CAPITA | AECOM

To:
Craig Cowperthwaite
Partnership and Strategic Overview
Ghyll Mount,
Gillian Way, Penrith,
CA11 9BP

Prepared by: Alastair Worsley 18/01/19

Checked by: David Clarke 21/01/19

Approved by: Jo Driffield 22/01/19

Date: 28/01/19

Capita
8th Floor,
The Observatory, Chapel Walks,
Manchester
M2 1HL

Tel +44 (0)161 819 4200

Project name: Kendal Appraisal Package

Document ref: ENV0000489C-CAA-IZ01-3KD-TN-Z-0009

From: Capita AECOM

Technical Note

Subject: Groundwater flooding in Kendal with proposed Flood Risk Management Scheme

Executive Summary

Flooding from groundwater can happen when the level of water within the rock or soil that makes up the land surface (known as the water table) rises above ground level. Cellars and basements are particularly vulnerable to groundwater flooding, especially in older properties where they were generally built as areas for storage rather than habitable spaces. A number of Kendal residents refer to their flooding experience in 2015 being from groundwater rather than overtopping of the river and therefore they have questioned the effectiveness of the proposed defences. Some residents are concerned that the defences will make the situation worse, holding back groundwater that would otherwise have naturally drained away.

Fluvial flood defences by design, need to create some form of impermeable barrier to prevent overtopping of the river and to manage seepage (flow of water through the ground) beneath them to an acceptable level. There is a risk that this impermeable barrier could prevent groundwater from discharging into the river. However, within the design of the Kendal Flood Risk Management Scheme measures have been incorporated to ensure that this does not happen. These include:

(a) Below ground, weep holes will be included in any impermeable barrier. A weep hole is a small opening that provides a flow path for water to move from within the ground to the river. These weep holes will have non-return valves to prevent movement of water the other way.

(b) Above ground, drain down structures will be included at strategic low spots along the length of defences. These will comprise a pipe through the defence that will allow water to flow from the dry side of the defence back towards the river when levels on the river side are lower than those on the dry side of defences. These pipes will have non-return valves to prevent the movement of water the other way.

Groundwater can be linked to water levels in the river so the risk could increase when river levels are high, however this will be managed through the inclusion of seepage cut off in the linear defence designs. It is therefore concluded that the proposed flood defences and pumping station site has a low risk of increasing groundwater flooding.

Introduction

The aim of this technical note is to provide a response to a request for further information by South Lakeland District Council's Planning Team relating to groundwater flooding. This note should be read in conjunction with the revised Flood Risk Assessment produced to support the planning application.

Background Information

Ground water flood risk management is the responsibility of the Lead Local Flood Authority (LLFA) which is Cumbria County Council in this instance. The Cumbria County Council Preliminary Flood Risk Assessment Report (2011) states that:

"There are records of groundwater flooding to basements of properties along Lound Road and Aynam Road in Kendal. These are in close proximity to the River Kent and the groundwater flooding tends to happen when river levels are high. This suggests an interconnection with high water levels in the Main River, possibly through the permeable gravel deposits on the valley floor."

Flooding from groundwater can happen when the level of water within the rock or soil that makes up the land surface (known as the water table) rises above ground level. The level of the water table changes with the seasons due to variations in the long-term rainfall. Flooding from groundwater is most common in geographical areas where the underlying bed rock is chalk, or fissured limestone, but can also happen in locations with sand and gravel near rivers.

Cellars and basements are particularly vulnerable to groundwater flooding, especially in older properties where they were generally built as areas for storage rather than habitable spaces. As such they can be susceptible to groundwater flooding during heavy and prolonged periods of rainfall, which can be made worse by the proximity of watercourses and the local geology/permeable ground conditions.

Inevitably, over time many cellars/basements have been converted into habitable space to varying design standards. Modern design standards include the use of chemical waterproofing materials often being referred to as a 'tanking system' to waterproof cellars/basements.

Properties in Kendal have in the past reported flooding to cellars/basements during prolonged periods of rainfall and high river levels. This suggests that the flooding to basements/cellars could be directly related to high river levels, either due to water flowing from the river into the cellar, or as a result of high water levels in the river preventing natural groundwater flows discharging into the river.

The cellars/basements in Kendal may have been 'tanked' comprehensively to a high standard or maybe to a lesser standard or not at all. It is often difficult to identify the source of cellar/basement flooding especially where tanking systems have failed due to age/cracking.

It is worth noting that even the best tanking systems have time limited guarantees (i.e.10 years) and need to be maintained to ensure continued effectiveness. If these systems fail it is sometimes due to cracks forming in the render system, especially at the junction of the floor slab. Due to the risk of failure and the level of damage this can bring it is always recommended to treat a tanked basement as requiring resilience measures such as tiled floors, cement render wall finishes, non-return valves and the use of permanent pumps to evacuate any water that does enter the basement.

Anecdotal evidence suggests that some of the cellars/basements on Aynam Road, Appleby Road and Parr Street may also be connected to the surface water drainage network or have soakaways to aid drainage post flooding. These drainage systems may also be causing flooding because of water 'backing up' during heavy and prolonged periods of rainfall. Where the tanking is installed and effective this can often trap water in the basement/cellar. This problem can be resolved by fitting a sump pump and removing the gravity connection to remove the drainage risk.

As described above, groundwater flooding is a complex subject and it is difficult to understand what the exact flow paths for water are through the ground. The level of the water table can be related to several factors such as volume of rainfall, the local geology and the water levels in the nearby watercourses (River Kent). When the river levels are low, ground water will be able to rise and flow underneath the houses, roads and river walls without restriction and discharge into the river. High river levels may prevent the 'natural flow' of ground water from occurring, increasing the groundwater pressure leading to cellar/basement flooding. The cellar/basement flooding experienced along Aynam Road may be a combination of natural rising groundwater levels that are made worse by high river levels.

Basic Principles of Seepage

Seepage is the movement of water through the ground due to a difference in water table levels and is a common problem associated with the design of flood defences. When under pressure, water will seek the easiest route to discharge and exploit any weaknesses in anything that blocks its path.

When flood defences are hydraulically loaded (i.e. when the water level on the river side is higher than on the defended side) water will choose to flow through the ground underneath the wall because it cannot move through the impermeable flood defence. If the quantity is modest, seepage under the defence may only be evident from wet ground conditions, whereas medium levels of seepage can usually be dealt with by pumping. Excessive levels of seepage are undesirable and can lead to local flooding and may damage the foundations of defences.

The common method to reduce the impacts of seepage is to increase the seepage path. The seepage path is the distance that the water has to travel from the source (in this case the river) to the receptor (in this case the ground level on the 'dry side' of the defences). The longer the seepage path from the source, the lower the volume of water at the receptor.

Flood Defence Design

Very few flood defences are completely watertight and most exhibit some leakage or seepage through the ground when holding back water. The proposed flood defences in Kendal will retain high river levels in the river channel and so seepage has been considered in the design of the flood defences.

During the outline design phase of the Kendal Flood Risk Management Scheme, assumptions were made that some amount of water would seep under the defences and that the mitigation method implemented will restrict any residual flows.

Measures have been identified to reduce the seepage flows underneath the proposed defences i.e. measures to increase the seepage path.

The first measure that we have included is to set defences back from the river as much as possible. By doing this we extended the horizontal distance that water has to travel before it reaches the proposed defence.

The second measure relates to the design of the foundations. The geometry of these structures has further increased the seepage path through inclusion of cut offs and by extending the length and depth below ground of the foundations. The increase in seepage path is displayed in Figure 1 below, showing a typical seepage flow path for a 900mm high wall with a cut off (a) and without this features (b). In the example shown, the flow path is 50% longer with the cut off in place. An increases seepage path results in a lower volume of water seeping below defences.

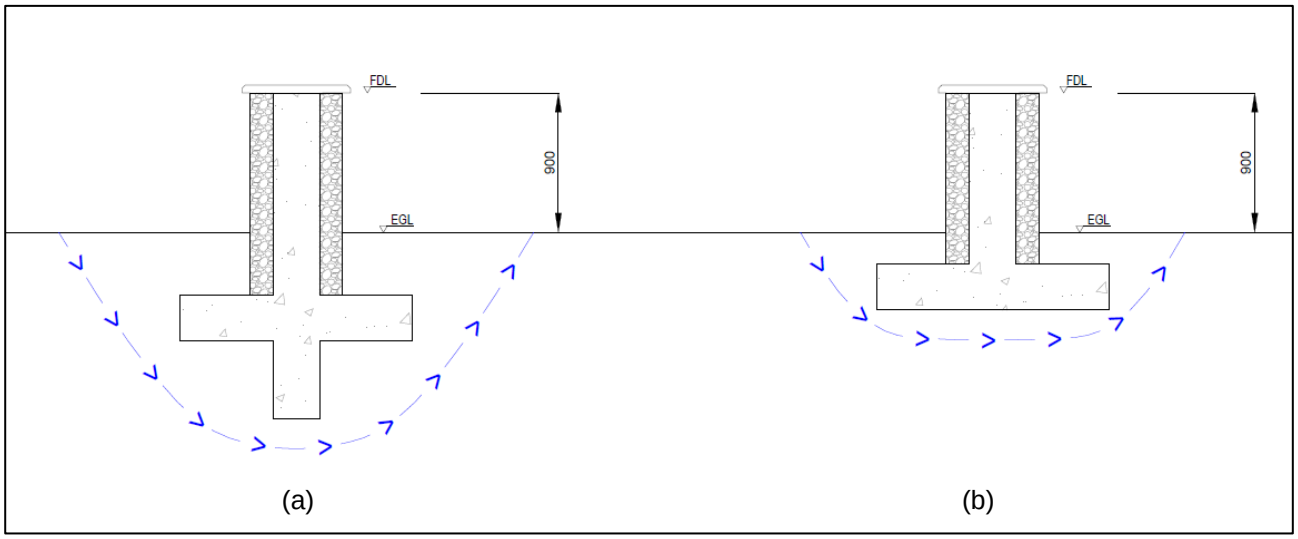

Figure 1: Approximate seepage paths (a) with and (b) without cut-off feature

Where the wall height increases in the design (i.e. a higher river level relative to the existing ground level), the width of the foundation has also been proportionately increased to ensure that the seepage path is extended to counteract the increase in hydrostatic head behind the wall.

In some locations, the new flood defence wall will be constructed directly on top of the existing river wall. It is recognised that water could potentially seep through the existing river wall due to it being in worse condition than any new defence. In these locations we have proposed additional concrete behind the existing wall to block this flow path. See Figure 2 below.

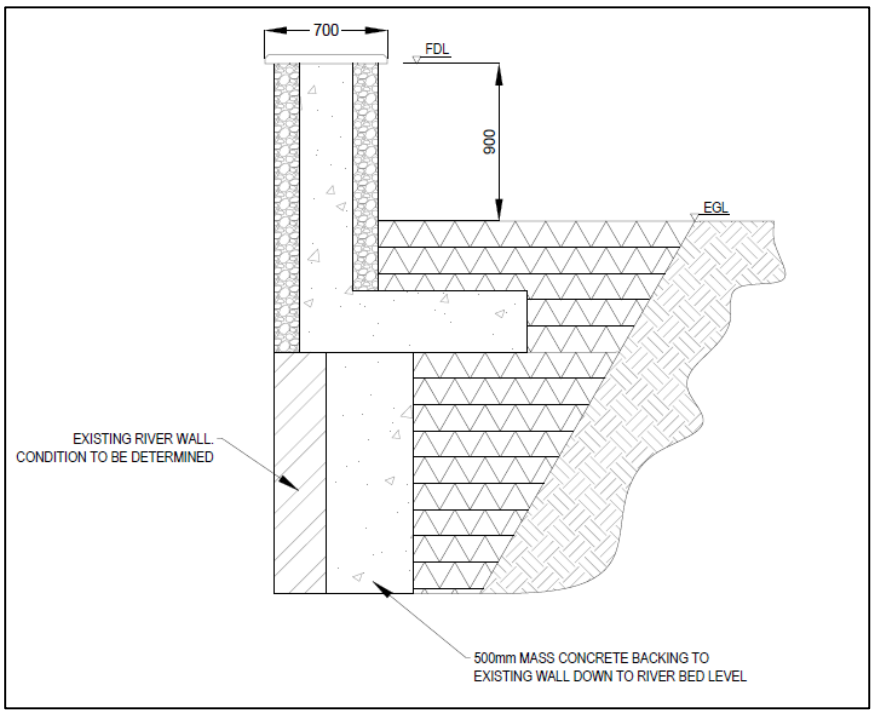

Figure 2: Seepage Mitigation - Existing Wall

The purpose of the flood defences is to create a form of impermeable barrier to prevent the river overtopping and to manage seepage from the river to acceptable levels. However, it is recognised that this impermeable barrier could also prevent groundwater from discharging into the river. To ensure that this is not the case, it is proposed that below ground weep holes will be included in any impermeable barrier. A weep hole is a small opening that provides a flow path for water to move from within the ground to the river. These weep holes will

have non-return valves to prevent movement of water the other way. Figure 3 shows how the weep hole would allow ground water to flow through the impermeable barrier into the river.

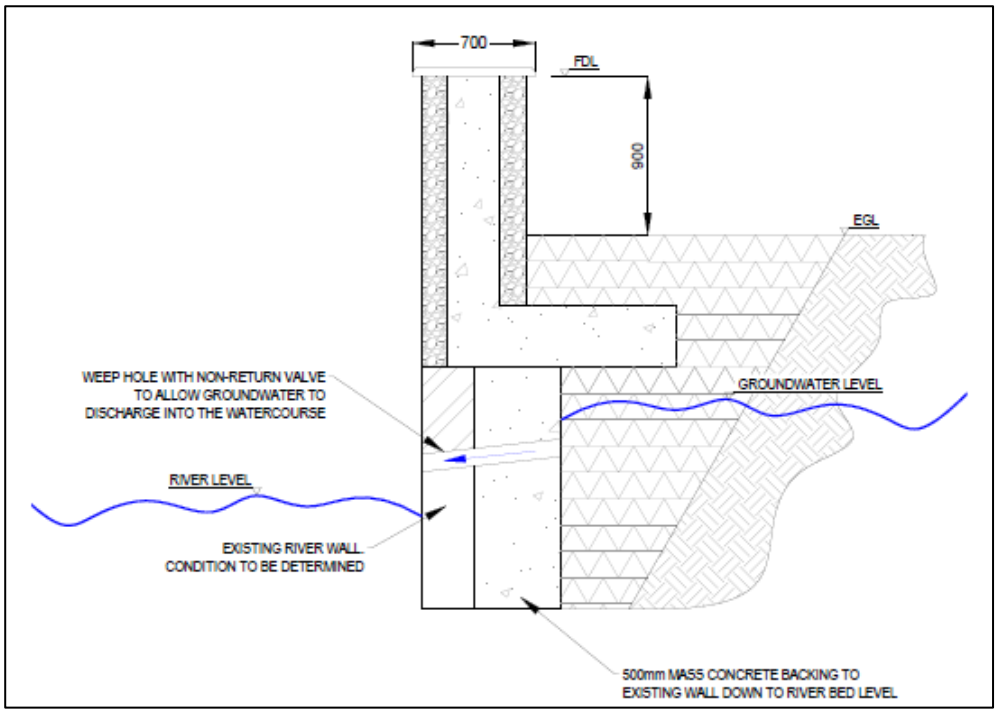

Figure 3: Weep hole to allow ground water to discharge to the river

It is also recognised that there may be some under defence seepage that could collect on the surface on the dry side of the defences and so multiple drain down points at strategic low spots along the length of the defences will be incorporated. At these locations, pipes will be installed through the defences that allow water to enter the river. Pipes will have a non-return valve installed on the wet side of the defence to prevent water backing up during times of flood. These features will also allow any water overtopping the defences, for storms larger than the design event, to drain back into the river once water levels have fallen.

Further Design Stage

Ground investigation work is being carried out, which includes soil boreholes of the ground, core samples of the river channel walls and permeability tests, to gain an accurate understanding of properties of the ground. Once this information is available, a seepage analysis will be undertaken to establish how much water will potentially seep under the defences. Depending on the results, we may have to amend our designs. In some areas, the assumption made to produce the existing design might be overly conservative and the cut off may be reduced and likewise other locations might have to be made more robust to deal with seepage (i.e. deeper cut offs and wider foundations might be required).

The information will also help us to confirm the number and locations of the proposed weep holes and drain down structures which will allow water on the ‘dry side’ of defences to drain into the river.

Further Considerations

The Environment Agency are not funded to remove the risk of groundwater or surface water flooding but are working with Cumbria County Council and United Utilities to assess locations where surface water flooding maybe a problem and to see what we can deliver jointly through the scheme and in the future to further reduce the risk of surface water flooding.

There are other features remote from the River Kent that will improve the flood risk to areas downstream. For instance, the pumping station at Gooseholme will primarily reduce the risk of flooding from Stock Beck but it will also help reduce surface water drainage flooding at properties further south. The areas that will see a benefit are the properties around Wildman St, Castle St, Castle Crescent and Ann Street.

In addition, we are also continuing to assess other locations that maybe susceptible to surface water with smaller scale mitigation being identified to improve the current flood risk from this source. These may include flood routing (high level overflows, raised kerbs, swales & landscaping) and drain down structures (to allow water to drain through our flood defence) where flood water may gather in low-lying areas behind any new flood defences.