

Gargrave Erosion Study – Key findings

Summary of report:

‘QXE-JBA-XX-XX-RP-EN-0001-S2-P01-
Gargrave_Erosion_Scoping_Report’

Agenda



- Geomorphological change in response to the weir collapse
- Conceptual erosion mitigation measures



Geomorphological change in response to weir collapse

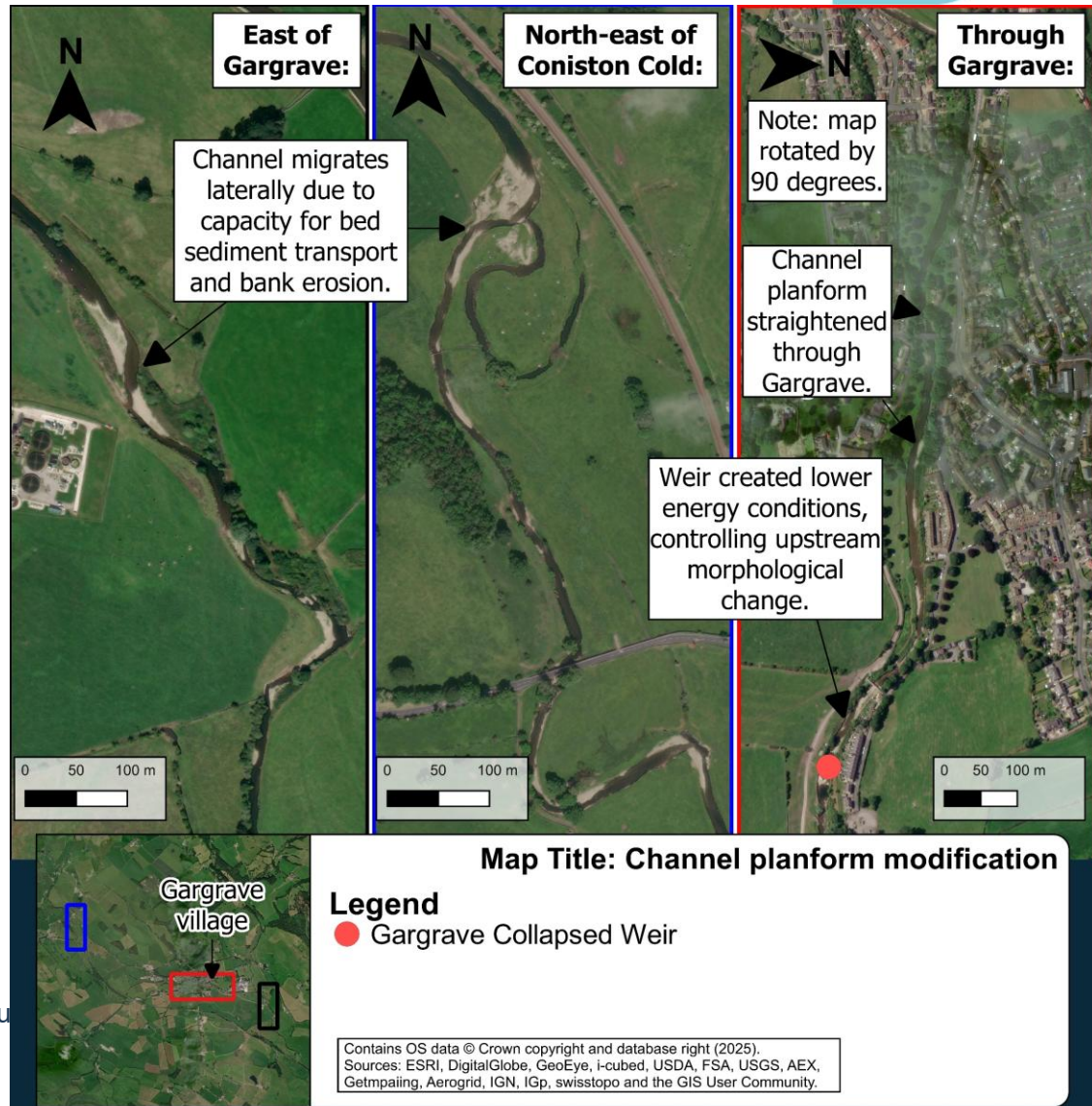
Pre-weir collapse conditions

- Bed and bank erosion was suppressed by the weir:
 - Created lower energy, depositional conditions upstream – impacts extending upstream to the road bridge.
 - Artificial stabilisation of bed and bank sediment transport rates.
 - The ‘corridor’ within which the river eroded its banks was restricted.



Pre-weir collapse conditions

- The Aire through Gargrave has been modified, suppressing flow energy and controlling bank erosion, via:
 - The weir
 - Channel straightening
 - Bank protection



Knick-point (head-cut) erosion

- Weir collapse triggered a knick-point (head cut) erosion to be transmitted upstream.
- Riverbed incision (erosion) into the mobile sediment built up upstream of the weir.
- The river is attempting to regain a natural bed longitudinal profile.
- Drop in bed level has (and is) causing bank instability.

Jan 2018



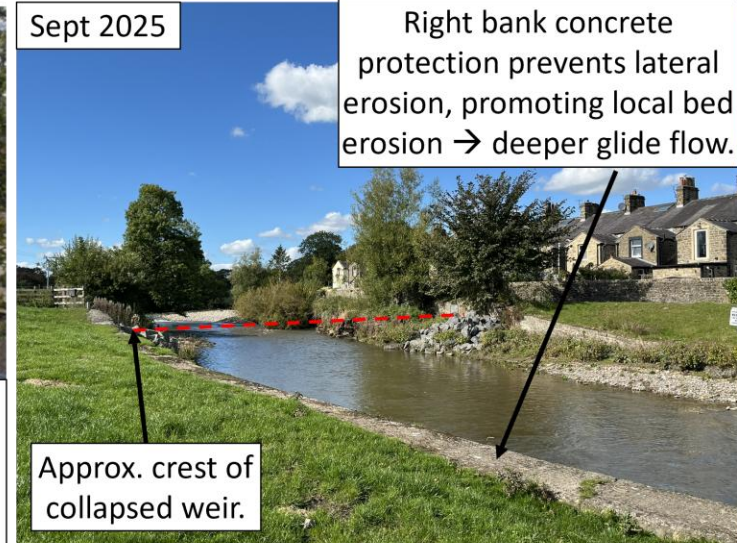
Low energy, depositional conditions upstream of weir.

April 2023



Bed level dropped by approx. 1.5m following collapse in 2022 → caused bed instability as the channel attempts to re-gain a stable gradient → knick-point erosion (head-cut) tracked up-stream.

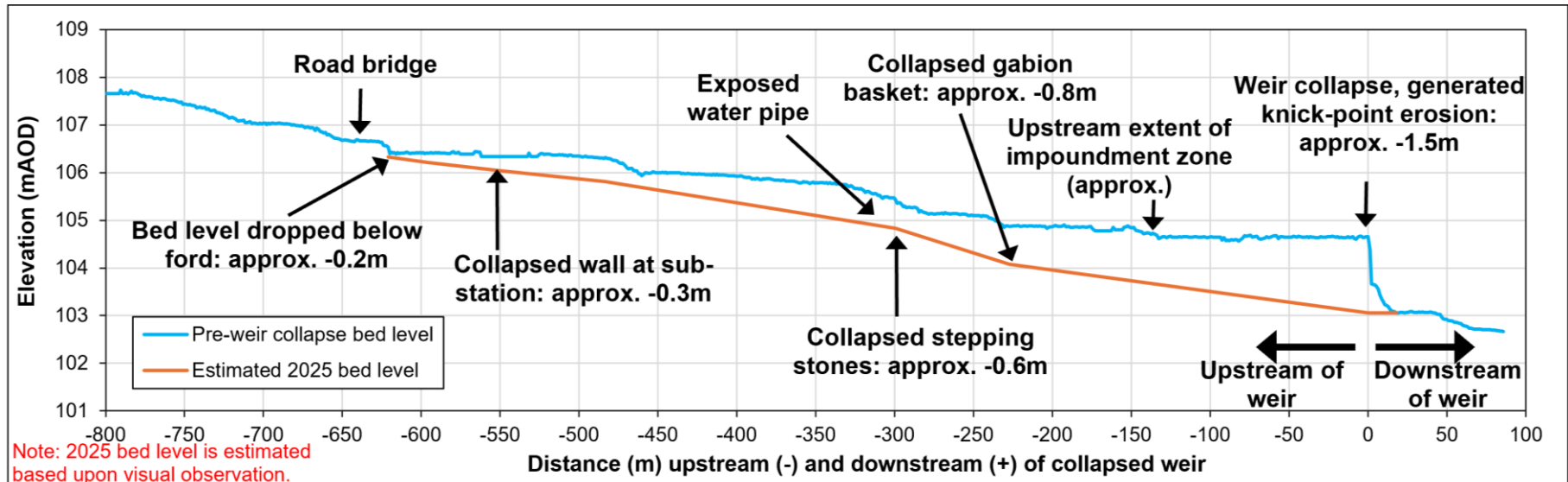
Sept 2025



Right bank concrete protection prevents lateral erosion, promoting local bed erosion → deeper glide flow.

Approx. crest of collapsed weir.

Bed profile of the knick-point erosion



At the collapsed weir

Facing upstream:

Jan 2018



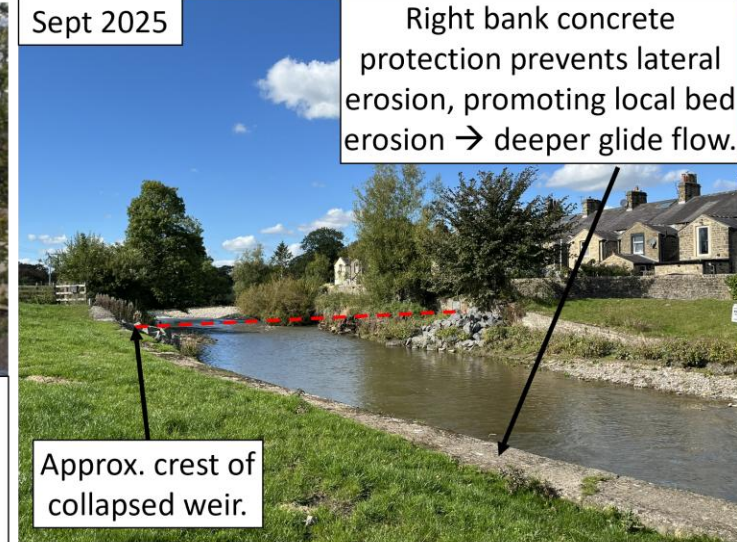
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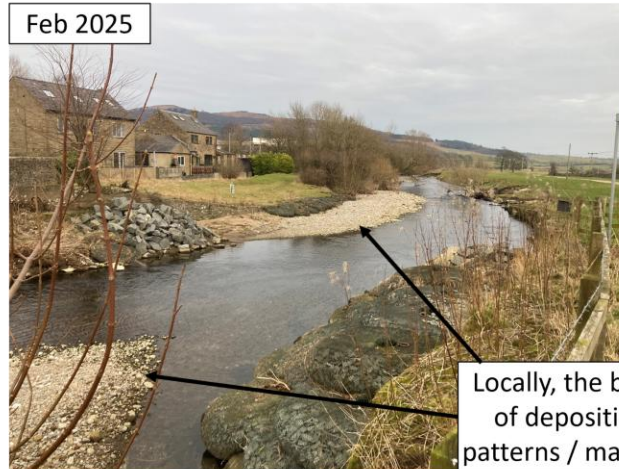
Approx. crest of collapsed weir.

Facing downstream:

Jan 2025



Feb 2025



Sept 2025



Locally, the bed may have generally stabilised here → development of depositional bar features → however, bars are migratory, and patterns / magnitudes of erosion and deposition may shift over time.

07/01/2026

15m upstream of the collapsed weir

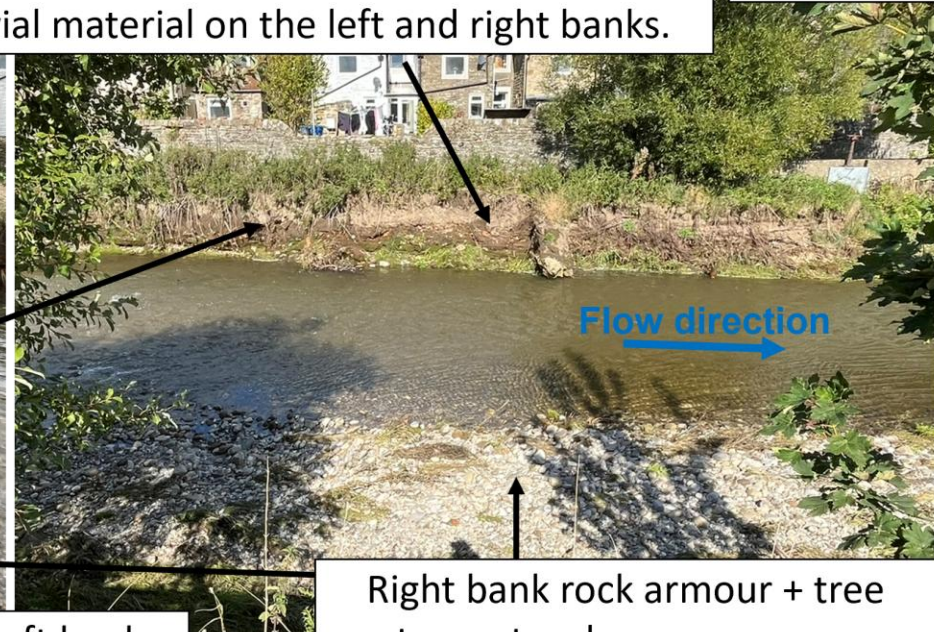
Jan 2024

Channel bed level has dropped by approx. 1.5m immediately upstream of the collapsed weir, exposing faces of alluvial material on the left and right banks.

Sept 2025



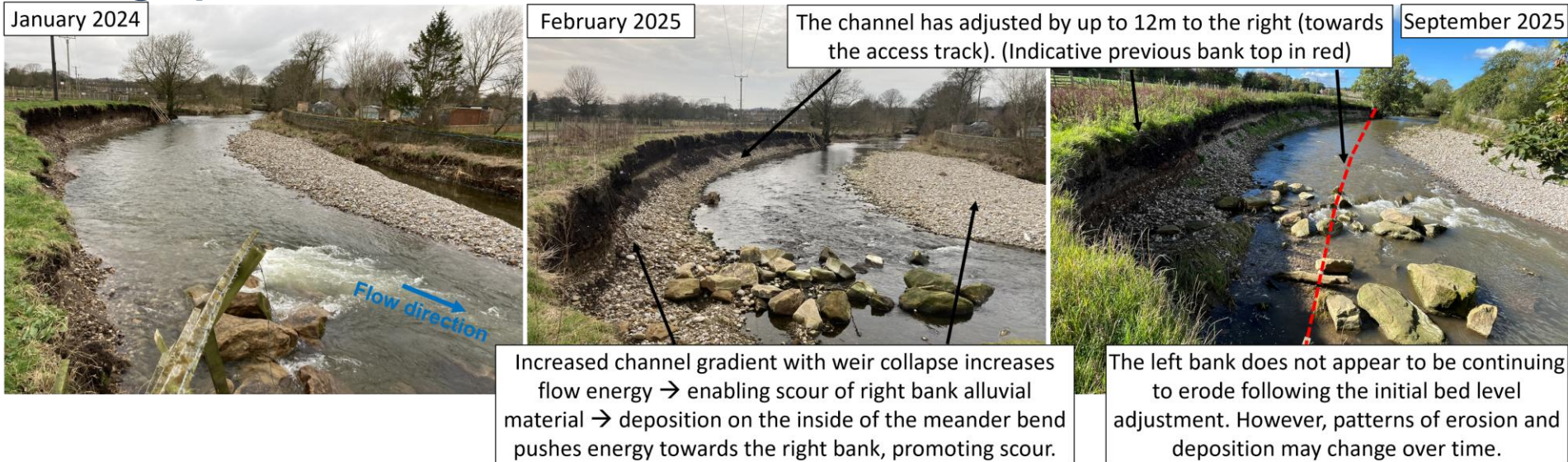
Since weir collapse and bed level adjustment, the left bank does not appear to have undergone significant further change.



Right bank rock armour + tree roots create a lower energy zone, forming a small gravel bar.

60m upstream of the collapsed weir

Facing upstream:



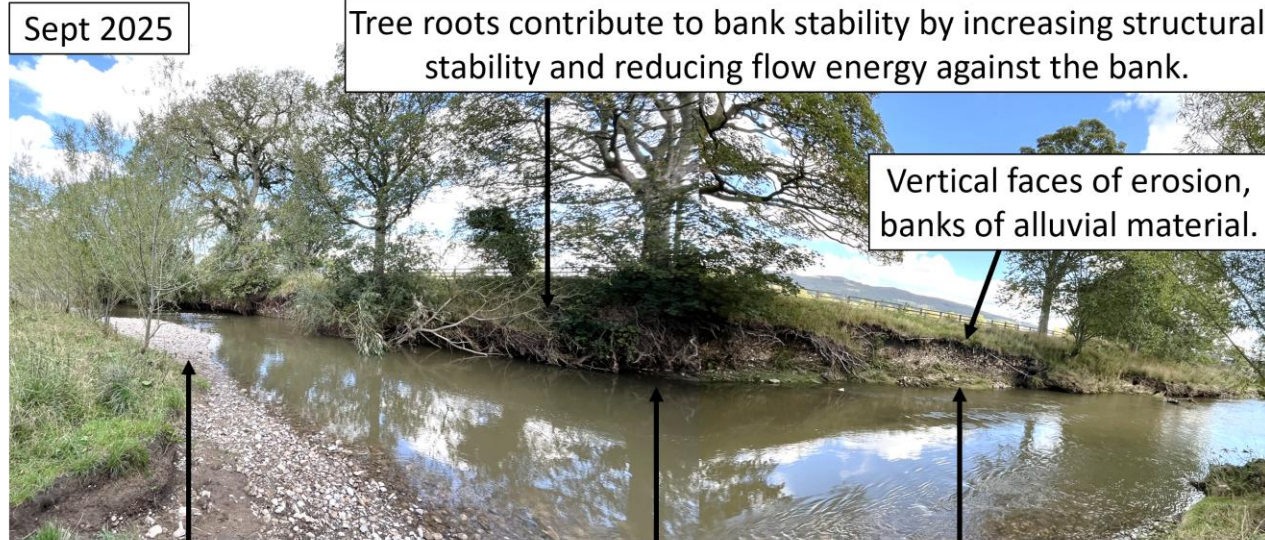
170m upstream of the collapsed weir – left bank erosion adjacent to Mill Lane

January 2018



Pre-weir collapse, moderate pockets of bank erosion existed on the outside of the bend (left bank), but banks were largely vegetated and stable.

Sept 2025



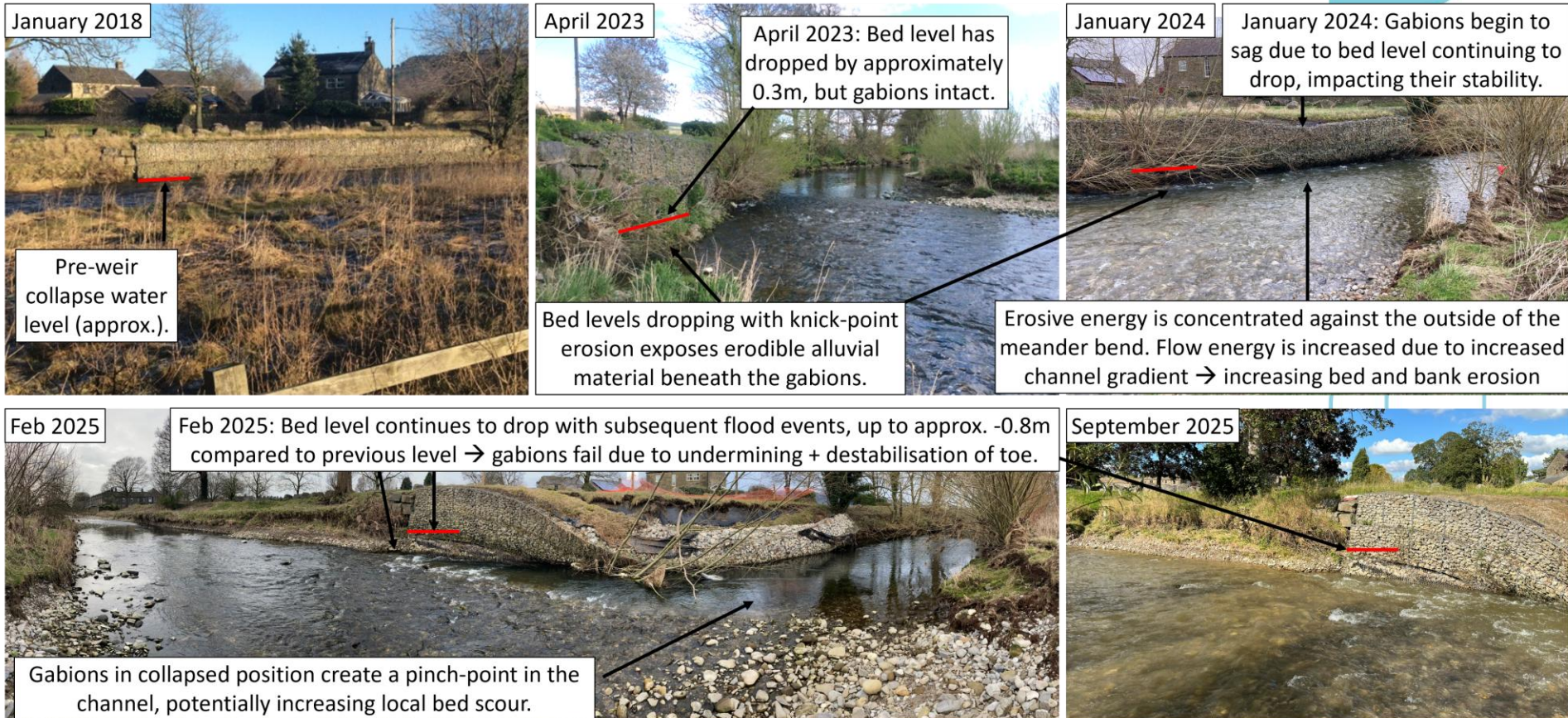
Tree roots contribute to bank stability by increasing structural stability and reducing flow energy against the bank.

Vertical faces of erosion, banks of alluvial material.

Increased sediment flux through the reach may be contributing to increased deposition on inside of the meander bend → pushing flow energy towards the outside of the bend.

With upstream progression of the knick-point erosion, bed levels dropped creating steeper banks with exposed alluvium + flow energy increased due to the increased channel gradient → causing bank erosion and undercutting of trees → channel has shifted towards Mill Lane.

230m upstream of the collapsed weir – left bank gabion collapse adjacent to Mill Lane



300m upstream of the collapsed weir – destabilised stepping stones



300m upstream of the collapsed weir – exposed water pipe

April 2023

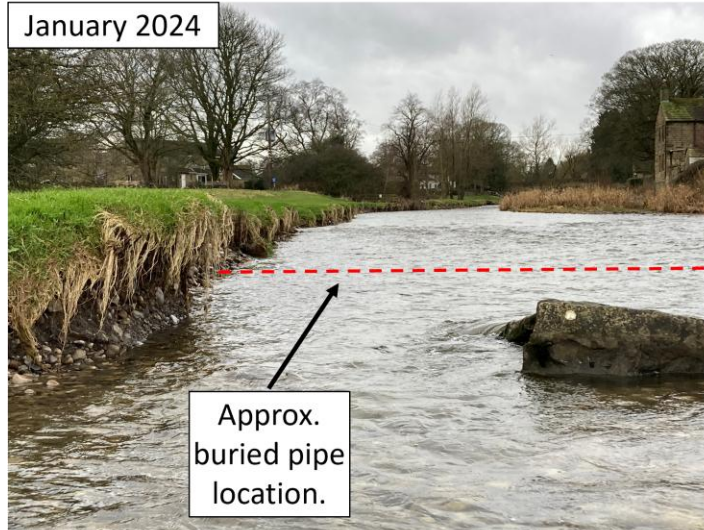
Prior to upstream progression of the knick-point, the pipe was buried within the bed and bed levels were continuous up and downstream of the pipe.

Approx.
buried pipe
location.



January 2024

Approx.
buried pipe
location.



February 2025

Face of erosion on the edge
of the previously stable bar
evidences bed incision.

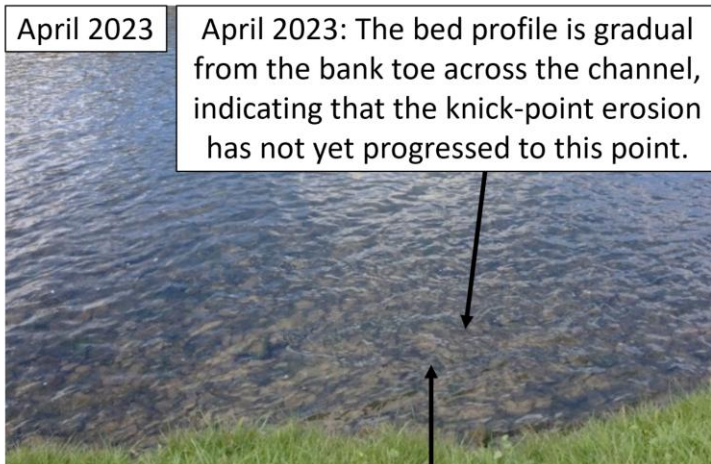
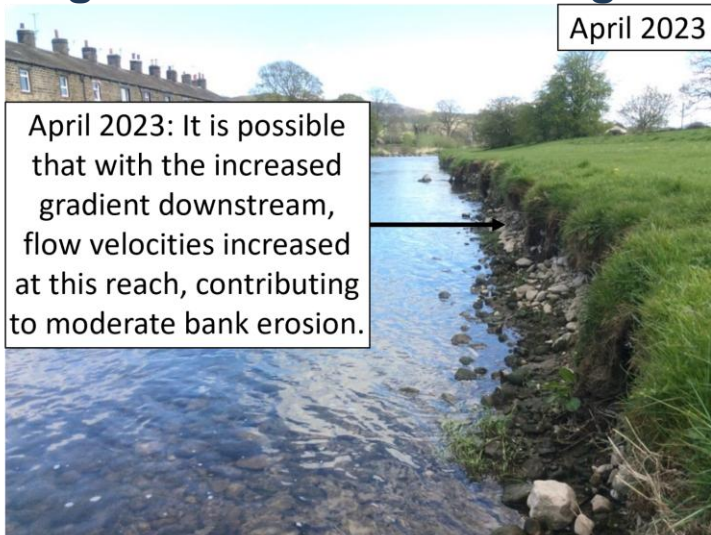


Upstream progression of the knick-point erosion
caused bed levels to drop upstream and
downstream of the pipe, exposing it from the bed.

September 2025

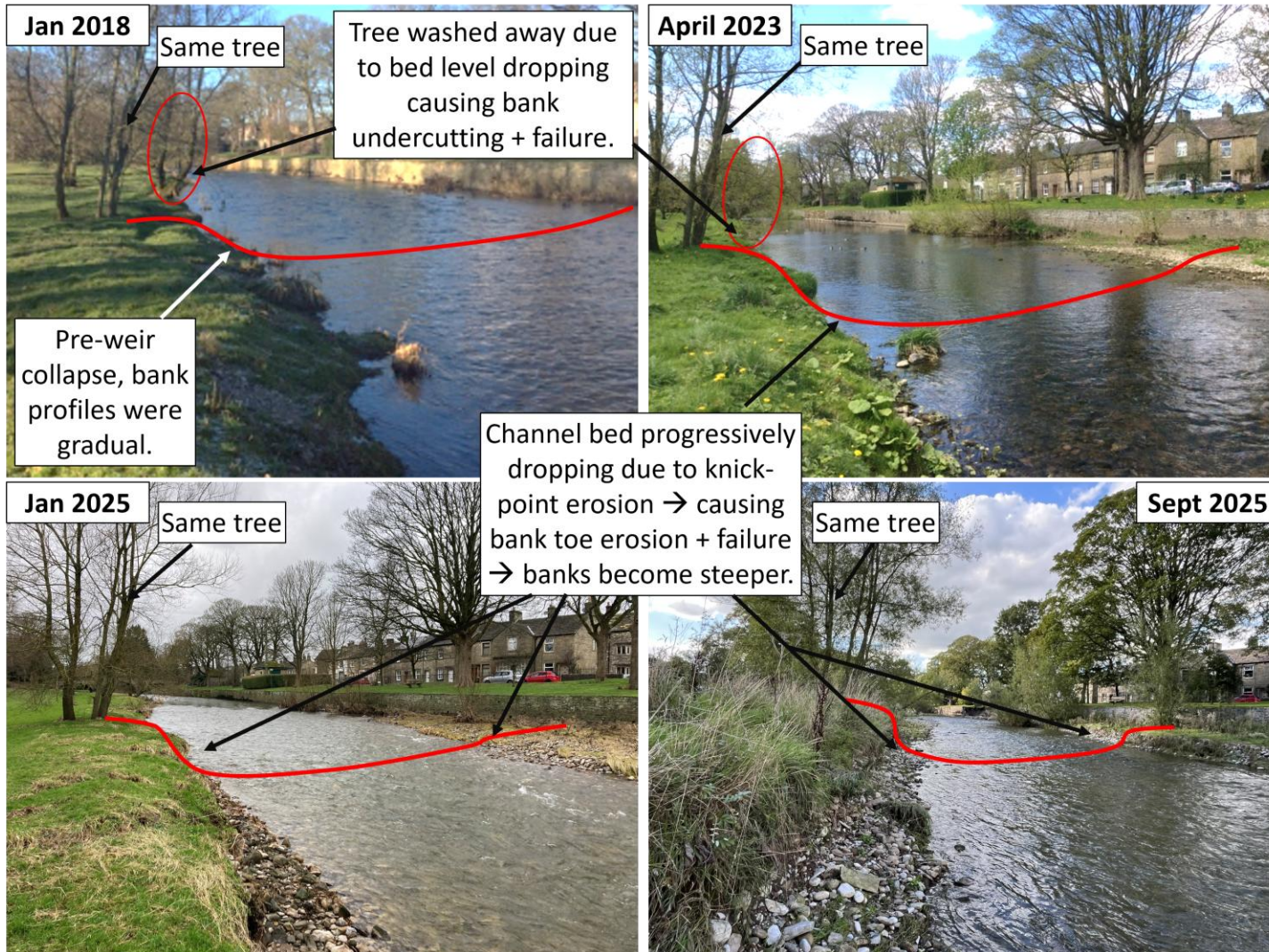


450m upstream of the collapsed weir – right bank erosion through the park



April 2023: Bed material has algal covering, indicating infrequent mobilisation, prior to knick-point erosion.

480m upstream of the collapsed weir – right bank erosion through the park



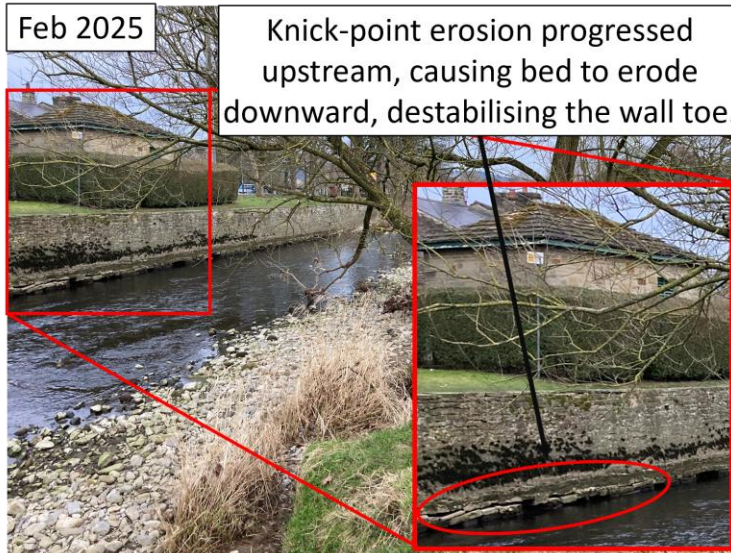
550m upstream of the collapsed weir – September 2025 wall collapse at substation

April 2023



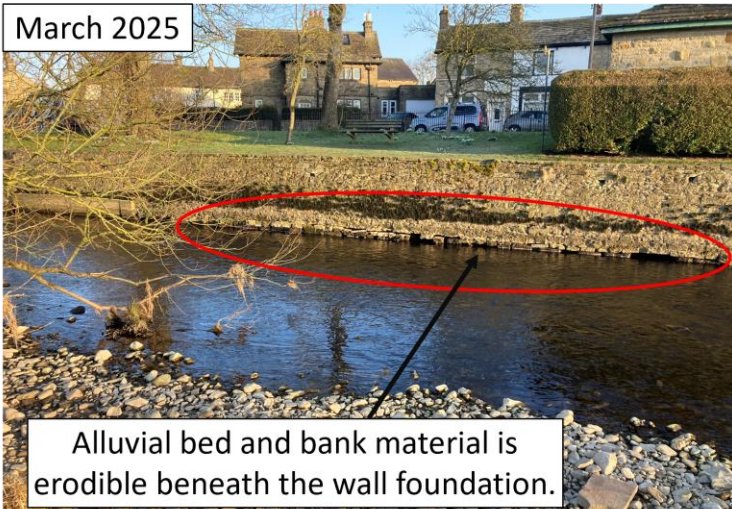
April 2023: The knick-point erosion has not yet progressed up to this point - bed levels generally unchanged compared to pre-weir collapse.

Feb 2025



Knick-point erosion progressed upstream, causing bed to erode downward, destabilising the wall toe.

March 2025



Alluvial bed and bank material is erodible beneath the wall foundation.

Sept 2025



Successive events continue to cause bed level to drop (by up to approx. - 0.3m since pre-wall collapse) → wall failed in 20-21st Sept 2025.

Risk of further wall collapse is present.

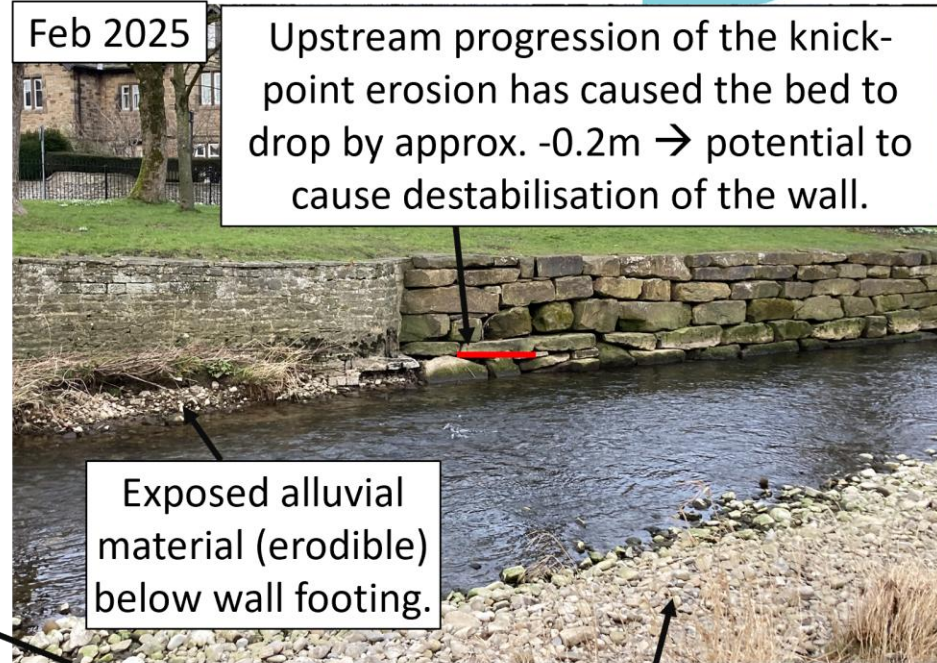
600m upstream of the collapsed weir – bed erosion at wall downstream of ford

April 2023



April 2023: The knick-point erosion has not yet progressed up to this point - bed levels generally unchanged compared to pre-weir collapse.

Feb 2025



Upstream progression of the knick-point erosion has caused the bed to drop by approx. -0.2m → potential to cause destabilisation of the wall.

Exposed alluvial material (erodible) below wall footing.

Bed material was previously largely non-mobile, indicated by algal + silt covering. Increased flow energy with increased channel gradient has increased sediment mobility, bar material is now clean.

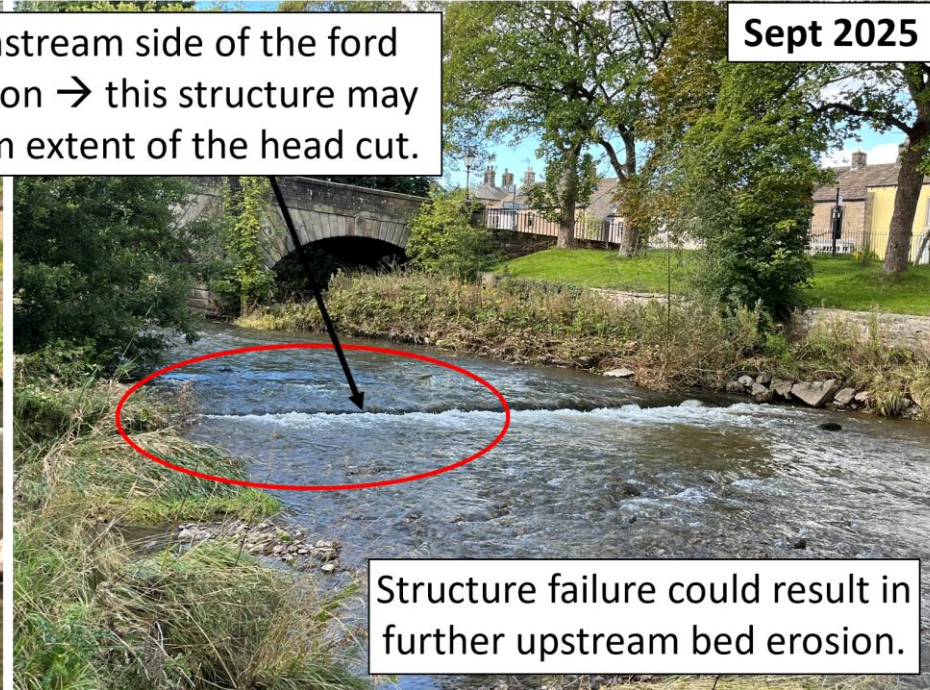
625m upstream of the collapsed weir – ford controls upstream extent of knick-point erosion

April 2023

Bed level has dropped on the downstream side of the ford structure → due to knick-point erosion → this structure may currently be controlling the upstream extent of the head cut.



Sept 2025



Structure failure could result in further upstream bed erosion.

780m upstream of the collapsed weir – upstream stepping stones

April 2023



Morphological change upstream of the ford is not significant → the knick-point erosion has not progressed upstream beyond the stone ford. Banks remain vegetated and bed sediment has an algal covering in 2023 and 2025, indicating infrequent mobility.

Sept 2025



Summary of morphological changes



- The impacted reach is undergoing a transition phase, attempting to regain a dynamic equilibrium of erosion and deposition.
- The channels morphological energy has increased towards its natural state. Therefore, the 'corridor' within which the river will adjust will be maintained into the future.
- Erosion management designs should seek to work with and accommodate the natural processes, where possible.
- Where infrastructure exists that cannot be set back, bank or bed protection measures should be designed to accommodate for the new channel geometry and increased energy.



Conceptual erosion mitigation measures

4 key measures

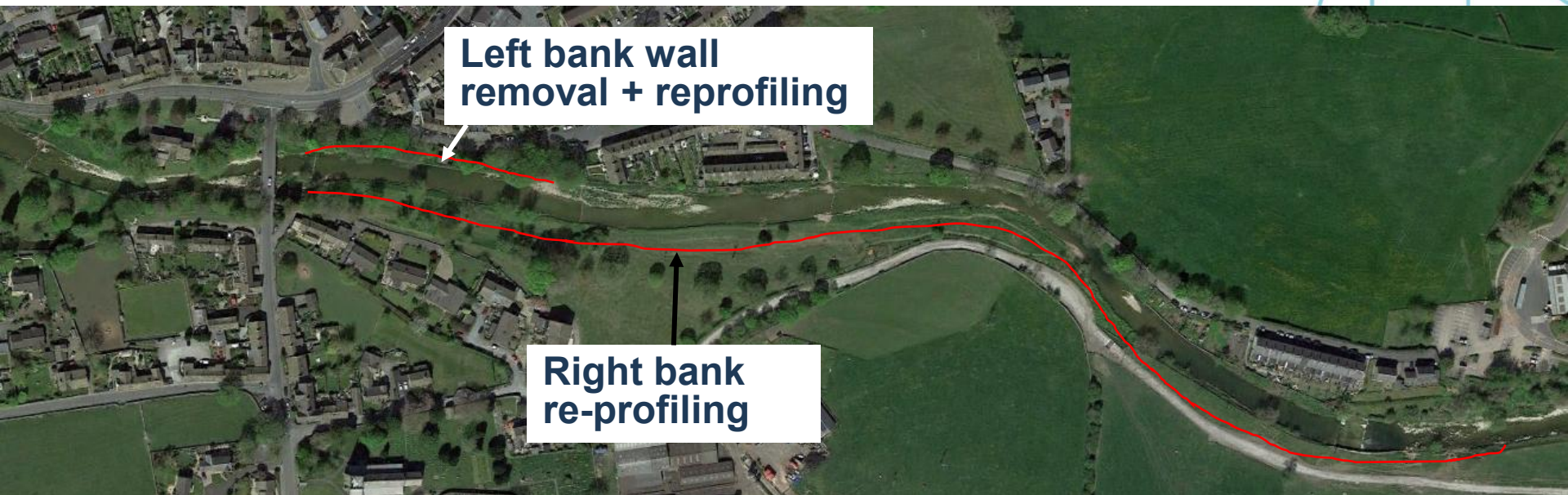
Channel width increasing and bank reprofiling

Aims:

- Reduce hydraulic flow confinement = reduce erosive energy.
- Provides space for natural morphological adjustment + evolution.

Implementation:

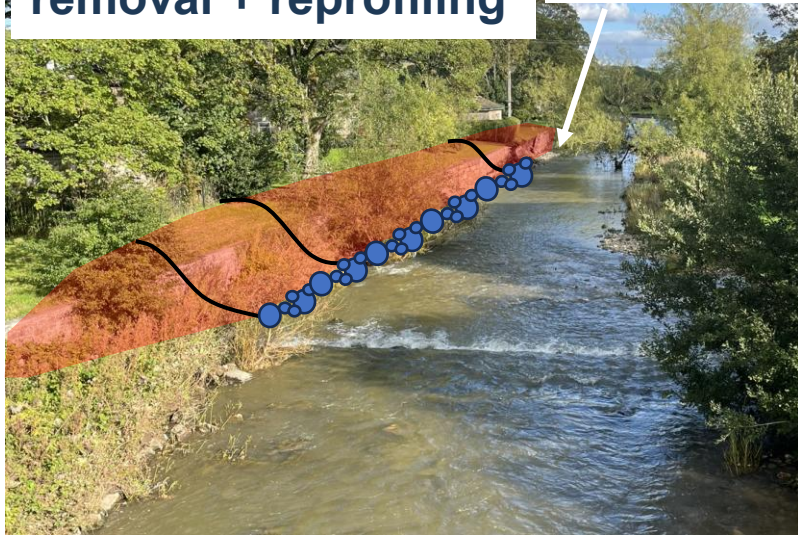
- Right (southern bank) along length of impacted reach and along failing left bank wall DS of bridge.
- May be targeted to identified constraints and opportunities.



Channel width increasing and bank reprofiling

**Left bank wall
removal + reprofiling**

**Potential
along full
length of wall**



**Right bank
re-profiling**



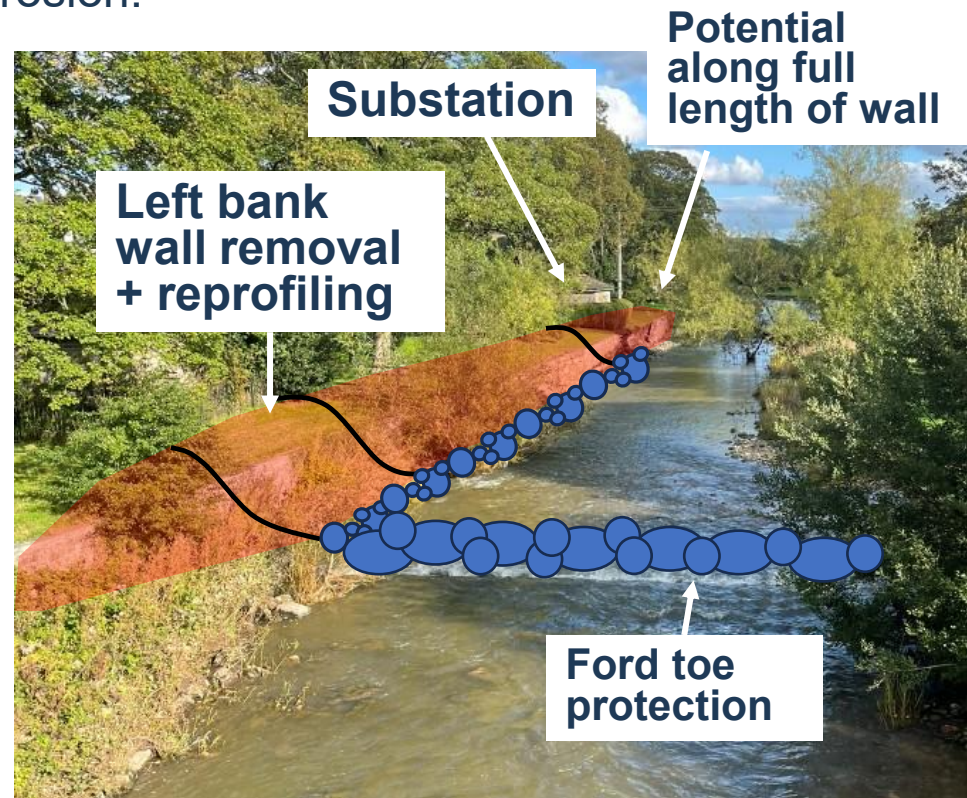
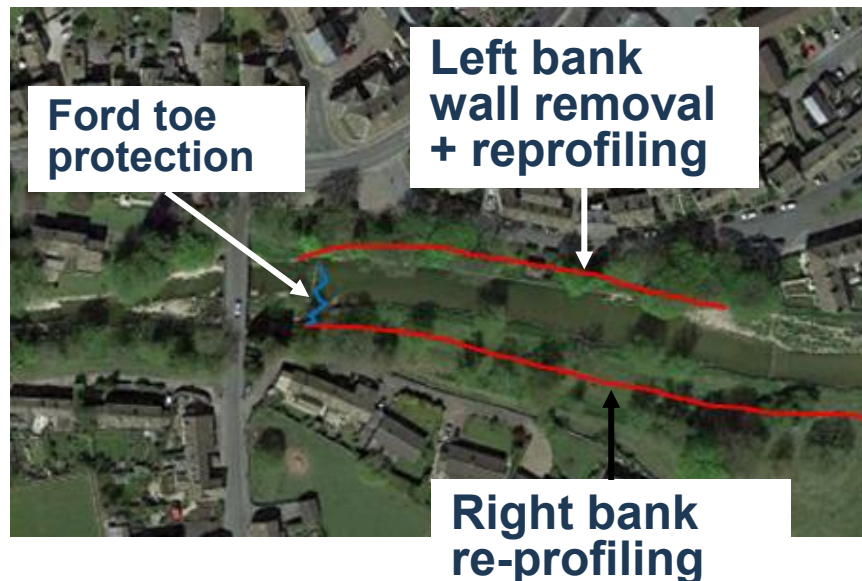
**Left bank
wall removal
+ reprofiling**

**Right bank
re-profiling**



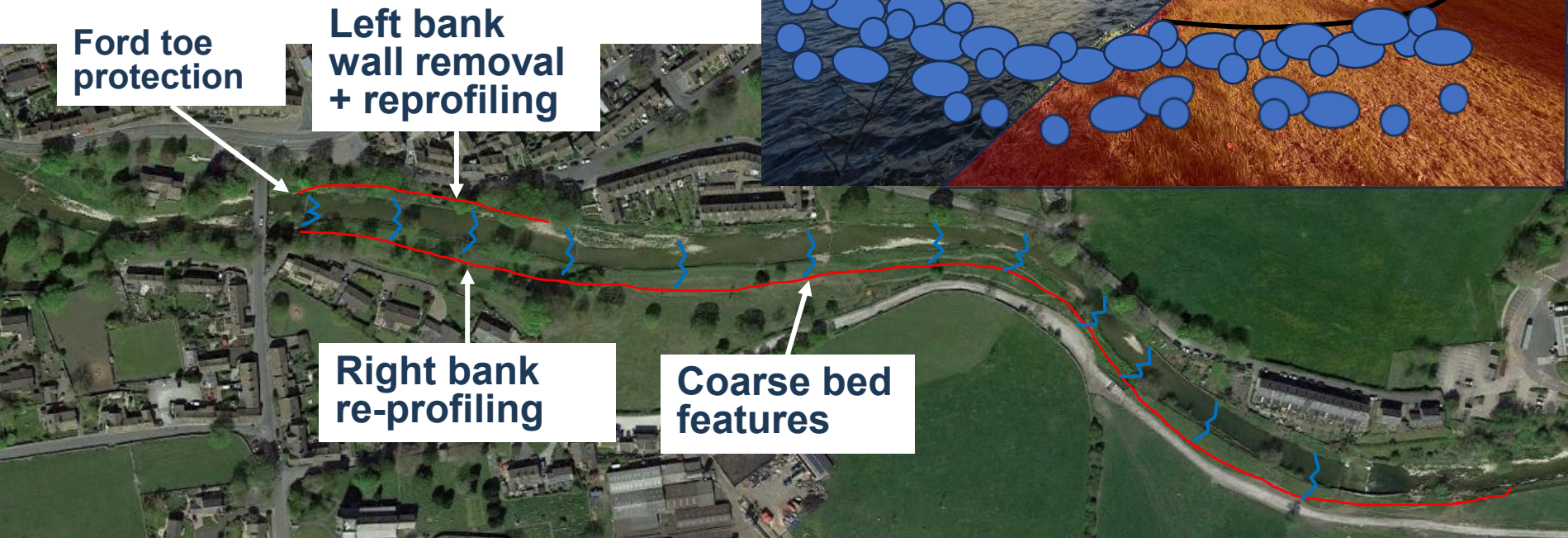
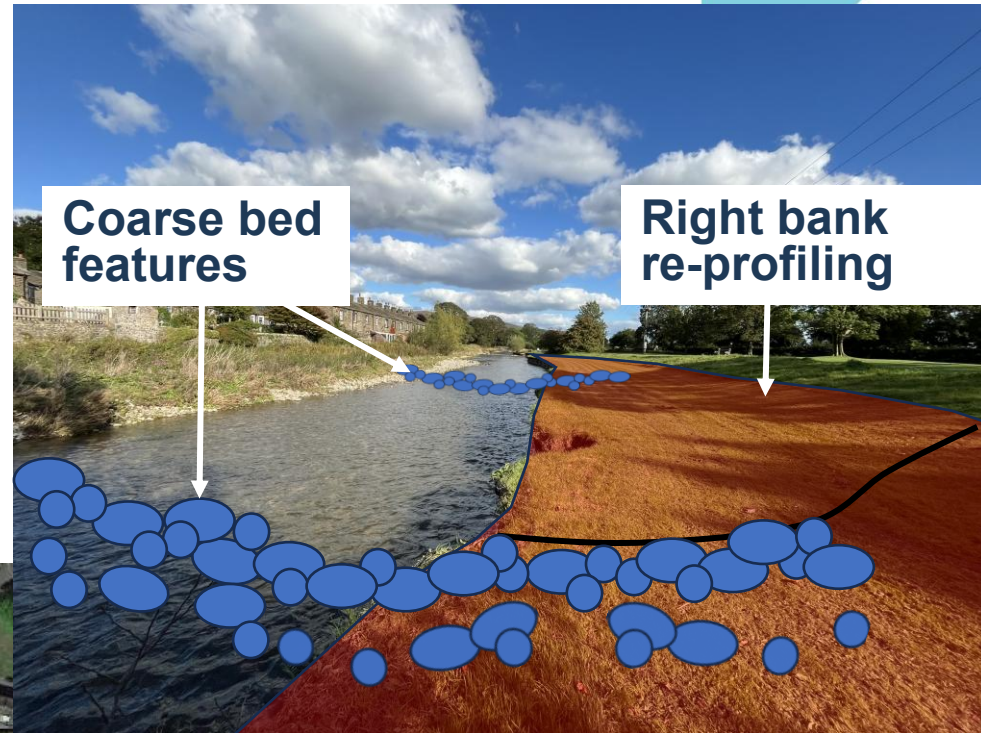
Stone ford protection measures

- Small boulder and cobble protection of the downstream toe of the ford.
- Control undermining + collapse of stone ford, mitigating risk of upstream migration of knick-point erosion.



Coarse bed features to control bed erosion

- Rapid or cascade features formed of cobbles and boulders to control bed erosion.
- Positioned at intervals along the impacted reach.
- Provides channel bed stability.
- Works with natural processes.



Targeted infrastructure protection

- Where infrastructure or risk receptors cannot be set back, additional bank or bed protection may be considered.



Questions?