Geomorphological Assessment: Afon Colwyn at Hafod Wydr

The Afon Colwyn rises on the western side of Eryi (Snowdon) on the Allt Maenderyn at 690 m above sea level (asl). It is a relatively short river that drains into the Afon Glaslyn at Beddgelert. The river is typical of an upland system, with a flashy run-off regime. The river is entrenched (several meters) within its valley, with relatively little floodplain along most of its course. The catchment is underlain by Ordovician-aged rocks (Rhyolitic Tuff, Microgabbro, Basalt), with the surficial geology dominated by glacigenic sediments (till, sands and gravels) deposited during the last glacial maximum (Fig. 1). The river is a single-thread, meandering system, with a low channel sinuosity.

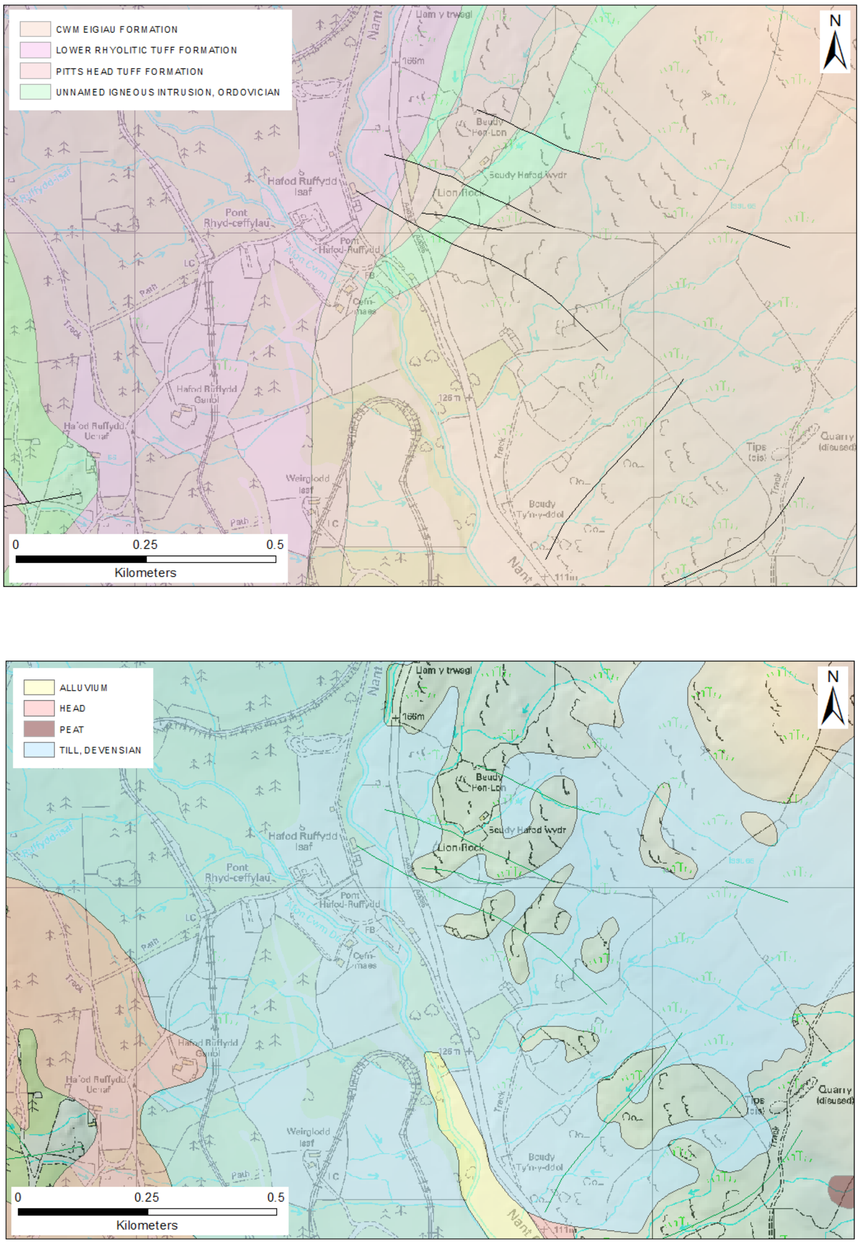


Figure 1: Solid Geology (top) and Superficial Geology (bottom) underlying the reach.

Planform Geomorphology (form and processes)

The Afon Colwyn at Hafod Wdyr is a laterally stable channel, lying within an incised valley (Fig. 2). The reach planform has a sinuosity index (SI) of 1.9, indicating it is a sinuous reach, though bends are irregular. The reach lies in a steep section of the Afon Colwyn, with a slope gradient of 5.5%.

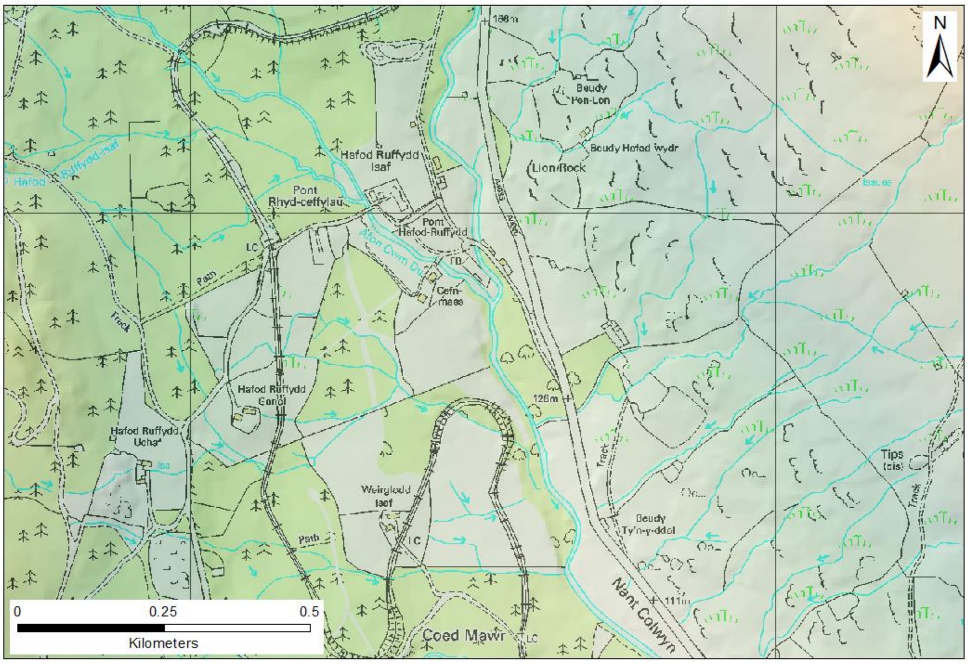


Figure 2: Proposed reach on the Afon Colwyn.

The reach is a typical mountain torrent, with a confined planform. The river eventually becomes a wandering/meandering gravel bed river in its lower section more typical of Welsh lowland rivers. The channel bed comprises boulder deposits and bedrock benches creating a step and pool sequence. The river flows over these small (1-1.5m) vertical drops forming cascades that plunge into the small pools. These steps are permanent features of this reach. During normal flow, energy will be dissipated as it flows over each rock step, however, during high flow (extreme) events these steps will become obsolete. Towards the end of the reach, the valley widens out a little and a limited floodplain is present.

The planform geomorphology will not be subject to alternation due to the nature of the system as outline above.

Sedimentology (bed and bank)

Along the reach, bedrock frequently outcrops within the channel and banks (see Appendix I, II; photos 1-4, 6-15). The banks appear to comprise large boulders, which are also prevalent on the valley sides but dense woody vegetation obscures much of the reach. The size of these large (b-axis is 1–2m) boulders that occupy the current channel banks and the limited valley floor appear out of proportion with the sediments currently occupying the channel and indicate they are the relics of glacial/deglacial transport. There is no evidence of out-of-channel deposition as the floodplain is almost non-existent for most of the reach under consideration. Due to the confined nature of the reach, there is little input from the valley slopes and instead sediment input to this reach is derived from upstream sources, from the adjoining tributary the Afon Cwm Du and smaller streams. Input is likely to be greatest during high flow events.

Immediately upstream of the proposed hydropower weir location, there is a crump weir and the river comprises a semi-natural pool at the start of the reach (see Appendix II, photo 5). This then cascades over a small rock step.

The channel bed, throughout the reach, comprises a mixed sediment profile. Sediments range from pebble to boulder-sized clasts (see Appendix II; photos 2, 6, 9). Observations in the field indicate the D min. B-axis is 3 cm and D max. B-axis is 100 cm. The clasts are well rounded, and many have a platy shape (related to bedrock).

The channel bed is not armoured, nor are the clasts imbricated. Sediment distribution along the reach shows a pattern of coarser sediment deposition within the pools, with some finer sediments deposited in the quieter (slower flow) sections of the reach. In the lee of large boulders within the channel, smaller (i.e. pebbles) clasts have accumulated. The clasts within the reach are well rounded, indicative of fluvial transport.

There is some indication of bank scour around larger tree roots, which infrequently intrude into the river due to the extent of bedrock and/or boulder deposits. Scour will be limited to the highest flow events.

There is a lack of fine sediments in this reach due to the winnowing of sediments under waning flows as high flows recede. In the fastest flowing sections (step-pool) of the reach, the alluvial sediments are be dominated by cobbles and boulders, whereas in the lower part of the reach (Appendix II; photos 12-16), where flow flowing zones of the reach the deposited sediments have a mixed-size profile.

Overall, the sediments present are typical of a mountain torrent system. They comprise coarse-calibre material, predominantly cobbles and boulders. Sediment transport within this river is typically occurring during higher flow i.e. winter or summer storm events (Fig. 1). Within the reach there is no bedload or suspended load sediment transport under normal/low flow conditions. Sediment transfer through the system is confined to high flow events when the bedload is mobilised. In-channel structures (i.e. weir, bedrock steps) become irrelevant during these high flow events.

The sediment dynamics of this reach are unlikely to be affected by the proposed scheme. This is because sediment transfer only occurs during high flows, which will be unaltered. Sediment accumulation in the weir pool will occur as part of the normal functioning of this river, with ‘flushing’ of sediments from pool to pool downstream during high flow events. The bed and bank materials will not be subject to increased erosion/deposition due to the fact the reach runs over bedrock, and where bank materials are present they comprise large boulders not currently moved under all flows experienced.

Channel Flow

The gauging station at Hafod Wydr has been recording flow on the Afon Colwyn since 1995, with data available via CEH's National River Flow Archive. The record indicates a mean flow of 0.582 ms^{-3}. The calculated flow percentiles (Fig. 3) give a Q95 (95% Exceedance) of 0.054 ms^{-3} and a Q10 (10% Exceedance) is 1.458 ms^{-3}; the relationship between these two percentiles indicates a 'flashy' flow regime, again typical of a mountain torrent. The largest recorded flow was 8.59 ms^{-3} in December 2015, and it is typically during autumn/winter when the highest flows are recorded for this river though summer extremes (e.g. 7.81 ms^{-3} June 2012) are present in the record. The number of small streams entering the Afon Colwyn in this reach are likely to have the biggest impact on channel flow during high flow events.

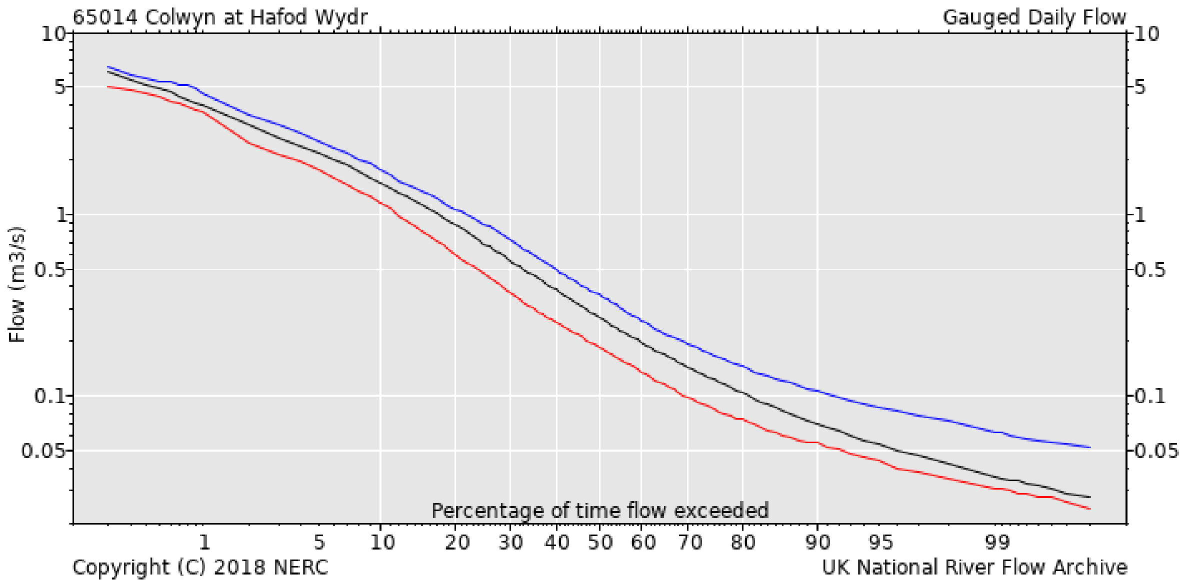


Figure 3: Flow duration curve for the Afon Colwyn (Source: https://nrfa.ceh.ac.uk/data/station/meanflow/65014).

There are no channel forms (e.g. bars) present within the reach, and therefore, residual flows will not be detrimental to the channel form or functioning. Both winter and summer high flow events will maintain the normal functioning of this reach irrespective of abstraction. It is under these conditions where sediment movement takes place.

Existing Structures

Crump weir:

Immediately above the proposed site of micro-hydropower weir, the channel has been engineered and a crump weir installed servicing the gauging station at Hafod Wydr (see Appendix II, photo 5). The weir is of concrete construction, and creates an artificial channel bed (5m wide) and banks (high wingwalls). CEH note that there is some gravel accumulation within this structure, which they remove annually. This is likely to be a gravel lag deposit, left behind after the last high flow passed through the weir, and would most probably be flushed through during the next high flow event. Removal of gravel from this site is indicative that not all sediment is fully transferred through this reach at present. However, engineered structures like this effectively increase flow in the downstream reach as there is no opportunity for erosion (dissipation of energy).

Downstream micro-hydro weir:

Downstream of the proposed scheme, there is an existing micro-hydro scheme and associated infrastructure (see Appendix II; photo 15). Flows here will be unaffected, and sediment transfer along this whole river occurs during high flow events so there will be no impedance of sediment transfer by introducing another small scheme.

Possible Impacts

Sediment transfer under the proposed scheme:

- Sediment transfer occurs during high flow events. A weir height (100cm) will slightly increase the height of the natural pool, but will not affect the semi-natural pool immediately downstream of the crump weir as this is still separated by a rock step and is 150cm lower than crest level of the pool. It is during high flow events when the sediments are transported through this system. These flows will continue to regularly transporting all grades of sediment through the pool, over the weir and through the reaches' step-pool system.
- The small reduction in flows during abstraction should have no significant effect on sediment transfer, as sediment does not move under normal flow conditions. Natural movement of sediments will continue unimpeded during high flow events.
- Proposed residual flows are relatively high and will maintain natural processes, and channel bed structure and substrate should remain unaltered by the hydro-scheme.

Impoundment under the proposed scheme:

- The weir will act to impound water, however, the structure is utilising a natural rock step and pool sequence. Water will not be backed-up beyond the extent of the current pool feature.

Sediment introduction due to temporary works:

- Invariably some sediment will be introduced into the system during the construction phase, however, this will have a short-term residency and be moved through the system during the next high flow event(s). This is true for the decommission phase as well.

Geomorphological adjustment due to the proposed scheme:

- This reach has a confined planform, thus in geomorphological terms the reach experiences little to no morphological change due to the nature of the bed and banks. As with sediment transfer, any morphological change would occur during extreme high flows that were able to overcome bank resistance, i.e. where boulders are present, and erode the glacigenic sediments that infill the valley. This has not been a feature of recent/historic channel behaviour and it is unlikely to be so during the lifetime of this micro-hydro scheme.
- There is unlikely to be any ecological impact as the morphology will not change for the reasons outline above.

Riparian zone adjustment due to the proposed scheme:

- There is no current interaction between the channel and floodplain, because for the most part the floodplain is absent. However, construction of the power house and ditch digging for installation of the outflow pipe will have a short-term impact on the limited floodplain area.

Possible Cumulative Impacts

- For the reasons outlined above, there are unlikely to be any cumulative impacts on the hydromorphology of the reach. The nature of the rock-lined/boulder-strewn confined channel planform, combined with the natural propensity for sediment transport to occur only during the highest of flows means it is particularly insensitive to change. Channel width and depth will remain unchanged due to the nature of the channel bed/bank structure, and there is little/no interaction with the riparian zone, thus its structure will also remain unaltered (WFD Article 5; Annex II).

Mitigation

Outflow pipe:

- To minimise any impact from the outflow pipe, it is suggested that cobbles/boulders be fixed around the pipe to mimic the channel bedform. This will ensure the dissipation of any excess energy that has the potential to cause localise scouring/disturbance to the channel bed as water re-enters the river. The addition of large clasts/boulders should be sourced locally (i.e. digging the outflow pipe trench should provide supply of boulders), and not taken from other parts of the reach.

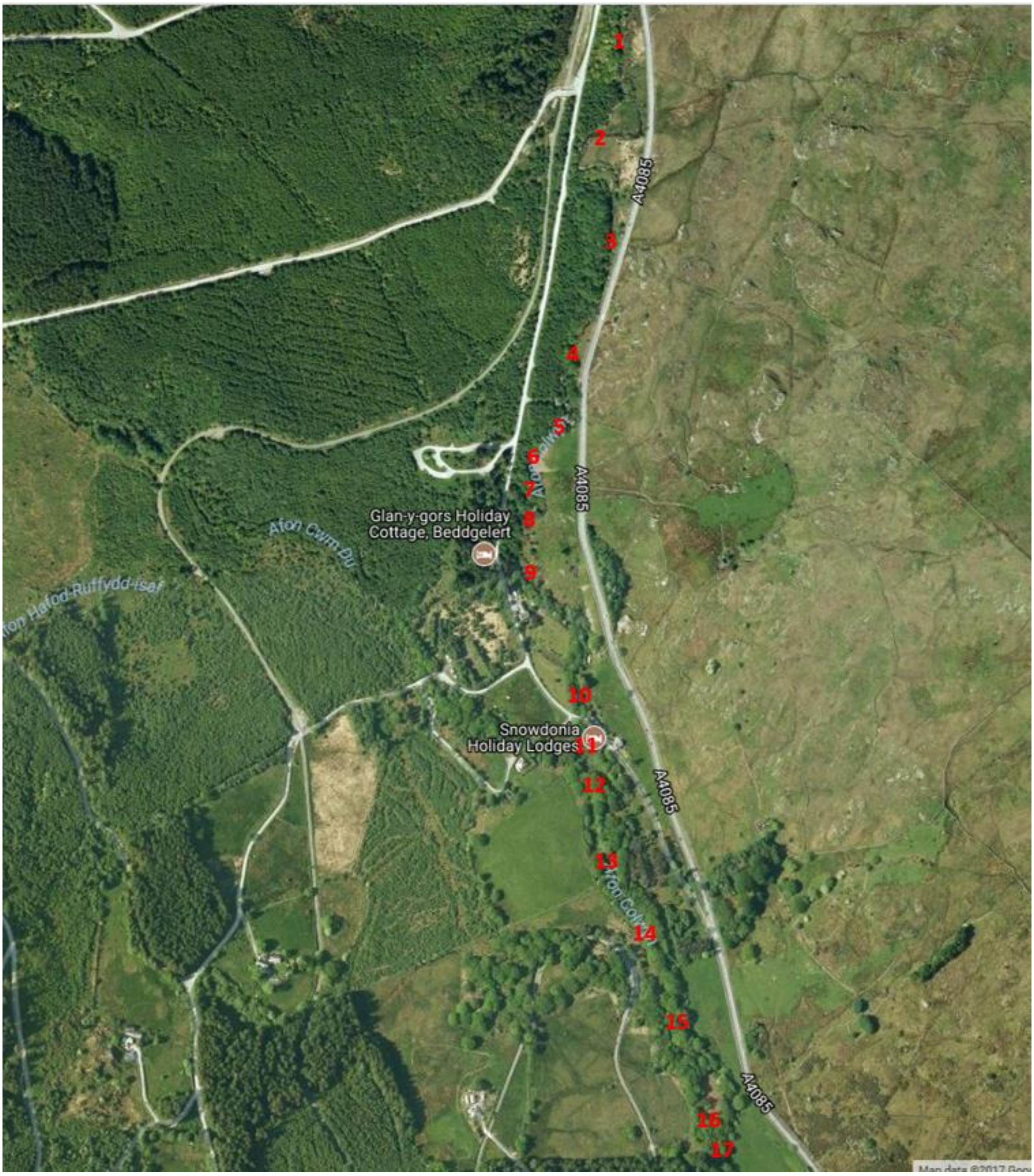
Conclusion

There is unlikely to be any hydromorphological elements impacts on this reach that would result in the deterioration of the rivers' Water Framework Directive (WFD) status, which could be described as 'high'. The proposed works and resultant micro-hydro infrastructure will not compromise Article 5 (Annex II, V) of the WFD in terms of the rivers' morphological attributes nor will they add specific pressures (e.g. substrate, impounding, flow manipulation) to put the river 'at risk'.

Dr. Lynda Yorke
Senior Lecturer in Physical Geography (Geomorphology)
Bangor University

APPENDIX I

Photo location Map; numbers correspond with photos in Appendix II.



APPENDIX II

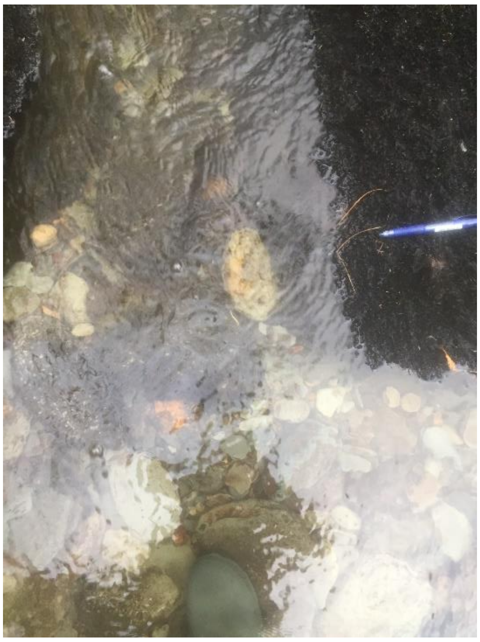
Photo survey of the River Colwyn, Hafod Wydr.

Location 1: SH57556 50790

A. Looking upstream

B. Left Bank

C. Right Bank



D. Looking down at the substrate

Location 2: SH57534 50673

A. Looking upstream

B. Right bank

C. Left bank

D. Looking down at the substrate

Location 3: SH57540 50554

A. Looking upstream

B. Right Bank

C. Left bank

D. Looking down at the substrate

Location 4: SH57485 50410

A. Waterfall – potential barrier

B. Looking upstream

C. Left bank

D. Right bank

E. Looking down at the substrate

Location 5: SH57480 50320

Location 6: SH57480 50320

A. Looking upstream

B. Right bank

C. Left bank

D. Looking down at the substrate

Location 7: SH57439 50244

A. Looking upstream

B. Right bank

C. Left bank

D. Looking at the substrate

Location 8: SH57430 50196

A. Looking upstream

B. Right bank

C. Left bank

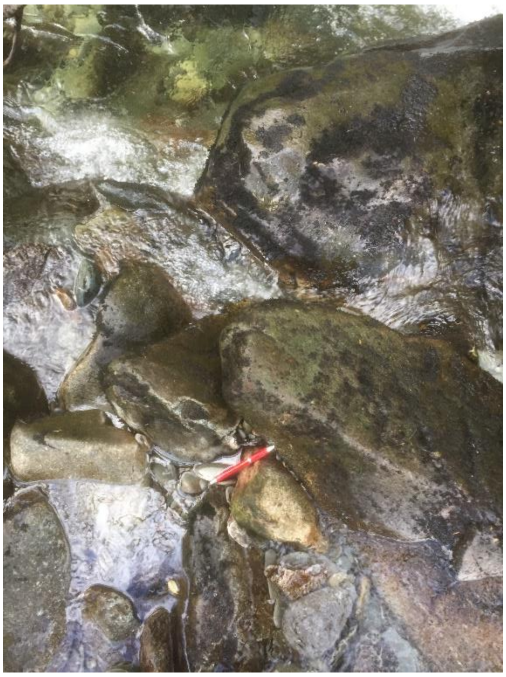
D. Looking down at the substrate

Location 9: SH57432 50110

A. Looking upstream

B. Right bank

C. Left bank



D. Looking down at the substrate

Location 10: SH57486 49954

A. Looking upstream

B. Left bank

C. Right bank

D. Looking down at the substrate

Location 11: SH57503 49903

A. Looking upstream

B. Right bank

C. Left bank

D. Looking down at the substrate

Location 12: SH57514 49834

A. Looking upstream

B. Right bank

C. Left bank

D. Looking down at the substrate

Location 13: SH57517 49758

A. Looking upstream

B. Left bank

C. Looking down at the substrate

D. Right bank

Location 14: SH57562 49621

A. Looking upstream

B. Left bank

C. Right bank

D. Looking down at the substrate

Location 15: SH57588 49621

A. Looking upstream

B. Left bank

C. Looking down at the substrate

D. Right bank

Location 16: SH57631 49507

A. Looking upstream

B. Right bank

C. Left bank

D. Looking down at the substrate

Location 17: SH57577 49690

A. Intake for newly constructed hydro scheme