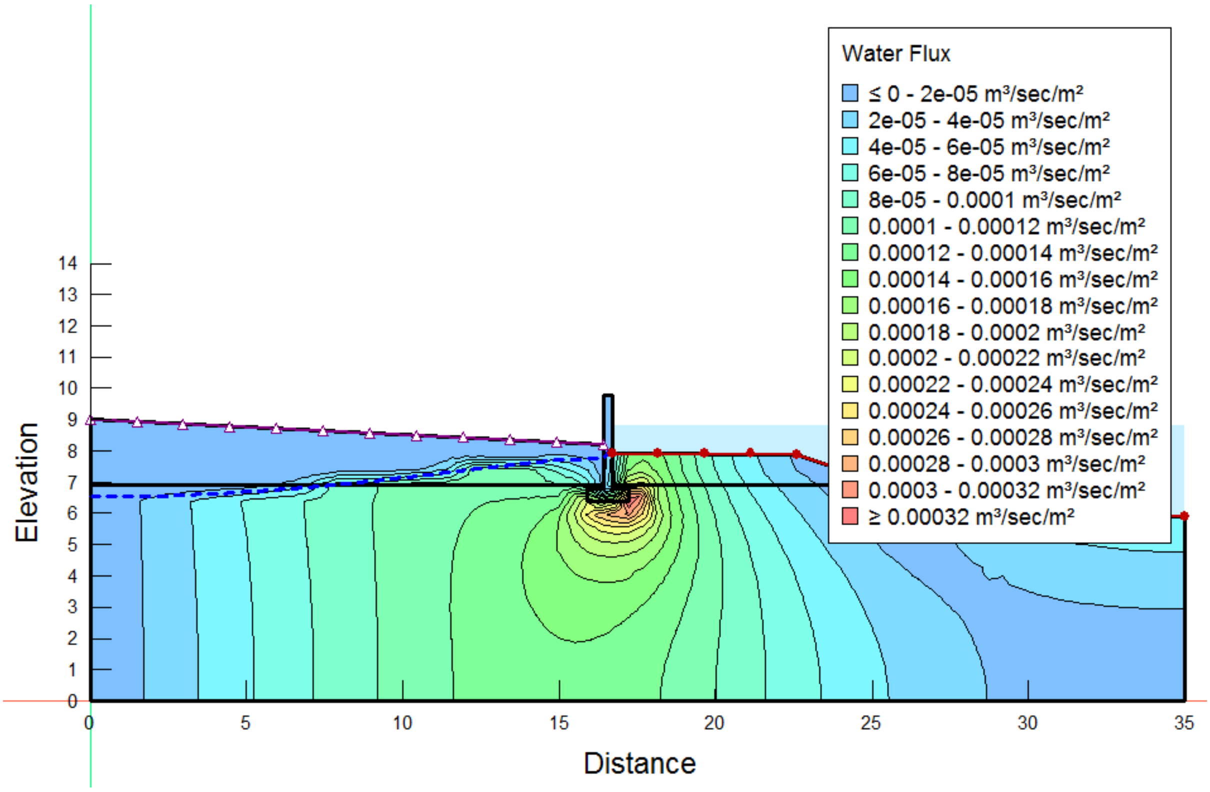
Appendix D – Seepage Analyses Outputs – SEEP/W



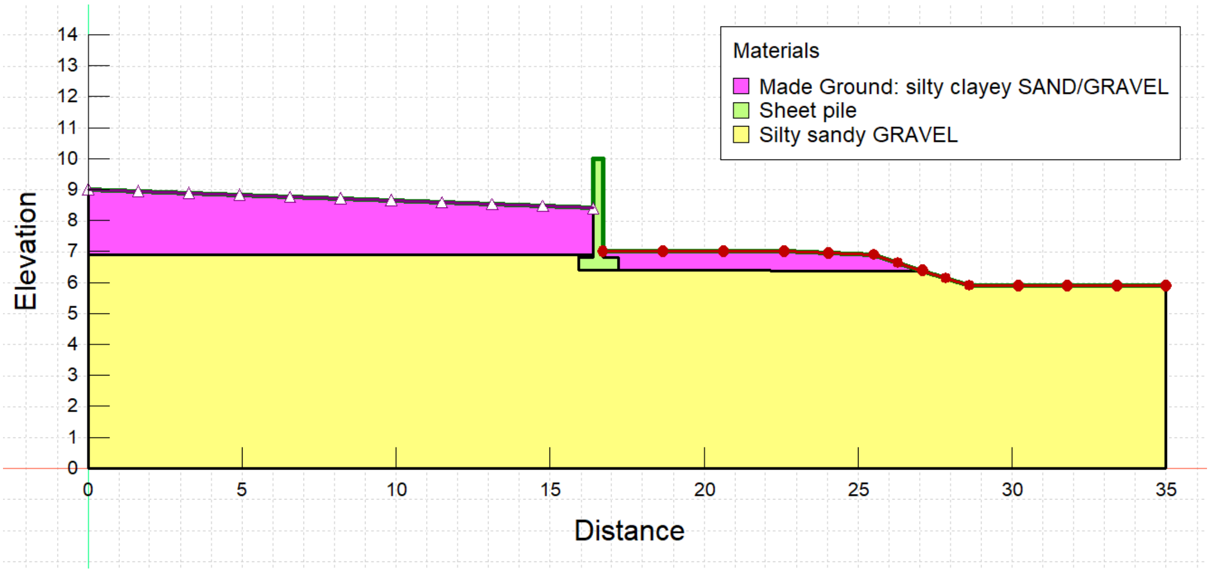
Appendix C - Figure 1: Section 14 Ground Model



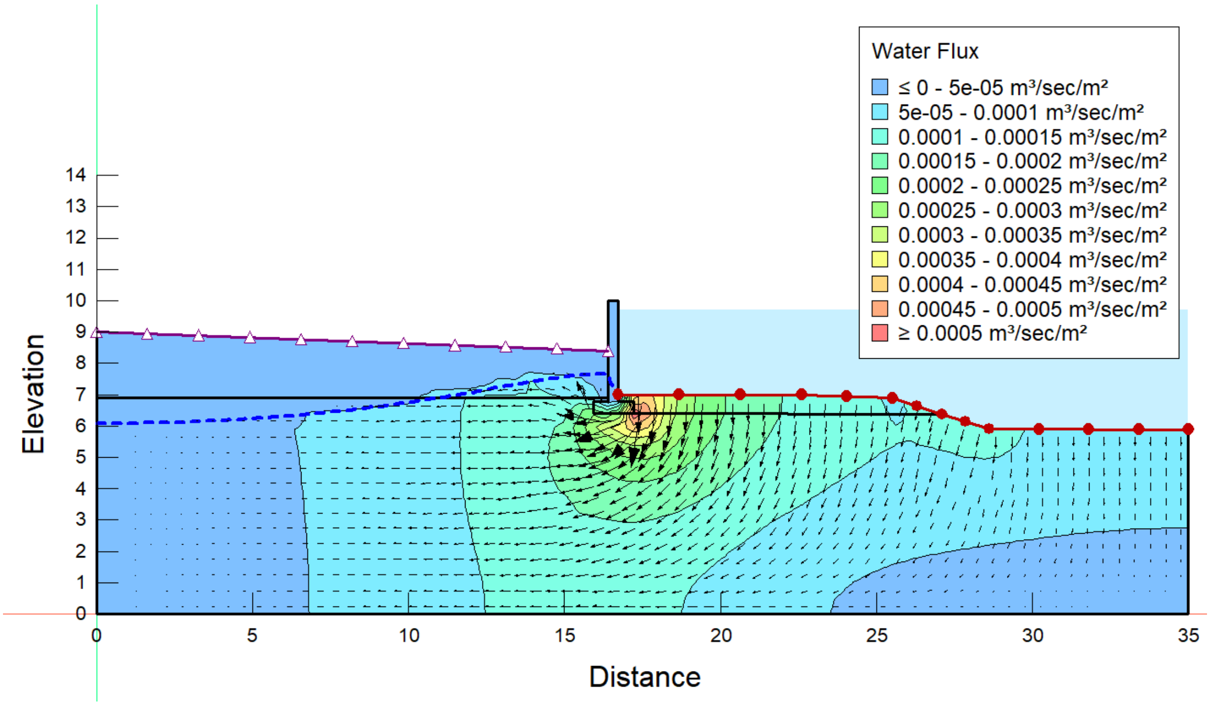
Appendix C - Figure 2: Section 14: Peak Flood. Water table at 0.6mbgl on dry side of structure



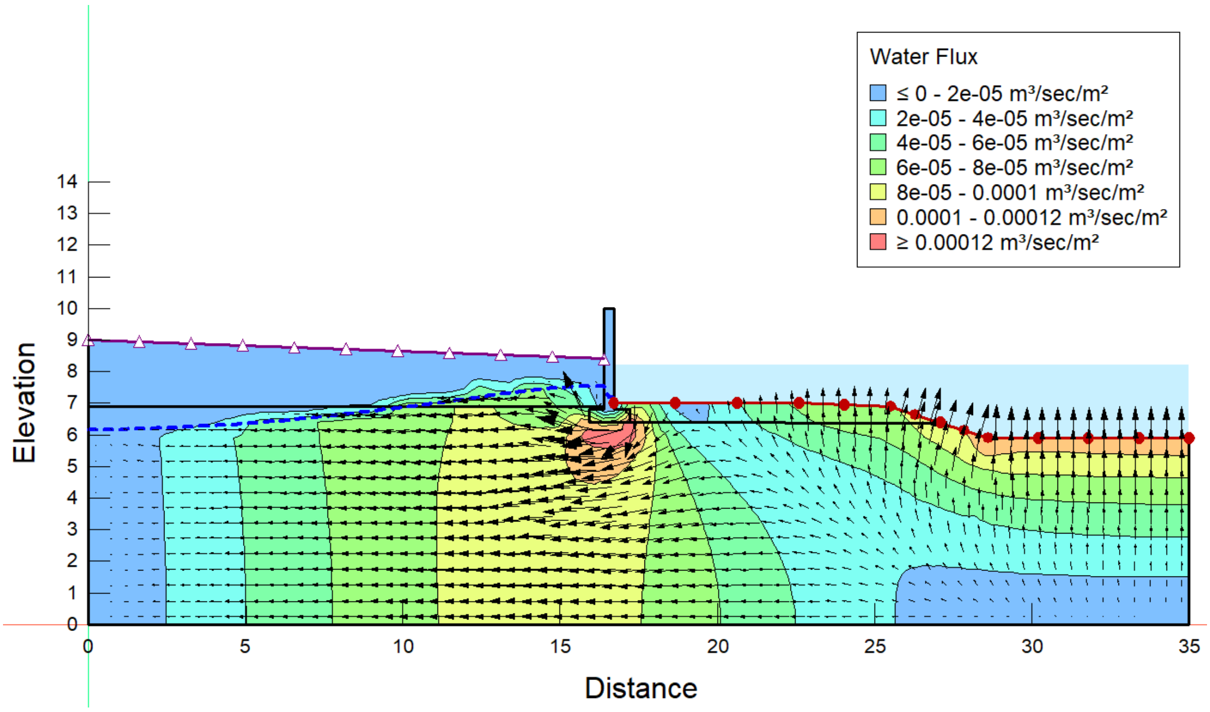
Appendix C - Figure 3: Section 14: 9 hrs Post Peak Flood. Water table at 0.4mbgl on dry side of structure



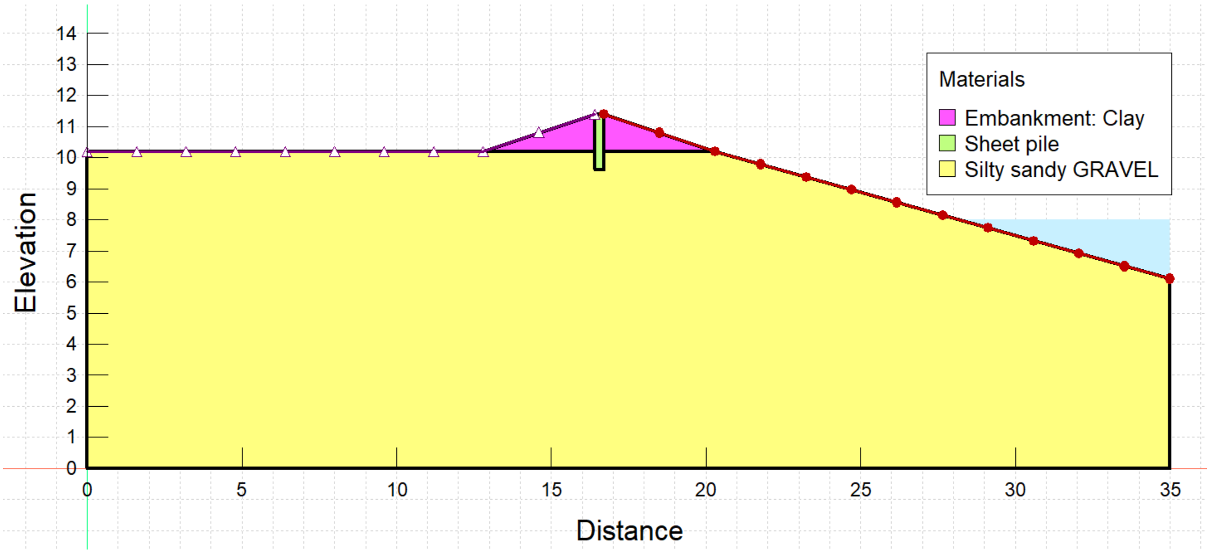
Appendix C - Figure 4: Section 34 Ground Model



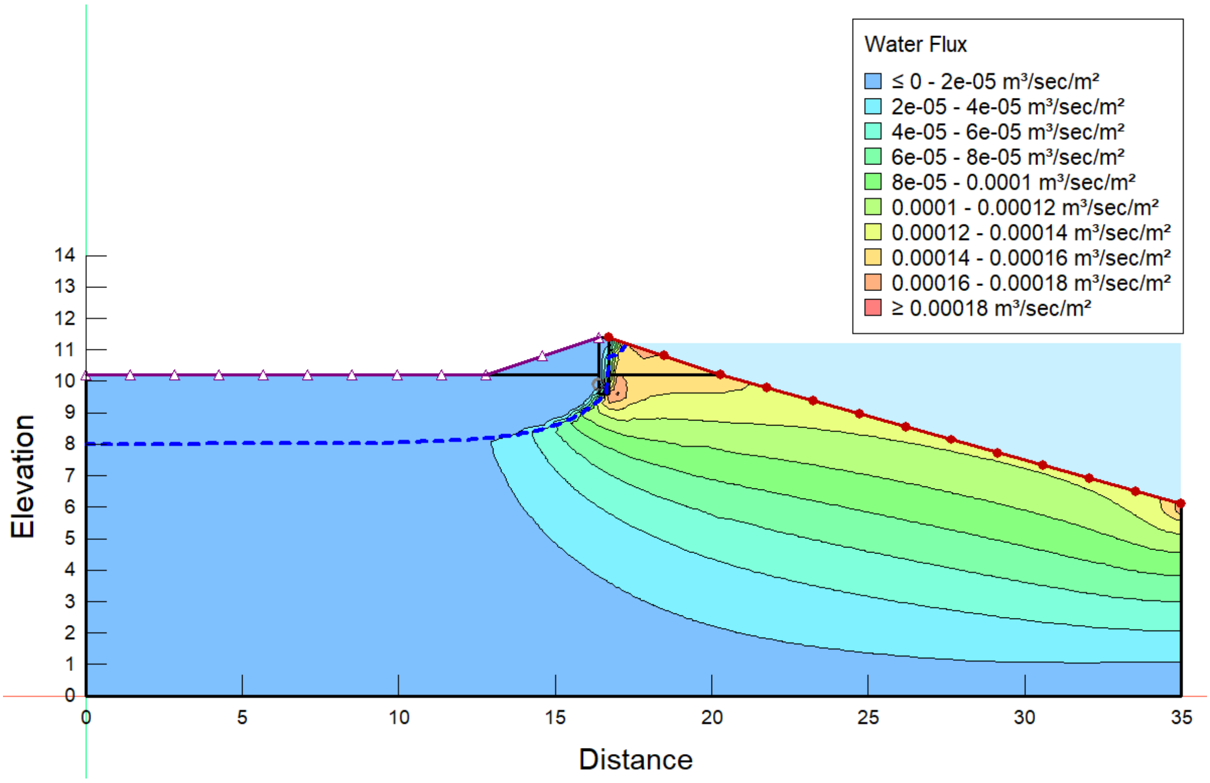
Appendix C - Figure 5:Section 34: Peak Flood. Water table at 1.0mbgl on dry side of structure



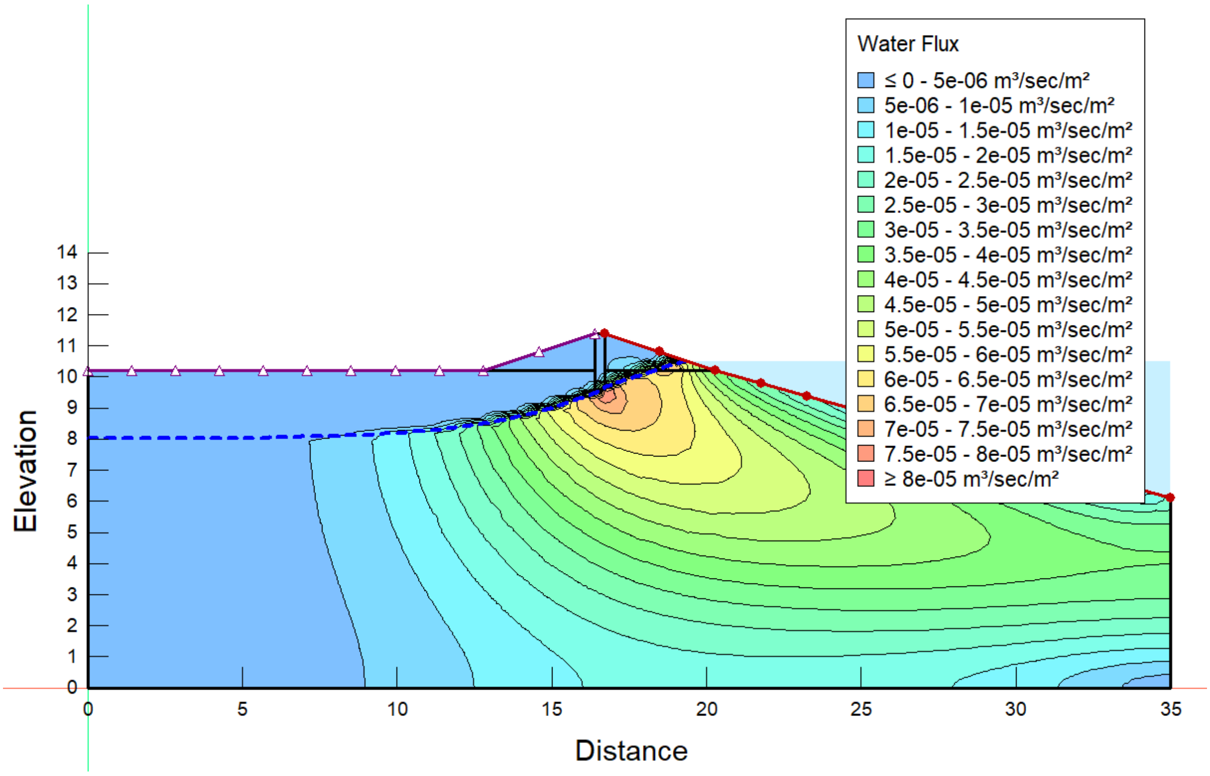
Appendix C - Figure 6: Section 34: 9hrs Post Peak Flood. Water table at 0.8mbgl on dry side of structure.



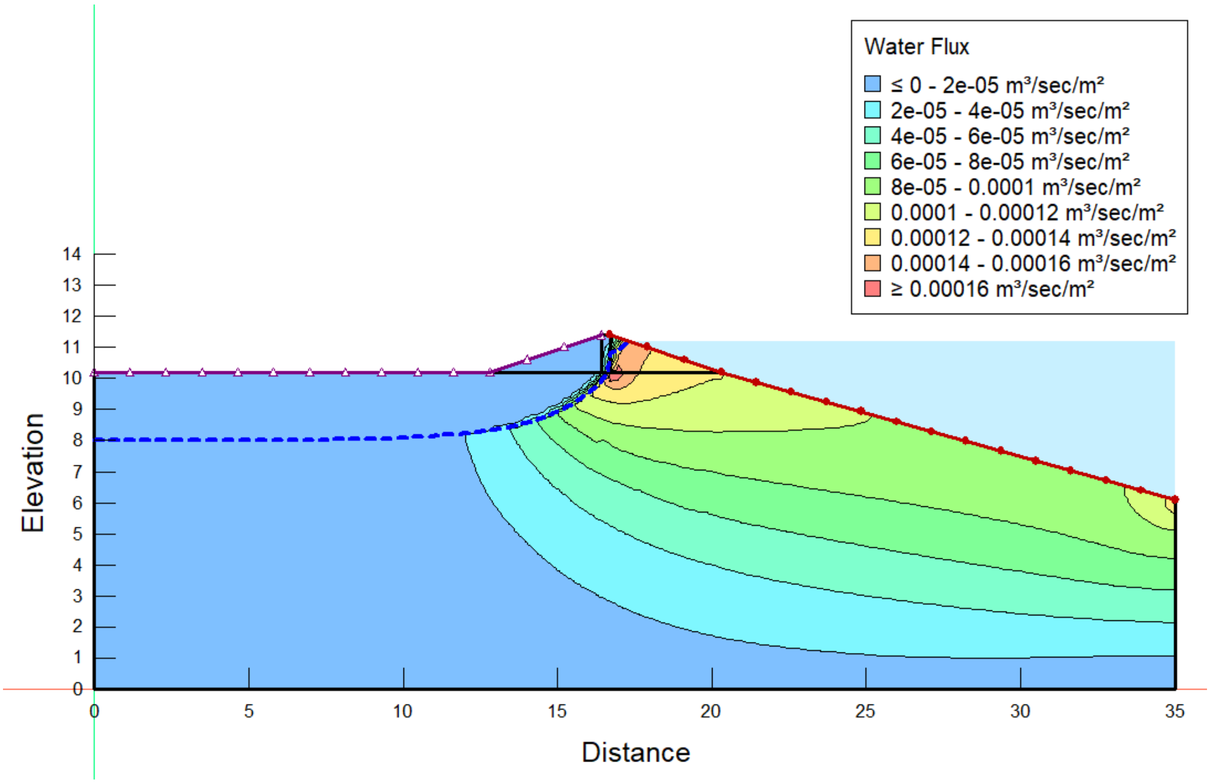
Appendix C - Figure 7: Section 59 Ground Model



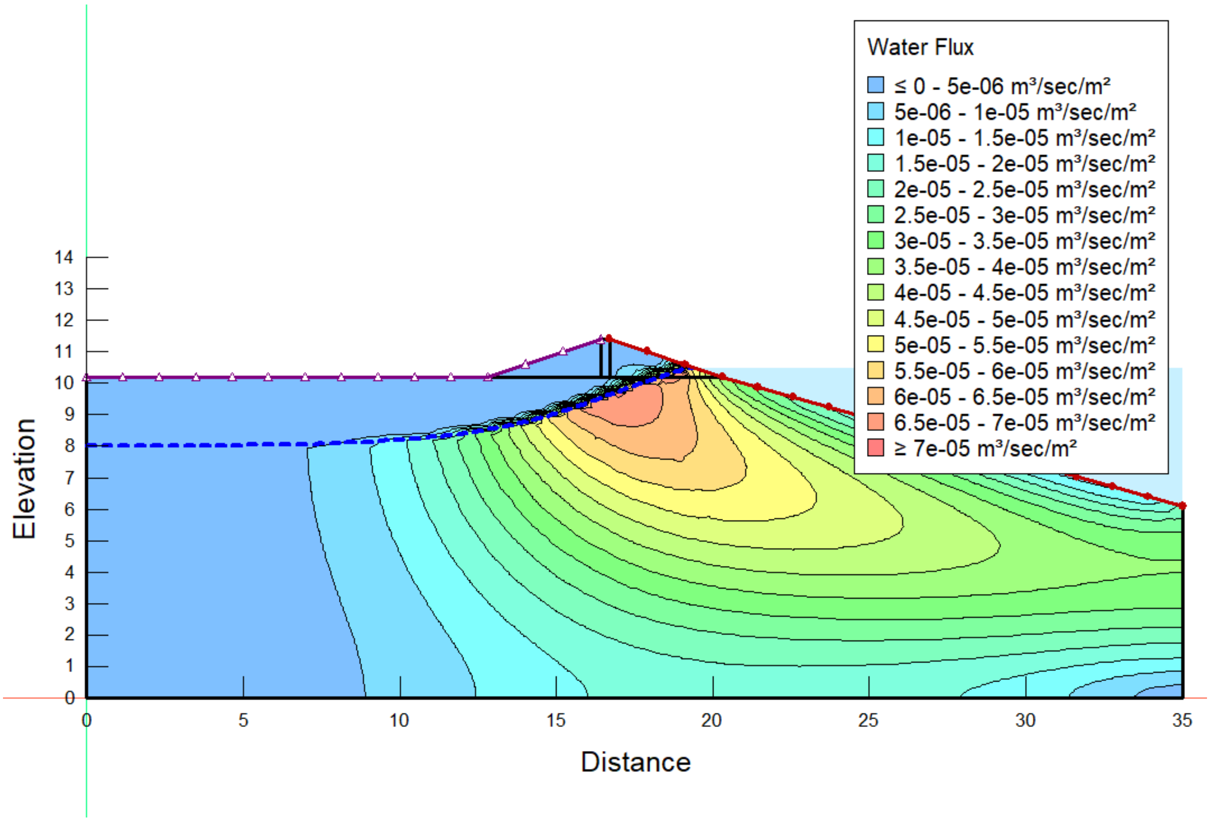
Appendix C - Figure 8 Section 59: Peak Flood: 1.5m cut-off embedment. Water table below GL on dry side.



Appendix C - Figure 9: Section 59: 9 hours Post Peak Flood: 1.5m cut-off embedment. Water table below GL on dry side.



Appendix C - Figure 10: Section 59: Peak Flood: no cut-off. Water table below GL on dry side.



Appendix C - Figure 11: Section 59: 9 hours Post-Peak Flood: no cut-off. Water table below GL on dry side.