

As part of Kendal and Upper Kent Catchment Flood Risk Management Scheme we have a package of measures that together will reduce flood risk on Stock Beck. This includes the delivery of a catchment drain that will divert surface and ground water flows from the upper reaches of Stock Beck into the River Mint, combined with the rehabilitation and repair of the culvert system, and construction of the new pumping station at Gooseholme. This package of measures will reduce flood risk within the residential areas of Kendal.

Ground investigations and surveys

The design and construction of a flood risk measures is complex. Ground conditions need to be fully understood so that the design team can assess the suitability of the combination of measures required to reduce flood risk as part of the Kendal and Upper Kent Flood Risk Management Scheme.

Site surveys and ground investigations are important. Building on a significant amount of desk-based research, they allow engineers to understand the existing natural processes which are occurring in the study area, for example, groundwater flow, surface water flow and fluvial activity. They provide detail on the composition of the ground and what impact that might have on the proposals.

The ground investigations also allow engineers to conduct an array of testing both at the time of the survey, and on samples in the laboratory. This enables a deeper understanding of how the ground will behave, and what the potential impact might be on the proposed flood risk measures.

Site location

Stock Beck is located to the east, and uphill of the River Mint and Sandylands residential estate.

Ground conditions

The ground conditions described below run from youngest to oldest. Although present across the study area, topsoil is not generally considered as a geotechnical unit, as during construction it would usually be removed.

Made Ground

Made ground is formed by processes where the original soil or rock has been removed or altered, and then either replaced with manmade materials or it can also be backfilled. Within the Stock Beck study area, made ground is found in areas of historic quarrying, infilled historic reservoirs and road construction. Made ground of thicknesses up to 0.2 m thick generally consisting of gravelly sands and sometimes plant matter has been found associated with the construction of Appleby Road.

Alluvium

Alluvium within the study area generally consists of loose gravels and sands. Alluvium has been deposited in low lying areas of the study area by the River Mint during flood events. It is thickest adjacent to the river and thins out away from the river. Within the Stock Beck study area, it is found to be between 1.0 and 1.2m deep.



Stock Beck catchment drain ground investigations and surveys study area is indicated by the red line.



Glacial deposits

A glacier is a slowly moving mass or river of ice formed by the accumulation and compaction of crystalline ice, snow, rock, sediment, and often liquid water. Glacial deposits underlie the alluvium across the whole of the Stock Beck study area.

The last glacial maximum occurred 20-30,000 years ago, at which point an extensive ice sheet covered much of Britain and Ireland, in places it was found at a depth of up to 1km thick. As the glaciers flowed across the country, they deposited sediment trapped either in or below the ice, these deposits are called Glacial Till. These glacial deposits infilled the topography that existed prior to the glaciation, this includes valleys previously formed by palaeo-rivers (rivers which existed prior to the glaciation). Glacial till is generally found as a sandy gravel across the study area often containing clay and boulders. Small zones of clay were also found with the predominantly gravelly glacial till.

Following on from the glacial maximum, the glaciers retreated and melted. This resulted in huge volumes of water flowing across the lake district. These river systems deposited thick layers of sands, gravels and cobbles over the exposed bedrock and glacial till. The deposits left by the rivers are called glaciofluvial deposits and are the thickest superficial unit found across the Stock Beck study area with thicknesses up to 12.9m recorded.

Bedrock

The bedrock underlying the Stock Beck area consists of the Kirkby Moor Formation, part of the Kendal group. The Kirkby Moor Formation is up to 425 million years old and can reach a thickness up to 430m. The formation was encountered as predominantly metamorphosed sandstone, with some layers of metamorphosed siltstone and mudstone present.

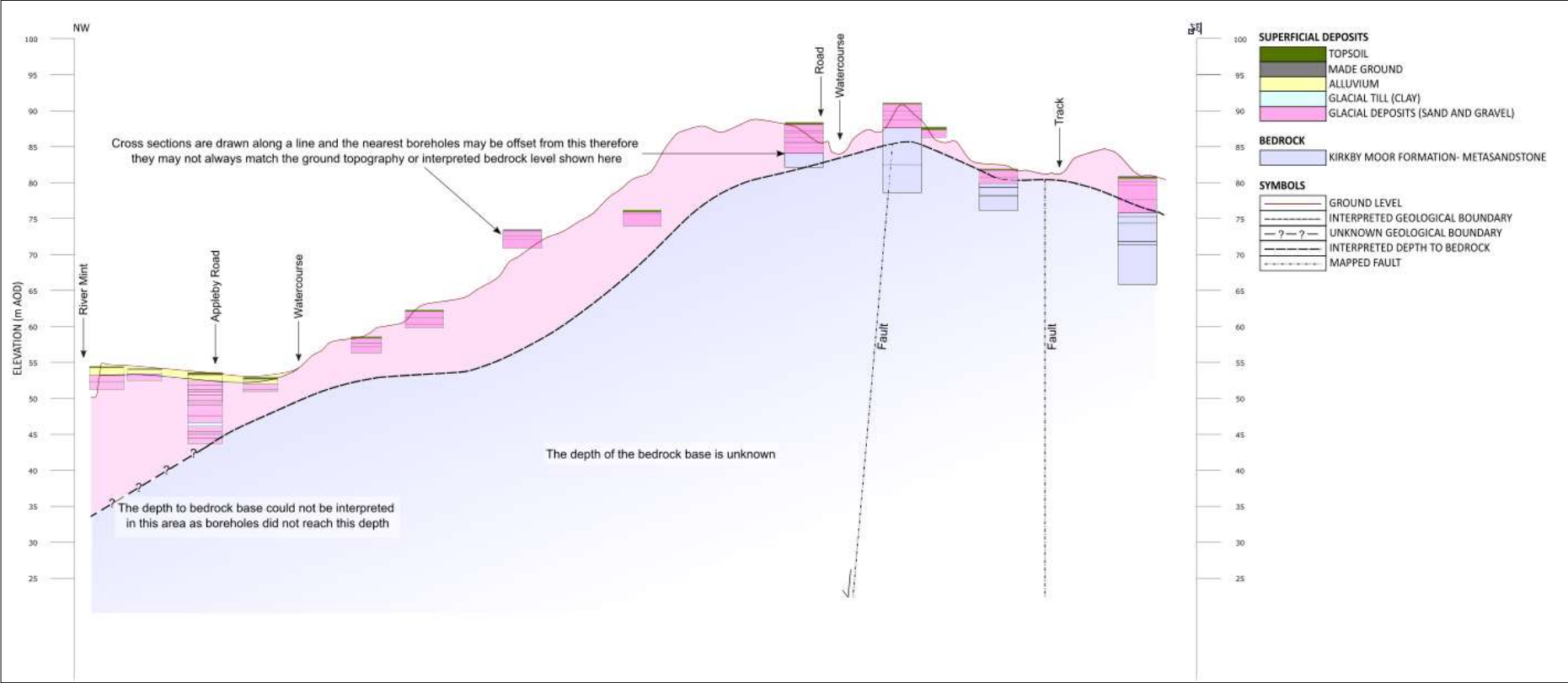
The Kirkby Moor Formation is also faulted within the study area. Faults are fractures or breaks in rock where movement has occurred. They are important as they can change the way that water moves through the bedrock and can also cause the rock to be weaker or broken in proximity to the fault.

Depth to Bedrock

The depth of bedrock and the nature of the overlying superficial deposits can have a major impact on the construction of a flood defence scheme. The depth to bedrock varies across the study area, ranging from 2.0 to 14.1m below ground level.

Indicative cross-section – depth to bedrock

The cross-section illustrates variation of the depth to bedrock, and variability of the superficial deposits across the whole of Stock Beck. It is indicative and has been produced to illustrate ground conditions through a cross-section of the area.



Indicative cross-section



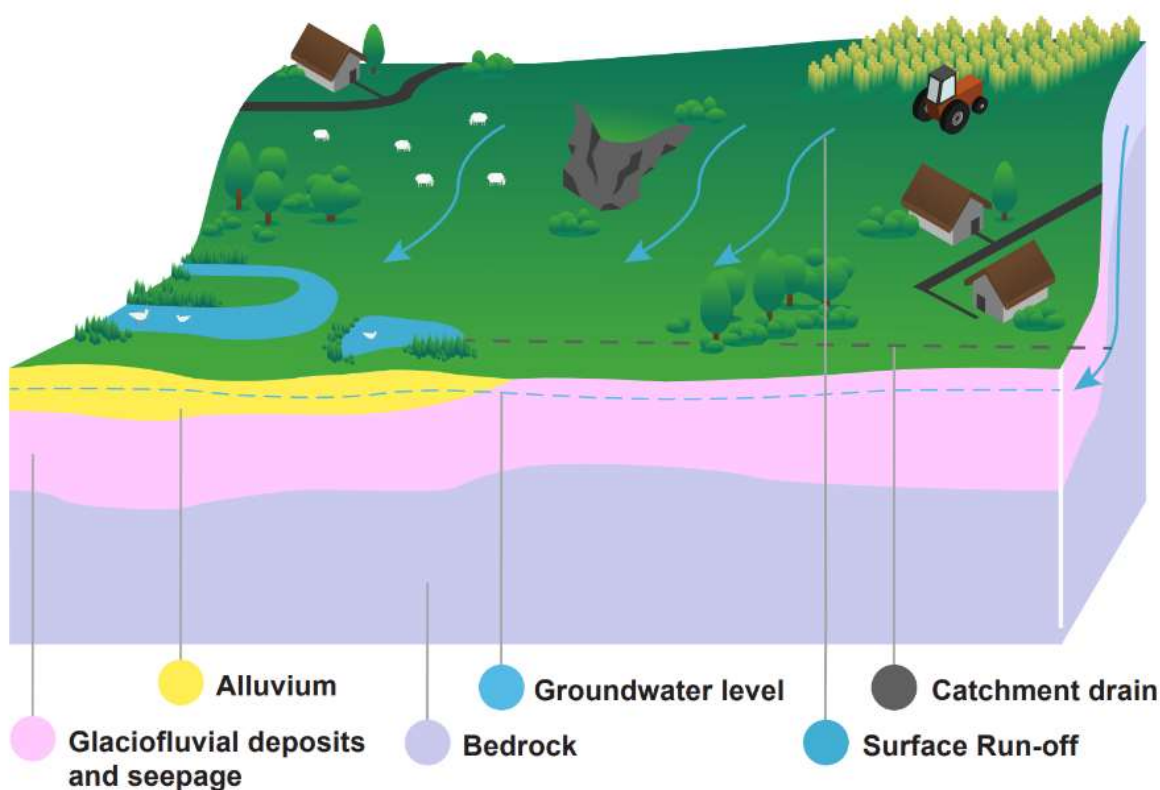
Design and construction of the Stock Beck catchment drain






The key factor identified through the ground investigation surveys which needs to be considered in the design of the flood risk management scheme is the composition and permeability of the superficial deposits in the area.

The superficial deposits overlying the Stock Beck study area are predominantly composed of sand, gravel, cobbles, and boulders which are highly permeable. The original design of an open drain therefore would not be feasible, as water would not be contained within the drain and would be able to freely flow into the ground. In discussion with landowners, the design has been updated and now incorporates a buried pipe which will contain the water diverted from Stock Beck East and North, into the River Mint.

Stock Beck block model

This visual illustrates the geology of the Stock Beck study area.



Key	
	River Kent
	Alluvium deposits formed by rivers. Generally comprises sands, gravels silts and soft clays
	Glaciofluvial deposits and seepage formed from the outwash of glaciers. Generally comprises sands, gravels, cobbles and boulders
	Weathered Bedrock Kirkby Moor Formation – Sandstone
	Bedrock Kirkby Moor Formation – Sandstone



Designing a viable scheme – the Environment Agency’s key tests

The suitability of each potential flood risk measure is assessed in more detail against the Environment Agency’s key tests: to ensure they are economically viable, technically feasible, environmentally sustainable, socially acceptable, and safe to deliver. Throughout this process multi-criteria analysis is used to evaluate potential risks, opportunities and their likely impact. On completion of the analysis each option is either discounted or progresses to the next stage in the design process.

- **Technical feasibility** – each option is assessed to ensure it is technically achievable, constructable, robust and reliable. This takes into consideration buildability, ongoing maintenance, and health and safety.
- **Environmental sustainability** – potential environmental impact of each option on the natural environment is assessed, together with the appropriateness of any specific land use designations and whether they align with the Environment Agency’s strategic environmental goals.
- **Economic viability** – takes into consideration ongoing maintenance, whether the benefits would outweigh the cost, and if the cost is within the scheme’s budget. Each option is also analysed to determine any other non-financial benefits they offer to the local community and environment, and/or the potential for this.
- **Social acceptability** – consideration is given to a number of criteria which include landowner constraints, location within designated sites, proximity to recreational areas or public rights of way (PROW), and overall social acceptability. As the scheme progresses we take this out for consultation in order to consider and incorporate feedback from the wider community.
- **Health and safety** – each option is reviewed to check that it can be designed, constructed and maintained safely. Identification of risks and opportunities to the wider community are also assessed and used to inform the design.



This process will ensure we design a scheme that provides a better standard of protection, delivered in the right places, at the time.