Summary Note

Document Control Sheet

Project Name:	Newry FAS - Phase 1
Project Number:	CO401607
Report Title:	Summary Note – Knox-Peebles Drain (D1)
Report Number:	01

This technical note outlines the constraints and considerations relating to the environmental and geotechnical design of the various elements to the Knox Peebles Flood Defence.

Proposed Works

The feasibility study suggested that the works proposed at this location were *"to construct either a flood wall or flood embankment at these locations to contain the flow within the channel and prevent flooding."* The maximum water level was 1.80mAOD (including 0.6m for freeboard), stating that the requirement for the defence length was split into 2no. sections (450m and 200m). It was also recommended that the bank be checked to this level, so the defence was consistent throughout its length.

Figure 2 - Flooding at PWS, Greenbank Industrial Estate

Figure 1 - Flooding at PWS, Greenbank Industrial Estate

During detailed design by Amey Consulting, an update to the modelling exercise concluded with a required height of 2.15mAOD for the flood defence. It was agreed that the length of the defence would stop short of the proposed 'Southern Relief Road' and those works could tie into the flood defences constructed for Newry FAS – Phase 1 at the required height.

D1 - Warrenpoint Road

Model results show with an embankment located along the right bank of the drainage ditch, the commercial properties in the industrial estate that were shown to flood in the baseline scenario are shown to be flood free in the option scenario during the 1% AEP plus 20% CC event.

The maximum in-channel water level in the upstream reach (model reference: NK1991_Break, IGR 308985 325136) during the 1% AEP plus 20% CC event is 1.51m AOD and the maximum in-channel water level in the downstream reach (model reference NK915_Break, IGR 309788, 323765) is 1.50m AOD. With an allowance of 600mm freeboard, the recommended minimum crest level for the wall is 2.11m AOD and 2.10m AOD respectively. Bank levels vary from 0.76m AOD to 2.12m AOD along the right bank of the drainage ditch.

Figure 3 – Modelling results for Knox-Peebles (Extracted from "Newry Summary Note")

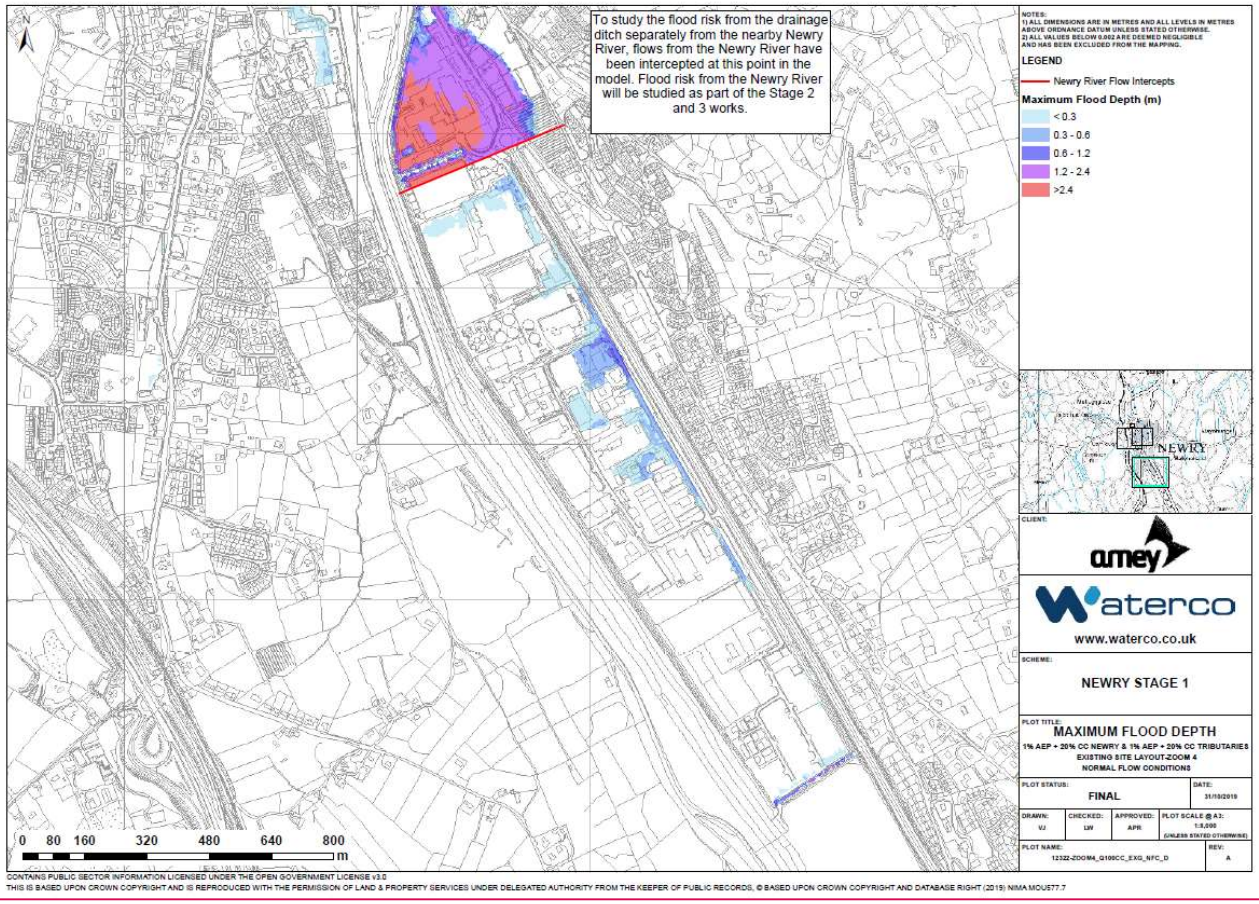


Figure 4 - Baseline flooding (Q100+CC) at Greenbank Industrial Estate (Extracted from "Newry Summary Note")

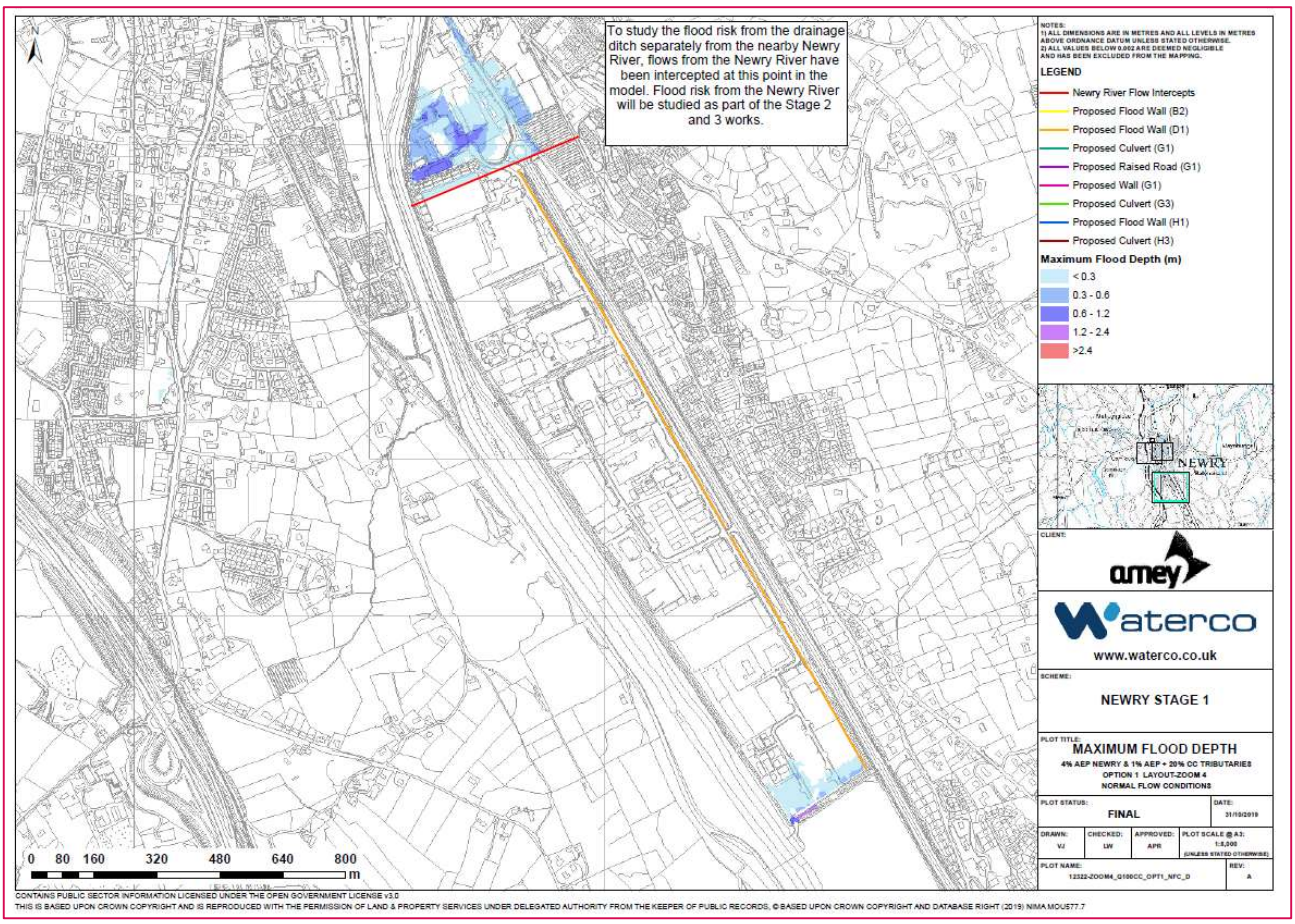


Figure 5 - Q100+CC flood maps with option implemented (Extracted from "Newry Summary Note")

Concerns Raised

Concerns have been raised with the site clearance of mature oak trees to enable the flood defence construction works at Knox Peebles, where an earth embankment and Redi-Rock retaining wall is proposed.

Design Consultations, Constraints & Considerations

- During the consultation period, leading to the Drainage Council review, Forestry Service was consulted to identify any areas of trees that may have been of concern. A response was received on 24/10/2019 from [redacted] to request further discussion on sites B2 (Downshire Road), H1 (Craigmore Road) and H3 (Armagh Road Drain). After discussing the sites, it was clarified that the areas of concern were outside of our works. On 31/10/2019 [redacted] confirmed the following *"Thank you for clarifying that no part of the woodlands shown on the H1, H3 and B2 sites will be affected by the proposed works. Forest Service has no further comments to make and does not object to the proposal."*

- Initially, the design focused on the installation of sheet piling set back from the kerb line, leaving room for the existing VRS barrier over the entire length of the site, circa 1050m. The installation of sheet piling to form the flood defence over the first circa 700m was determined by the lack of available space and the ground conditions, indicating a high level of seepage, therefore requiring sheet piling.

- Between circa Ch700 to Ch1050m exists an additional width of river embankment. Continuation of the sheet pile proposal would require a number of mature trees to be cleared to enable the flood defence construction. To continue the sheet piling option, as per circa

Ch0-700m, would require the mature trees to be cleared to avoid the risk of future failure, as discussed further below. Therefore, a more aesthetically pleasing earth embankment with a Redi-rock retaining wall structure was proposed and designed. This solution provides defence against flooding, while lessening the seepage issue and avoiding the need for an additional 350m of VRS.

- Both sides of Knox Peebles Stream are heavily vegetated. Consideration was given to avoid the loss of the trees/vegetation on the Warrenpoint Rd side of the site. Due to the existing topography, a minimal increase in embankment height was achieved without required a solid defence to be constructed. Unfortunately, the loss of some mature trees was considered necessary if any flood defence was to be constructed on the Greenbank Industrial Estate side.

Environmental Constraints & Considerations

- Environmental site walkovers were carried out by the Amey environmental team during the preliminary and detailed design of the scheme. At Knox Peebles Stream the location of invasive species and mature trees was mapped using GIS to inform the detailed design of the flood defences. The majority of the vegetation between the stream and the road though Greenbank Industrial Estate was self-seeded, young saplings, scrub and stands of Japanese knotweed and giant hogweed. There were a number of mature oak trees, that had been planted along the bank previously. These trees did not appear to have been maintained recently, the trunks had heavy ivy growth and some cracks/holes in branches. Some of them had been cut down some years previously with some stumps left on the site. Some of the remaining trees did not appear to be in good health and in some cases the roots of the trees have been undermined by Knox Peebles Stream.

- A desk study was also carried out during the design process and the site was not in an area with Tree Preservation Orders.

- Due to their maturity, cracks in the branches and the ivy cover, these oak trees were considered to have some potential to support roosting bats. Therefore a requirement was included in the contract documents for the contractor to undertake bat roost potential surveys prior to site clearance. Also, the trees and scrub had potential to support nesting birds. As such, there was a requirement for the contractor to undertake vegetation clearance outside of the bird nesting season to ensure no impact on nesting birds using the vegetation or found along the stream. Any delay to the required clearance of the trees has the potential to delay the flood alleviation scheme until such times that trees can be felled safely in the knowledge that bat roosting is not an issue.

- The section between CH700 and Ch 1050m included a little extra space for the inclusion of an alternative flood defence. Consideration was given to extending the sheet piling, but the issue of the mature trees and potential root structure would mean that the trees would need to be removed, to avoid the future risk of the trees falling causing potential to injure/kill people or damage passing vehicles.

Geotechnical Constraints & Considerations

The first stage of the geotechnical design process was to obtain historic exploratory hole information and carry out a site-specific ground investigation (GI) along the proposed flood defence location. There was a total of 16 No. exploratory holes obtained from the historic and recent GI's relevant to the design.

The GI information was used to derive different ground models along the flood defence. Notably all ground models derived contained soils predominantly granular in nature. The shallow soils comprised predominantly Granular Made Ground and Granular Raised Marine Deposits to maximum

recorded depth of 8.59m below ground level. Hydraulic conductivities (permeabilities) of 1x10-4 and 3.5x10-5 m/s were assigned to these materials respectively using testing obtained during the ground investigations; these values were used in seepage analysis of multiple site cross sections by modelling the proposed flood defences and ground to determine the cut-off levels required to reduce seepage flow to acceptable levels.

Along the 1050m length of flood defence, the maximum flood height was modelled as 1.53m. The defence types proposed after detailed design were a combination of embedded sheet pile wall, embedded king post wall and earth bund. A minimum design life of 120 years was required for all the proposed flood defence elements in accordance with BS EN 1990:2002.

It should be noted that the alignment of the flood defences was assumed to be fixed locations as dictated by the hydraulic modelling carried out.

The constraints and considerations when deciding upon what type and detail of flood wall required at each section of the flood defence included the following;

- A highways design stipulation was imposed by requiring a minimum 1m clearance of the proposed flood wall from the existing VRS (vehicle restraint system).

- Flood embankment design is based upon CIRIA 731 'The international Levee Handbook' and CIRIA 749 'Application of Eurocode 7 to the design of flood embankments.' Design consideration to the earth bund sections was given to sufficiently controlling seepage and erosion, both through and beneath the embankment; whilst ensuring hydraulic uplift would not occur. The performance and durability of a flood embankment, in relation to seepage and erosion, was controlled through the selection of an appropriate fill material or installation of sheet pile through its centre. The clay core option specified a low permeability (less than 1 x 10-6m/s) which sufficiently inhibits the passage of water through the embankment. Typically, fine-grained silts and granular sands are more vulnerable to erosion and granular soils generally have higher permeabilities (more than 1 x 10-6m/s). Flood embankments would not typically be constructed solely using granular materials without additional measures in place to deal with seepage.

- Limited space was available between road and river-bank along a large section of the defence (CH12-CH712) meaning a conventional unreinforced earth bund was not feasible as this defence type would require typical slope gradients of 1:3 (if using low permeable cohesive fill exclusively) as dictated by slope stability analysis carried out in accordance with Eurocode 7 and allowing for a typical crest width of 3m in accordance with CIRIA C731 guidance; International Levee handbook. This resulted in an earth bund with cross sectional footprint more than 12m which was not available between the above chainages. This defence type was considered possible between CH0-12 and CH682-1069 due to the greater space available along these sections although slope gradients up to a maximum of 1:2 were proposed by using engineered granular fill within the earth bund as required to achieve long-term slope stability.

- The ground conditions; The presence of Made Ground (inherently variable in nature and strength) and the low strength Raised Marine Deposits led to shallow foundations not being exclusively feasible without significant dig and replace below formation level; such excavation would encroach into carriageway, potentially be unstable and require groundwater pumping. Replacement with granular fill was also not feasible due to the seepage pathway this would create. Additionally, bearing resistance of spread foundations was significantly reduced due to the proximity to the steep gradient of the slope towards the river. The modelling of flood water pressure behind a spread founded wall would increase the bearing pressure at the edge of the foundation due to the eccentric loading the flood water pressure induces. These reasons led design options towards an embedded wall solution between CH12-712.

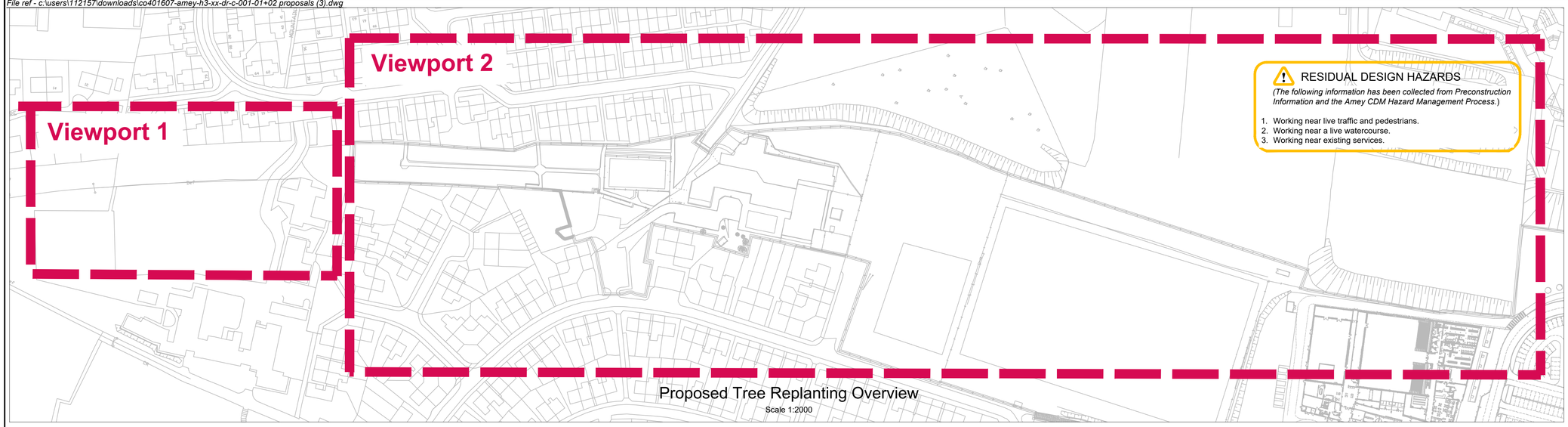
- The groundwater conditions; a high groundwater level was modelled as indicated by the GI which exerted a hydrostatic pressure behind the embedded flood wall during the normal river level condition. The existing groundwater conditions made spread foundation less feasible and had an influence on the embedment wall depth and details.

- Due to the high hydraulic conductivities of the granular soils (as previously referenced) seepage cut off was required to prevent excessive flow through the granular soils in a flood scenario. As spread foundations were deemed unfeasible between CH12-712, the embedded wall option had to incorporate a seepage cut off element; sheet piling would achieve this by its very nature of providing a continuous impermeable barrier along the level it is embedded to. Carrying out seepage analysis demonstrated the reduction of seepage flow by modelling the sheet piles to their proposed embedment level. The use of king posts as an alternative for the entire length between CH12-712 was rejected due to the low performance of this embedded wall type in relation to seepage cut-off.

- At 5 No. locations along the embedded wall section existing services prevented continuous sheet piling between CH12-712. At these locations spanning of services was achieved by proposing localised King Post embedded wall sections. These areas provided high seepage flows to occur during a flood condition, but this has been allowed for in the seepage assessment of the flood defence. The effect of the high flows across these short sections is counterbalanced by the very low seepage rate assessed for the sheet piled sections resulting in an overall seepage volume that is acceptable.

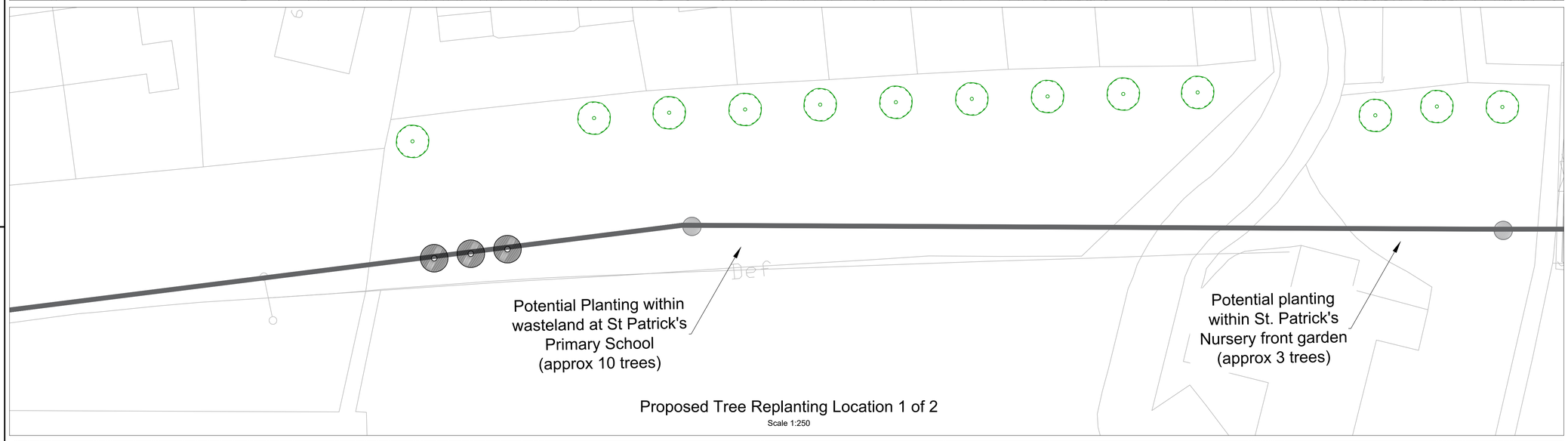
File ref - c:\users\112157\downloads\co401607-amey-h3-xx-dr-c-001-01+02 proposals (3).dwg

0 100



Proposed Tree Replanting Overview

Scale 1:2000



Proposed Tree Replanting Location 1 of 2

Scale 1:250

Proposed Tree Replanting Location 2 of 2

Scale 1:1000

Notes

1. All dimensions are in meters, unless specified otherwise.
2. All levels are in meters above ordnance datum.
3. All species of replanted trees to be agreed with Client and Project Manager before ordered.
4. All areas marked on drawing for guidance only, discussions with landowners required before planting.
5. No replanting to be undertaken that could potentially comprimise proposed culvert or manhole.

Key

- Proposed Culvertline (for reference)
- Proposed Manholes (for reference)
- Potential Tree Replanting area
- Tree

Avenue Trees planted at 10m centres

Alnus glutinosa "Common Alder"
Size: 16-18cm
Description: Advanced Nursery Stock
Height: 4.0-4.5m
(Very adaptable tree will tolerate wet marginal land, dry land and moderately tolerant of salt)

Betula pendula "Silver Birch"
Size: 16-18cm
Description: Advanced Nursery Stock
Height: 4.0-4.5m

Carpinus betulus "Common Hornbeam"
Size: 16-18cm
Description: Advanced Nursery Stock
Height: 4.0-4.5m
(Thrives in heavy soil tolerant of periodic water logging, Not great in very dry soils)

Prunus avium 'Plena' "Cherry"
Size: 16-18cm
Description: Advanced Nursery Stock
Height: 4.0-4.5m

Pyrus calleryana 'Chanticleer'
Size: 16-18cm
Description: Advanced Nursery Stock
Height: 4.0-4.5m

Standalone Specimen Trees

Fagus Sylvatica "Common Beach"
Size: 16-18cm
Description: Advanced Nursery Stock
Height: 4.0-4.5m
(Tree size when fully mature 6m canopy X 10m in height)

Acer campestre "Field Maple"
Size: 16-18cm
Description: Advanced Nursery Stock
Height: 4.0-4.5m
(Tree size when fully mature 7m canopy X 10m in height)

Pinus sylvestris "Scots Pine"
Size: 16-18cm
Description: Advanced Nursery Stock
Height: 4.0-4.5m

Rev	Revision details	Drwn	Chkd	Appd	Date

Designed:	MS	Date:	01/06/2022
Drawn:	MS	Date:	01/06/2022
Snr Tech Check:	AS	Date:	-
Checked:	JK	Date:	01/06/2022
Approved:	EMcG	Date:	01/06/2022

amey consulting
www.amey.co.uk

Client
Department For Infrastructure
Rivers HQ
49 Tullywiggan Road
Loughry, Cookstown BT80 8SG

Department for Infrastructure
www.infrastructureni.gov.uk

Project Name
Newry Flood Alleviation Scheme Stage 1

Drawing Title
Site H3 - Armagh Road Drain
Proposed Locations for Replanting

Original Drawing Size : A1	Scale : As Shown
Dimensions : m	

Drawing Status	Suitability
Authorized and Accepted - For Construction	A1

Drawing No	Rev
CO401607-AMEY-H3-XX-DR-C-001-03	C01