Newton Stewart
FLOOD PROTECTION SCHEME

NEWTON STEWART FLOOD PROTECTION SCHEME – SUPPORTING DOCUMENT GEOMORPHOLOGY IMPACT ASSESSMENT

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Sweco UK Limited

Dumfries & Galloway COUNCIL

SWECO

Change list

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1 Introduction

Sweco were commissioned by Dumfries and Galloway Council (DGC) to design a flood protection scheme for the town of Newton Stewart. As part of this work, a fluvial geomorphology and scour assessment was required to inform the design of the scheme.

There are two rivers which flow through Newton Stewart, and are in close proximity to the proposed flood defences: the River Cree and the Penkiln Burn. The reaches of these rivers which pass through Newton Stewart, and will potentially be impacted by the implementation of the flood scheme, were included in the assessment. The extents of the rivers included in the assessment are shown in Figure 2-1.

1.1 Scope

This report summarises the methods and results of the geomorphology and scour assessment and includes the following:

- A desktop review of the available information related to the geomorphology of the site;
- A summary of the methods and results of the river reconnaissance survey undertaken to describe the baseline geomorphic condition of the rivers;
- A scour and erosion assessment to determine what affect the proposed scheme will have on rates of bank erosion and scour on the rivers;
- Proposed solutions and mitigations for areas predicted to have increased bank erosion.

2 Baseline Study

A baseline study was undertaken to determine the baseline geomorphic conditions of the River Cree and the Penkiln Burn. This comprised of both a desktop and field assessment.

The rivers in Newton Stewart were divided into three separate reaches for the purpose of classifying their baseline geomorphic conditions (see Figure 2.1):

1. The River Cree from King George V footbridge at Ghyll Crescent to the B7078 Cree bridge.
2. The River Cree from the B7078 Cree bridge to the A75 road bridge.
3. The Penkiln Burn from the footbridge at Kirkland Farm to the confluence of the River Cree.

Figure 2. 1: Map showing the survey extents for the River Reconnaissance Survey

2.1 Desktop Assessment

Background information related to the physiography and geomorphology of the site were reviewed prior to the field assessment. This included superficial and bedrock geology mapping, historical OS maps, WFD status information, and aerial imagery (Google Earth). The following provides a summary of the information reviewed.

The River Cree is situated on a wide flood plain, surrounded by undulating hills. The flood plain is composed of alluvial deposits (sand, silt and gravel), with the upland areas comprising a mixture of glaciofluvial and glaciomarine deposits. The underlying bedrock is from the Gala Unit, composed of sedimentary wacke[1].

The Penkiln Burn sits in a narrow V-shaped valley as it passes through Minnigaff before meeting the River Cree approximately 400 m north of the Cree Bridge. Both the Penkiln Burn and the River Cree have relatively straight planforms as they pass through Minnigaff and Newton Stewart, respectively.

SEPA's flood maps[2] indicate that there are high rates of geomorphic activity on the rivers within Newton Stewart (Figure 2.2). On the River Cree, there are high erosion rates both upstream and downstream of the Penkiln Burn confluence, and high rates of deposition both upstream and downstream of the Cree Road Bridge and upstream of the A75 Road Bridge. On the Penkiln Burn there are high rates of erosion upstream of the River Cree confluence.

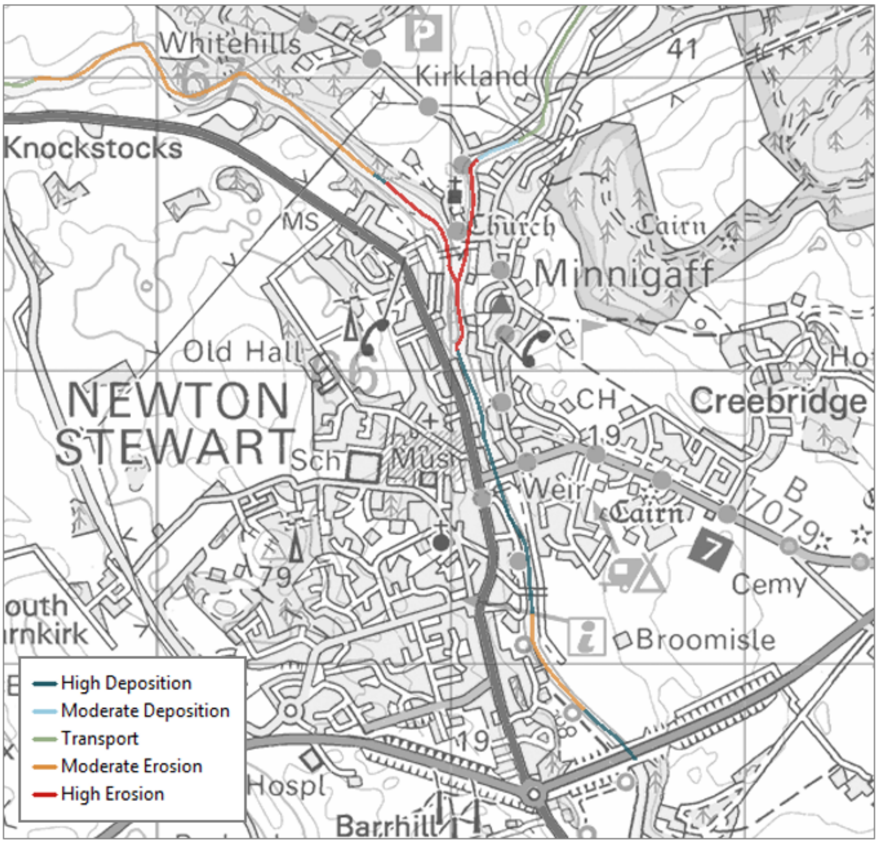

Figure 2. 2: SEPA's Flood map showing rates of geomorphic activity on the River Cree and Penkiln Burn

Analysis of historic OS mapping[3] indicates that the confluence of the Penkiln Burn with the River Cree was previously located approximately 400 m upstream of its present location (Figure 2.3). Land has been built up behind Mill Island to separate the River Cree from the Penkiln Burn, relocating the conference to the south of Mill Island.

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[1] British Geological Survey, Geology of Britain map (http://mapapps.bgs.ac.uk/geologyofbritain3d - accessed 14/08/2018)
[2] SEPA Flood Maps http://map.sepa.org.uk/floodmap/map.htm (accessed 14/08/18)
[3] National Library of Scotland, Georeferenced map viewer (https://maps.nls.uk/geo/explore - accessed 14/08/2018)

Figure 2. 3 Comparison of historical and current OS mapping showing changes in location of the confluence between the River Cree and the Penkiln Burn (A) HIstorical OS map from 1842-1914 (B) Current OS map.

Both the Penkiln Burn and the River Cree are monitored by SEPA, as part of the Water Framework Directive (WFD). The WFD requires that all European Union (EU) countries achieve 'good status' for all ground and surface waterbodies. To achieve 'good status' overall, a waterbody must achieve good status in all the assessment criteria (biological, hydro-morphological, physio-chemical and chemical quality), therefore, deterioration in one of these criteria may result in the waterbody failing to meet the WFD objectives.

In the most recent SEPA waterbody classifications (2016), the River Cree has an overall waterbody status of 'moderate', and a hydro-morphology status of 'good'. The Penkiln Burn has an overall waterbody status of 'good', and a hydro-morphology status of 'good'[4].

2.2 Field Assessment

2.2.1 Methods

A River Reconnaissance Survey was undertaken on August 13th, 2018, using the standard methods and data collection form as detailed in the Stream Reconnaissance Handbook [5]. A River Reconnaissance Survey is a standard geomorphic technique to conduct a rapid geomorphic assessment to characterize the existing geomorphology, and identify the main geomorphic processes occurring on the reach of interest. A River Reconnaissance form was completed for each of the three reaches.

2.2.2 Results

Results of the River Reconnaissance survey are summarised below and are presented in full in Appendix A –. A map indicating the locations of geomorphic processes and morphological pressures is provided in Figure 2.4.

[4] SEPA Water Classification Hub - https://www.sepa.org.uk/data-visualisation/water-classification-hub/ (accessed 14/08/208)
[5] Thorne, C.R. 1998. Stream Reconnaissance handbook, John Wiley and Sons, Chichester, England.

Figure 2. 4 Map showing locations of geomorphic processes and morphological pressures

2.2.2.1 River Cree – King George V Foot Bridge to Cree Road Bridge

The upstream reach of the River Cree has a plane bed morphology: a wide low gradient channel, with a relatively straight planform and rapid-uniform flow. The bed is relatively featureless, and armored by a substrate of cobbles, with some gravels.

There are several morphological pressures on the upstream reach of the River Cree. There is a flood wall, which extends down the right bank, from the confluence with the Penklin Burn to the Cree Road Bridge. There is also extensive hard bank protection, on both banks throughout most of the reach, including the made-ground behind Mill Island. A rip-rap revetment was observed do (Figure 2.5). Flow deflection veins ('croys') are in place both upstream and downstream of the King George V foot bridge. These, combined with the bank protection and armoring, prevent the channel avulsing and returning to a more natural course. In addition, the Cree Road Bridge adds significant morphologic pressure to the river due to the large in-stream bridge footings (Figure 2.6).

Figure 2. 5 (A) Rock mattress reinforcement on the surface of the made-ground behind Mill island. (B) Rip-rap revetment on the left bank of the made-ground behind Mill island.

There was limited evidence of erosion on the banks along the reach. This is likely due to the extensive bank protection and re-grading of the banks throughout most of the reach. Several areas of deposition were observed during the site visit, particularly downstream of the croys in the section upstream of the Penkiln Burn confluence, and upstream of the Cree Bridge (Figure 2.6). There is also a large junction bar at the Penkiln Burn confluence.

Figure 2. 6 Cree Bridge taken from upstream looking downstream. A large depositional bar has been deposited upstream of the bridge.

2.2.2.2 River Cree – Cree Bridge to A75 Road Bridge

Overall the downstream reach has a slightly sinuous planform, and a plain bed morphology with rapid-uniform flow. The River Cree is narrower on this reach compared to the upstream reach, due to the presence of a weir immediately downstream of the Cree Road Bridge. The weir directs flow down the centre of the channel, resulting in deposition at the channel margins downstream, particularly on the left bank.

Figure 2. 7 Photo showing the weir on the River Cree downstream of the Cree Bridge. Deposition has occurred downstream of the weir.

In addition to the weir, there are several other morphological pressures. There is a flood wall located on the right bank of the river between the Cree Road Bridge and the Old Sparling Bridge. There is also extensive bank protection down the right bank of the river, extending from the timber yard to just upstream of the A75 Road Bridge. The bank protection here is in the form of gabion baskets, which were observed to be failing in several locations.

A 30-cm deep tension crack was observed along the edge of the footpath at the top of the right bank, at the bend in the river just upstream of the A75 Road Bridge (Figure 2.8A). The gabion baskets appear to have failed in this section, and the bank is slumping due to erosion at the toe. Downstream of this location, the right bank of the river is undercut due to scour around the A75 Road bridge. A failed outflow pipe, and 'bulging' gabion baskets were observed under the road bridge (Figure 2.8B). The road embankments from the A75 are causing flow constriction under the bridge, resulting in increased scour in this area.

Figure 2. 8 River Cree, close to A75 road bridge (A) Tension crack along the footpath at the top of the right bank, upstream of the bridge. (B) Failed outflow pipe on the right bank under the A7 bridge. (C) Scour under the A75 road bridge (taken from the upstream of the bridge, looking downstream).

2.2.2.3 Penkiln Burn – Kirkland Farm Footbridge to River Cree Confluence

The Penkiln Burn flows through a steep sided V-shaped valley. The planform is relatively straight, and the channel has a step-pool morphology, which transitions to plane bed, with rapid-uniform flow close to the confluence with the River Cree.

The channel bed is composed of cobbles and boulders, with some bedrock exposures in the base and sides of the channel, particularly around the Kirkland Farm footbridge.

There was little evidence of bank erosion on the Penkiln Burn, however basal scour was evident from the exposed bedrock in the base of the channel. Deposition was evident throughout the reach by the presence of lateral and medial bars.

Morphological pressures on the Penkiln Burn include a road bridge, and bank protection along the gardens of the houses upstream of the Penkiln Road Bridge (Figure 2.9, Figure 2.3). Additionally, as noted above, the made-ground behind Mill Island has resulted in relocation of the confluence between the River Cree and the Penkiln Burn. This man-made ground has been reinforced with rock mattresses, which adds pressure to the channel.

Figure 2. 9 Penkiln Burn (A) Bedrock exposed in channel at the Kirkland Farm footbridge. (B) Bank Reinforcement in gardens upstream of the Penkiln road bridge.

3 Scour Assessment

3.1 Methods

A scour and erosion assessment was undertaken for the River Cree and the Penkiln Burn, to determine if the proposed flood scheme would result in increased rates of bank erosion. Cross sectional data and flow depths from the 1D model outputs[6] for the 1 in 2-, and 1 in 200-year flood events, were used to calculate an estimated shear stress at each cross-section, using the slope-depth shear stress equation:

$$\tau = \gamma d s \qquad \text{(Equation 1)}$$

Where shears stress (τ) is calculated using the specific weight of water, and the (γ) depth (d) and surface water slope (s). The specific weight of water was assumed to be 9.807kN/m^3, which is the specific weight of water at 5°C.

During the site visit, both rivers were observed to have a bed substrate composed of particles of gravel size (or above). Based on this observation, the critical shear stress at which particles will mobilise was estimated to be 0.06, from the Shields Curve[7], a well-known and robust method to determine shear stress in channels. Cross sections with shear stress greater than or equal to the critical shear stress of 0.06 were determined to have higher erosion potential, due to the higher shear stress being able to mobilise particles more easily. Cross sections with shear stresses lower than 0.06 were determined to have lower erosion potential, due to shear stress not being high enough to mobilise particles.

Shear stresses for each cross section, estimated from the baseline model, were compared with those estimated from the design model, for both the 1 in 2-year and 1 in 200-year events. It is noted that 1D model outputs used in this analysis can only give an *average* shear stress across a model cross section, and cannot distinguish whether particular sections of the channel have higher shear stresses than others, and vice versa.

3.2 Results

Erosion potential maps for the 1 in 2-year flood event (A) and the 1:200-year flood event (B) are provided in Appendix B. Along with maps showing change in erosion potential between the baseline and design model, for the 1 in 2-year flood event (C) and the 1:200-year flood event (B).

The results indicate that there are extensive areas of high scour potential throughout the lengths of the River Cree and the Penkiln Burn in the project area. A section of potentially high scour is predicted to occur on the upper reach of the Penkiln Burn due to the steep gradient of the channel, resulting in high velocities in this section. However, scour will be limited by the bedrock, which is exposed in the base and sides of the channel. Scour potential is predicted to increase for the 1 in 200-year event, compared to the 1 in 2-year event along the Penkiln Burn. High scour potential is predicted along most of the Penkiln Burn for the 1 in 200-year event.

On the River Cree, extensive areas of potentially high scour are estimated to occur downstream of the Cree Road Bridge and the old Sparling foot bridge. This is likely due to constriction of flow due to the bridge abutments, resulting in increased flow velocities downstream. There is also high erosion potential downstream of the foot bridge at Ghyll Crescent on the River Cree, adjacent to the made ground behind Mill Island. This is likely due to relocation of the confluence with the Penkiln Burn, and higher rates of erosion may be due to the river attempting to return to its natural course.

Scour potential increases for the 1 in 200-year event compared to the 1 in 2-year event along the River Cree. For the 1 in 200-year event potentially high scour is predicted upstream of the A75 road bridge. This is due to the high volume of water backing up behind the bridge, resulting in increased water depths and increased scour.

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[6] Provided by Kaya Consulting 15/08/2018

[7] Shields, A. (1936). Application of similarity mechanics and turbulence research on shear flow. Mitteilungen der Preußischen Versuchsanstalt für Wasserbau. 26. Berlin: Preußische Versuchsanstalt für Wasserbau.

3.3 Mitigation and Recommendations

The need for bank protection was assessed in accordance with SEPA's Good Practice Guide on Bank Protection[8]. As noted above, several extensive sections of high scour potential were predicted on both the Penkiln Burn and the River Cree. Most of the River Cree through Newton Stewart, and parts of the Penkiln Burn already have hard bank protection (Figure 2.3). However, due to the proximity of the flood defences to the river and the need for repair of the bank protection in many areas, some bank protection measures are required.

The gabion baskets along the right bank of the River Cree, from the proposed location of the new Sparling Bridge to the A75 road bridge are showing signs of failure in multiple locations. These will need to be removed as part of the re-profiling of the channel in this section. Due to the high potential for scour in this section, bank protection will still be required for the two-stage channel. Gabion baskets are generally not recommended as, due to their permeability, they are susceptible to failure requiring costly repairs.

A reinforced geotextile with rock-roll toe is recommended for the banks of the two-stage channel (Figure 3-1). The geotextile is robust enough to withstand high flow velocities, and the rock-rolls will prevent toe erosion with the intention to prevent the bank being undermined and collapsing. The geotextile can be seeded to provide vegetation cover for the banks, creating habitat whilst being aesthetically pleasing.

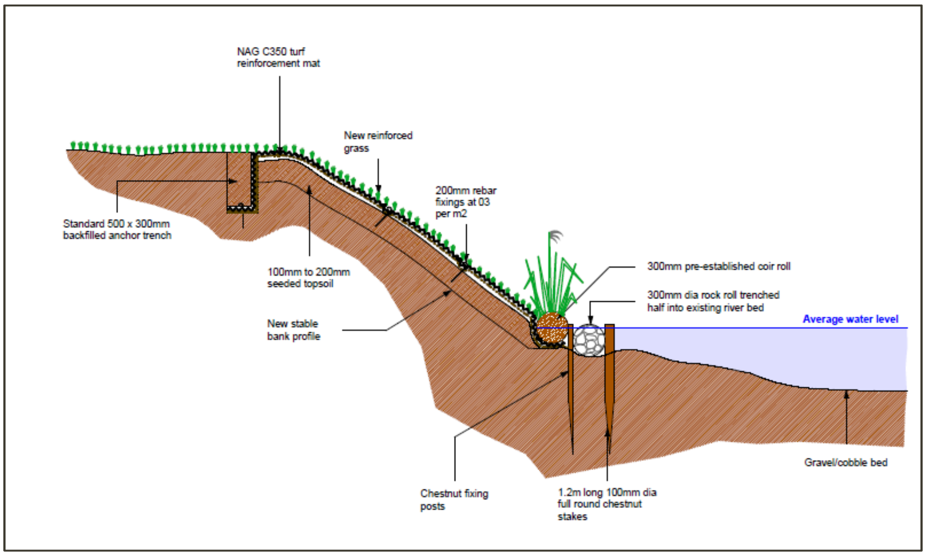


Figure 3-1: Example of a reinforced geotextile with rock roll toe (source: salixrw.com)

Due to the proximity of the proposed flood walls to the tops of the river banks, the defence foundations are potentially at risk from erosion. Where the flood walls or embankments are located along the top of the banks or in-stream, it is recommended that the foundations are protected with a robust bank protection, comprising stacked stones walls to tie into the flood walls, and extended geotextile reinforced banks to tie into the embankments.

4 Summary and Conclusions

The River Cree and the Penkiln Burn flow through Newton Stewart. These are both gravel bed rivers which have the potential to be geomorphologically active according to the scour assessment. Multiple morphological pressures are in place on both watercourses in the form of bridges, extensive bank protection, and relocation of the River Cree and Penkiln Burn confluence.

Several extensive sections of high scour potential were predicted on both the Penkiln Burn and the River Cree. The majority of the River Cree, and parts of the Penkiln Burn already have hard bank protection (Figure 2.5 and Figure 2.9). However, due to the proximity of the flood defences

[8] SEPA (2008) Engineering in the Water Environment Good Practice Guide. Bank Protection: Rivers and Lochs.

to the river, and the need for repairs to the bank protection in many areas, some additional bank protection measures are required. This includes removing the gabion baskets along the section of the River Cree which is to be reprofiled, and replacing them with a reinforced geotextile with rock roll toe.

Appendix A – River Reconnaissance Survey Results

STREAM RECONNAISSANCE RECORD SHEET						
PROJECT	Newton Stewart FPS		**RIVER NAME**	River Cree	**DATE**	13/08/2018
STUDY REACH		**FROM**: King George V Foot Bridge **TO**: Cree Bridge				
UTM COORDINATES						

REGION AND VALLEY DESCRIPTION	**AREA AROUND RIVER VALLEY**	
	Terrain	Hills
	Drainage Pattern	Regular
	Surficial Geology	Till
	Rock Type	-
	Land use	Suburban
	Vegetation	Woodland
	RIVER VALLEY AND VALLEY SIDES	
	Location of River	In valley
	Valley Shape	Symmetrical
	Height of Valley Sides (m)	30 – 50m
	Valley Side Slope angle	20% - 40%
	Valley side failures	None
	FLOOD PLAIN (VALLEY FLOOR)	
	Valley Floor Type	Fragmentary
	Valley Floor Width	1 – 5 river width
	Surficial Geology	Fluvial – alluvium
	Land Use	Suburban
	Vegetation	Shrubs
	Riparian Buffer Strip	Fragmentary
	Width of riparian buffer	<1 river width
	VERTICAL RELATION OF CHANNEL TO VALLEY	
	Terraces	None
	Trash Lines	Absent
	Over bank Deposits	None
	Levees	None
	LATERAL RELATION OF CHANNEL TO VALLEY	
	Planform	Sinuous
	Location in valley	Middle
	Lateral activity	None
	Floodplain Features	None
	Present Status	Adjusted
	Stability Status	Stable
CHANNEL DESCRIPTION	**CHANNEL DIMENSIONS**	
	Average top bank width (m)	25
	Average channel depth (m)	4
	Average water width (m)	15
	Average water depth (m)	1
	Reach slope (%)	1
	Flow type	Uniform/Rapid

	Bed controls	None
	Control types	n/a
	Width controls	Frequent
	Control types	Revetments/Bridge abutments/Dykes and groynes
	BED SEDIMENT DESCRIPTION	
	Bed material	Gravels and cobbles
	Bed armour	None
	Sediment depth (cm)	12
	Bed forms (sand)	Flat bed (none)
	Island or bars	Occasional
	Bar types	Point bars/Mid-channel bars/Junction bars
LEFT BANK	**LEFT BANK CHARACTERISTICS**	
	Type	Composite
	Protection status	Revetments
	Bank materials	Gravel/cobbles
	Average bank height (m)	1
	Average bank slope (%)	65
	Bank profile shape	Straight
	Tension cracks	None
	Crack depth (m)	-
	LEFT BANK VEGETATION	
	Vegetation	Artificially cleared/shrubs/trees
	Tree types	Deciduous
	Density and spacing	Sparse/clumps
	Roots	Normal
	Location of Vegetation	Whole bank
	Diversity	Mixed stand
	Health	Healthy
	Age	Mature
	Height (m)	12
	Lateral extent	Single row
	Left bank photo	
	LEFT BANK EROSION	
	Extent of erosion	n/a
	Erosion Location	General
	Present Status	Intact
	Severity of erosion	n/a
	Erosion processes	Parallel flow
	Distribution on bank	Whole bank
	LEFT BANK FAILURES	
	Geotechnical failure scars and blocks	None
	LEFT BANK TOE SEDIMENT ACCUMULATION	
	Stored Bank Debris	Cobbles/boulders
	Vegetation	None/fallow
	Roots	Normal
	Toe bank profile	Planar
RIG HT	**RIGHT BANK CHARACTERISTICS**	
	Type	Non-cohesive

	Protection status	Hard points
	Bank materials	Gravel/cobbles
	Average bank height (m)	1.5
	Average bank slope (%)	100
	Bank profile shape	Straight
	Tension cracks	Occasional
	Crack depth (m)	0.3
	RIGHT BANK VEGETATION	
	Vegetation	Artificially cleared/Shrubs/Trees
	Tree types	Deciduous
	Density and spacing	Sparse/clumps
	Roots	Normal
	Location of vegetation	Upper bank
	Diversity	Mixed stand
	Health	Fair
	Age	Mature
	Height	12
	Lateral extent	Single row
	RIGHT BANK EROSION	
	Extent of erosion	n/a
	Erosion Location	General
	Present Status	Intact
	Processes	Parallel flow
	Stored bank debris	Cobbles/boulders
	Vegetation	-
	Roots	-
	Distribution on bank	Whole bank
	RIGHT BANK FAILURES	
	Geotechnical failure scars and blocks	None
	Failure Locations	n/a
	Present Status	Stable
	Instability severity	n/a
	Instability extent	n/a
	Failure mode	n/a
	Distribution of Failure	n/a
	RIGHT BANK TOE SEDIMENT ACCUMULATION	
	Present debris storage	Some bank debris
	Vegetation	None/fallow
	Age	-
	Stored bank debris	Cobbles/boulders
	Roots	Normal
	Toe bank profile	Planar

STREAM RECONNAISSANCE RECORD SHEET					
PROJECT	Newton Stewart FPS	**RIVER NAME**	River Cree	**DATE**	13/08/2018
STUDY REACH		**FROM**: Cree bridge **TO**: A75 Bridge			
UTM COORDINATES					

REGION AND VALLEY DESCRIPTION

AREA AROUND RIVER VALLEY	
Terrain	Plains
Drainage Pattern	Regular
Surficial Geology	Fluvial
Rock Type	
Land use	Suburban
Vegetation	Agricultural land
RIVER VALLEY AND VALLEY SIDES	
Location of River	On alluvial plain
Valley Shape	Asymmetrical
Height of Valley Sides (m)	5 – 10m
Valley Side Slope angle	< 20%
Valley side failures	none
FLOOD PLAIN (VALLEY FLOOR)	
Valley Floor Type	Indefinite
Valley Floor Width	>10 river widths
Surficial Geology	Fluvial – alluvium
Land Use	Suburban
Vegetation	Unimproved grassland
Riparian Buffer Strip	Fragmentary
Width of riparian buffer	<1 river width
VERTICAL RELATION OF CHANNEL TO VALLEY	
Terraces	None
Trash Lines	Absent
Over bank Deposits	None
Levees	None
LATERAL RELATION OF CHANNEL TO VALLEY	
Planform	Straight
Location in valley	Middle
Lateral activity	None
Floodplain Features	None
Present Status	Adjusted
Stability Status	Stable

CHANNEL DESCRIPTION

CHANNEL DIMENSIONS	
Average top bank width (m)	20
Average channel depth (m)	3
Average water width (m)	20
Average water depth (m)	1.5
Reach slope (%)	1
Flow type	Uniform/Rapid
Bed controls	None

	Control types	n/a
	Width controls	Occasional
	Control types	Boulders/Revetments/Bridge abutments/Dykes and groynes
	BED SEDIMENT DESCRIPTION	
	Bed material	Gravels and cobbles
	Bed armour	None
	Sediment depth (cm)	10
	Bed forms (sand)	Flat bed (none)
	Island or bars	Occasional
	Bar types	Point bars/Mid-channel bars
LEFT BANK	**LEFT BANK CHARACTERISTICS**	
	Type	Composite
	Protection status	Revetments
	Bank materials	Gravel/cobbles
	Average bank height (m)	1
	Average bank slope (%)	85
	Bank profile shape	Straight
	Tension cracks	Occasional
	Crack depth (m)	0.3
	LEFT BANK VEGETATION	
	Vegetation	Grass and flora/shrubs/trees
	Tree types	Deciduous
	Density and spacing	Sparse/clumps
	Roots	Normal
	Location of Vegetation	Whole bank
	Diversity	Mixed stand
	Health	Healthy
	Age	Mature
	Height (m)	15
	Lateral extent	Narrow belt
	LEFT BANK EROSION	
	Extent of erosion	General
	Erosion Location	n/a
	Present Status	Intact
	Severity of erosion	n/a
	Erosion processes	Parallel flow
	Distribution on bank	Whole bank
	LEFT BANK FAILURES	
	Geotechnical failure scars and blocks	None
	LEFT BANK TOE SEDIMENT ACCUMULATION	
	Stored Bank Debris	Small soil blocks
	Vegetation	Shrubs
	Roots	Normal
	Toe bank profile	Planar
RIGHT BANK	**RIGHT BANK CHARACTERISTICS**	
	Type	Composite
	Protection status	Hard points

	Bank materials	Gravel/cobbles
	Average bank height (m)	1
	Average bank slope (%)	85
	Bank profile shape	Straight
	Tension cracks	Occasional
	Crack depth (m)	0.3
	RIGHT BANK VEGETATION	
	Vegetation	Grass and flora/Shrubs/Trees
	Tree types	Deciduous
	Density and spacing	Sparse/clumps
	Roots	Normal
	Location of vegetation	Whole bank
	Diversity	Mixed stand
	Health	Healthy
	Age	Mature
	Height	15
	Lateral extent	Narrow belt
	RIGHT BANK EROSION	
	Extent of erosion	n/a
	Erosion Location	General
	Present Status	Intact
	Processes	Parallel flow
	Stored bank debris	-
	Vegetation	-
	Roots	-
	Distribution on bank	Whole bank
	RIGHT BANK FAILURES	
	Geotechnical failure scars and blocks	None
	Failure Locations	n/a
	Present Status	Stable
	Instability severity	n/a
	Instability extent	n/a
	Failure mode	n/a
	Distribution of Failure	n/a
	RIGHT BANK TOE SEDIMENT ACCUMULATION	
	Present debris storage	Little bank debris
	Vegetation	None/fallow
	Age	-
	Health	-
	Roots	Normal
	Toe bank profile	Planar
	Present debris storage	Little bank debris

STREAM RECONNAISSANCE RECORD SHEET					
PROJECT	Newton Stewart FPS	**RIVER NAME**	Penkiln Burn	**DATE**	13/08/2018
STUDY REACH		**FROM**: Kirkland Farm Foot Bridge **TO**: Confluence with River Cree			
UTM COORDINATES					

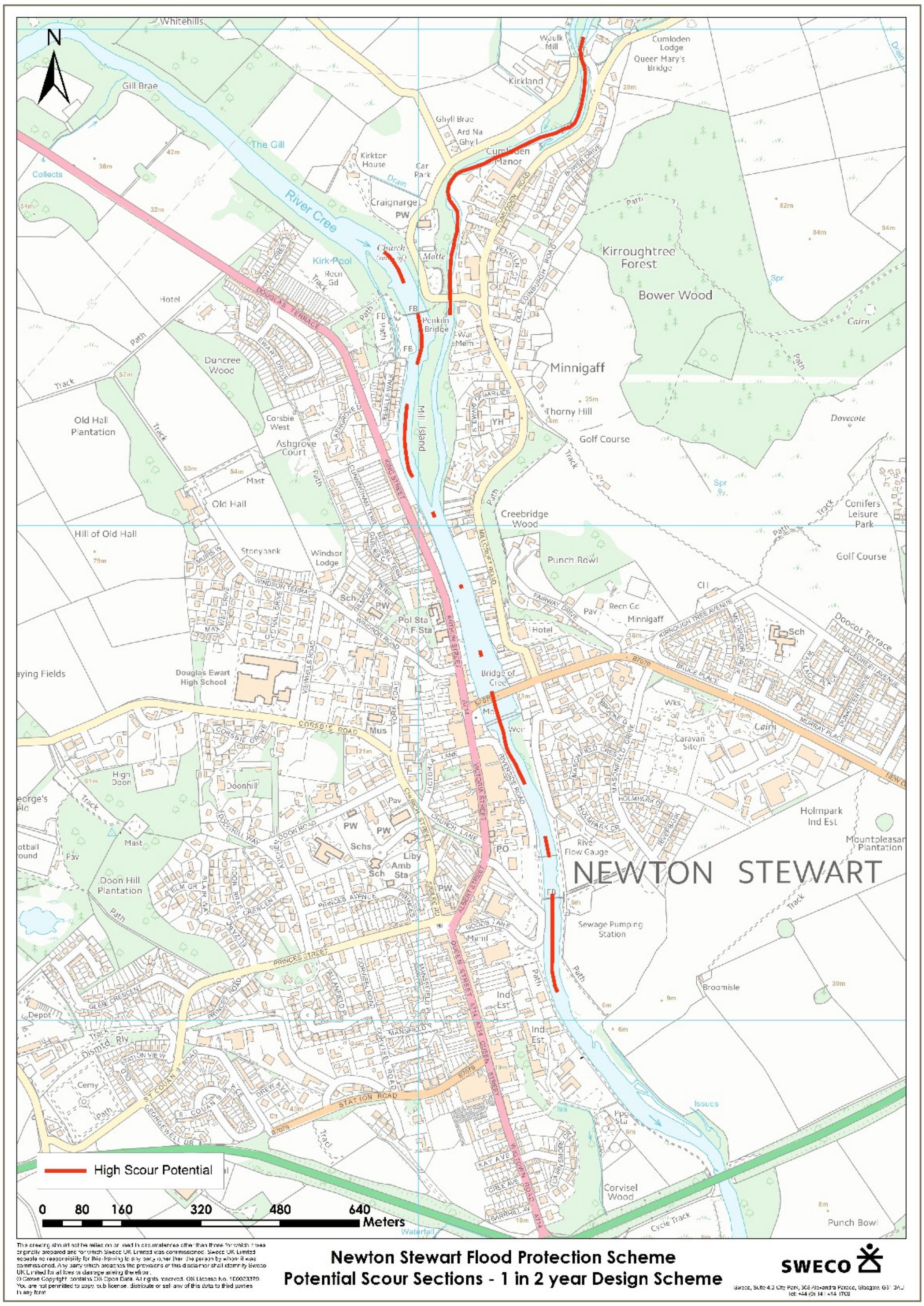
REGION AND VALLEY DESCRIPTION	**AREA AROUND RIVER VALLEY**	
	Terrain	Hills
	Drainage Pattern	Regular
	Surficial Geology	Till
	Rock Type	-
	Land use	Suburban
	Vegetation	Woodland
	RIVER VALLEY AND VALLEY SIDES	
	Location of River	In valley
	Valley Shape	Asymmetrical
	Height of Valley Sides (m)	30 – 60m
	Valley Side Slope angle	60% - 100%
	Valley side failures	None
	FLOOD PLAIN (VALLEY FLOOR)	
	Valley Floor Type	None
	Valley Floor Width	None
	Surficial Geology	Bedrock
	Land Use	Suburban
	Vegetation	Deciduous forest
	Riparian Buffer Strip	Continuous
	Width of riparian buffer	1 - 5 river width
	VERTICAL RELATION OF CHANNEL TO VALLEY	
	Terraces	None
	Trash Lines	Absent
	Over bank Deposits	None
	Levees	None
	LATERAL RELATION OF CHANNEL TO VALLEY	
	Planform	Straight
	Location in valley	Right
	Lateral activity	None
	Floodplain Features	None
	Present Status	Adjusted
	Stability Status	Stable
CHANNEL DESCRIPTION	**CHANNEL DIMENSIONS**	
	Average top bank width (m)	25
	Average channel depth (m)	5
	Average water width (m)	15
	Average water depth (m)	0.5
	Reach slope (%)	5

	Flow type	Steep and step-pool
	Bed controls	Occasional
	Control types	Solid bedrock/Boulders
	Width controls	Occasional
	Control types	Bedrock/boulders/Revetments/Bridge abutments
	BED SEDIMENT DESCRIPTION	
	Bed material	Cobbles and boulders
	Bed armour	None
	Sediment depth (cm)	-
	Bed forms (sand)	Flat bed (none)
	Island or bars	Occasional
	Bar types	Mid-channel bars/Junction bars
LEFT BANK	**LEFT BANK CHARACTERISTICS**	
	Type	Cohesive
	Protection status	Hard points
	Bank materials	Sand/silt/clay
	Average bank height (m)	5
	Average bank slope (%)	60
	Bank profile shape	Straight concave
	Tension cracks	None
	Crack depth (m)	-
	LEFT BANK VEGETATION	
	Vegetation	Trees
	Tree types	Deciduous
	Density and spacing	Sparse/continuous
	Roots	Normal
	Location of Vegetation	Whole bank
	Diversity	Mixed stand
	Health	Fair
	Age	Mature
	Height (m)	10
	Lateral extent	Wide belt
	Left bank photo	
	LEFT BANK EROSION	
	Extent of erosion	n/a
	Erosion Location	General
	Present Status	Intact
	Severity of erosion	n/a
	Erosion processes	Parallel flow
	Distribution on bank	Whole bank
	LEFT BANK FAILURES	
	Geotechnical failure scars and blocks	None
	LEFT BANK TOE SEDIMENT ACCUMULATION	
	Present debris storage	Some bank debris
	Stored Bank Debris	Cobbles/boulders
	Vegetation	None/fallow
	Roots	Normal

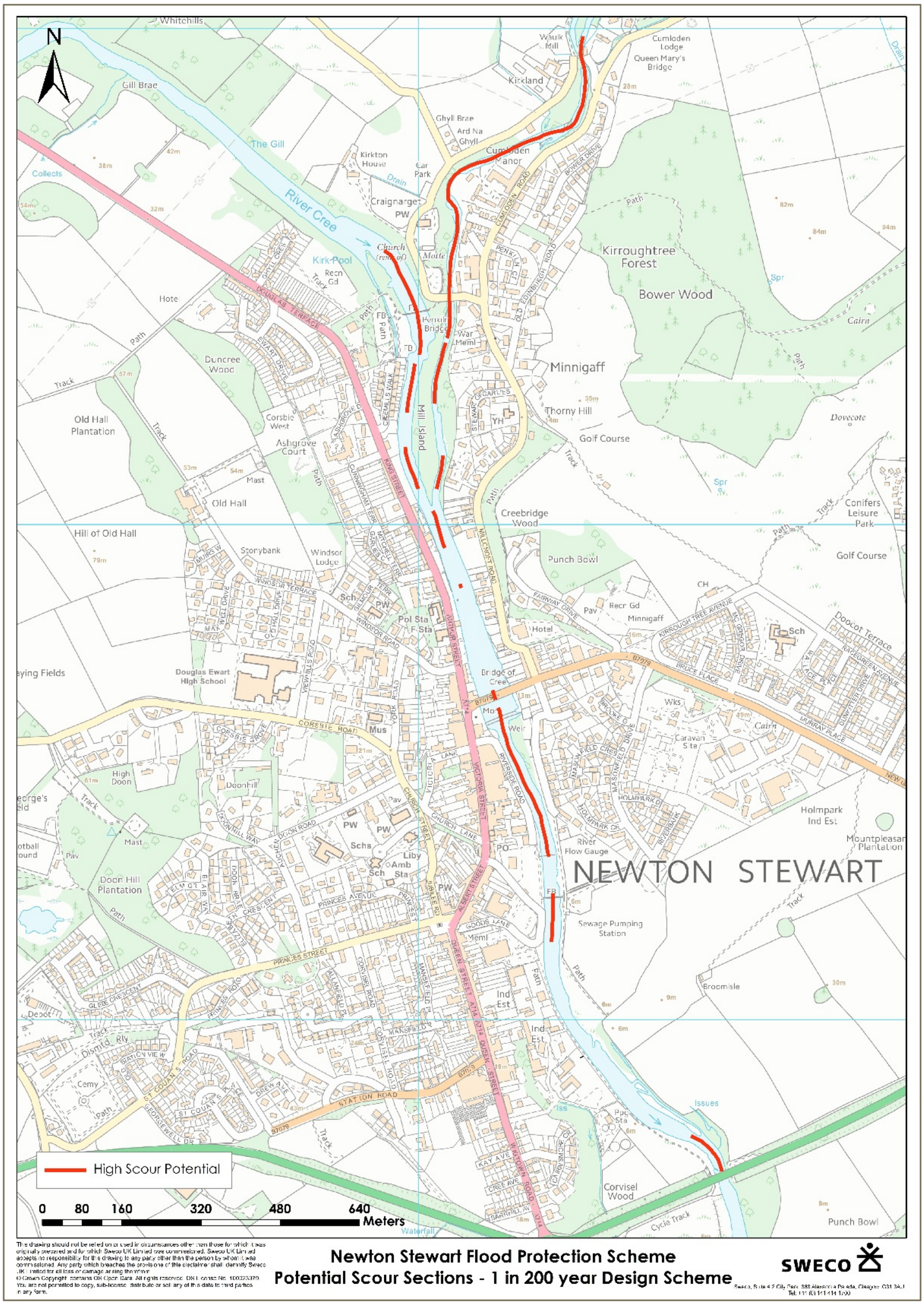
	Sediment balance	Steady state
	Toe bank profile	Planar
RIGHT BANK SURVEY	**RIGHT BANK CHARACTERISTICS**	
	Type	Cohesive
	Protection status	Unprotected
	Bank materials	Sand/silt/clay
	Average bank height (m)	20
	Average bank slope (%)	75
	Bank profile shape	Straight concave
	Tension cracks	None
	Crack depth (m)	0.3
	RIGHT BANK VEGETATION	
	Vegetation	Trees
	Tree types	Deciduous
	Density and spacing	Sparse/continuous
	Roots	Normal
	Location of vegetation	Whole bank
	Diversity	Mixed stand
	Health	Fair
	Age	Mature
	Height	15
	Lateral extent	Wide belt
	RIGHT BANK EROSION	
	Extent of erosion	n/a
	Erosion Location	General
	Present Status	Intact
	Processes	Parallel flow
	Stored bank debris	Cobbles/boulders
	Vegetation	-
	Roots	-
	Distribution on bank	Whole bank
	RIGHT BANK FAILURES	
	Geotechnical failure scars and blocks	None
	Failure Locations	n/a
	Present Status	Stable
	Instability severity	n/a
	Instability extent	n/a
	Failure mode	n/a
	Distribution of Failure	n/a
	RIGHT BANK TOE SEDIMENT ACCUMULATION	
	Present debris storage	Some bank debris
	Vegetation	None/fallow
	Age	-
	Stored bank debris	Cobbles/boulders
	Roots	Normal

	Toe bank profile	Concave/upwards
	Sediment balance	Accumulating

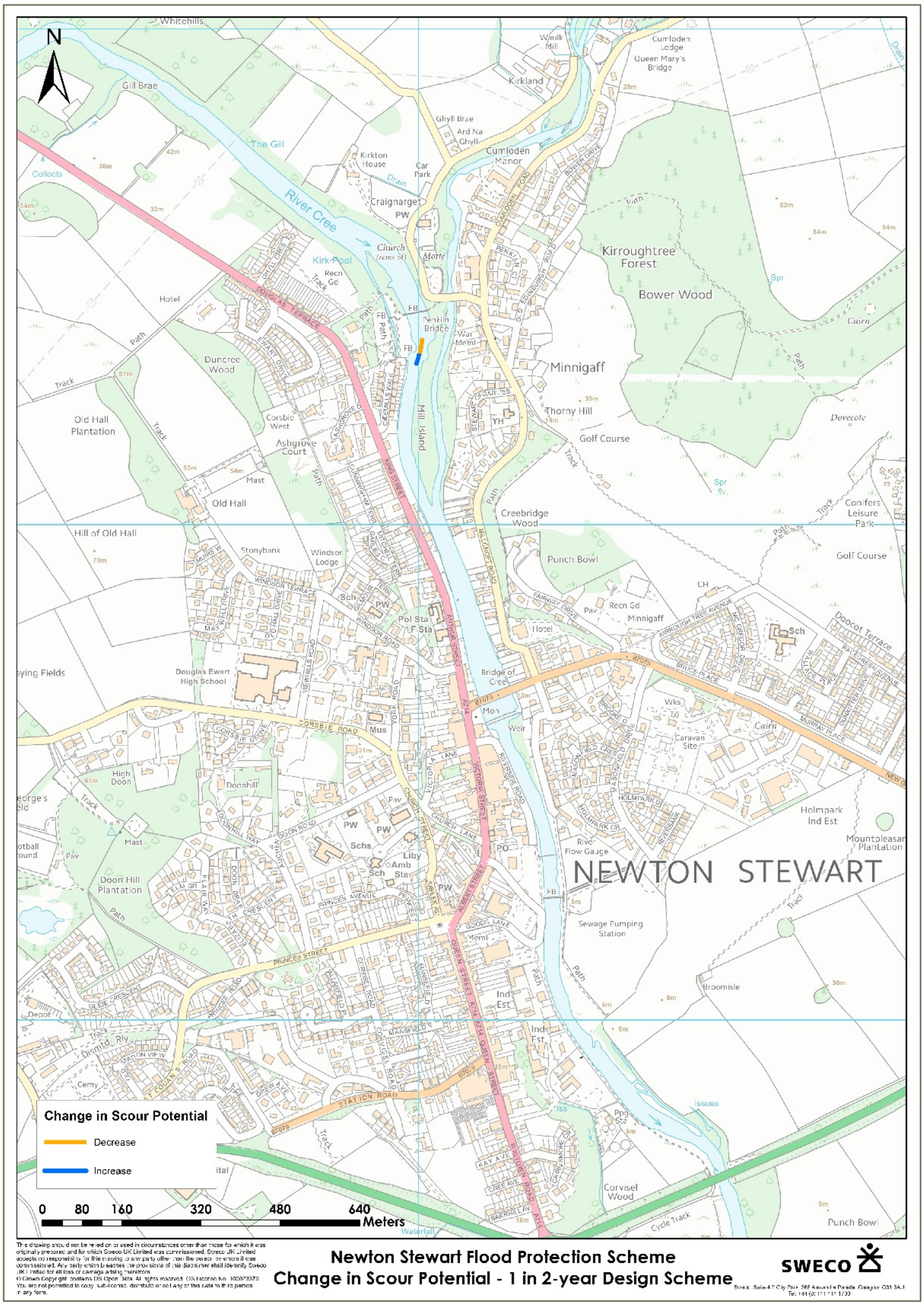
Appendix B – Scour Potential 1 in 2-year Event



Appendix C - Scour Potential 1 in 200-year Event



Appendix D - Change in Scour Potential Post Design - 1 in 2-year Event



Appendix E - Change in Scour Potential Post Design - 1 in 200-year Event