# Appendix A11.8: Watercourse Crossings Report

## 1 Introduction

1.1.1 This Appendix provides additional information relating to watercourse crossings to be constructed or modified as part of the proposed scheme.

- **Section 2** provides a general description of the design approach being adopted.
- **Section 3** considers each watercourse crossing in turn identifying the preferred approach that has been adopted at this stage in the proposed scheme development.

1.1.2 This Appendix is to be read in conjunction with the relevant sections of the Environmental Statement and in particular Chapter 11 (Road Drainage and the Water Environment).

## 2 Design Approach

2.1.1 At each proposed watercourse crossing consideration has been given to the nature and size of the crossing, fluvial scour and environmental requirements.

2.1.2 There are a range of different types of watercourse crossings of differing size to be constructed as part of the proposed scheme including simply supported beam bridges, arch bridges and rectangular/circular culverts.

2.1.3 At each watercourse crossing, consideration has been given to the 'opening size' of the bridge/culvert required to pass the design fluvial event[1] incorporating appropriate freeboard. This also includes consideration of the impact of the proposed watercourse crossing on flood risk, associated with the design flood event[1], which is reported in Appendix A11.3 (Flood Risk Assessment) of the Environmental Statement.

2.1.4 The design approach being adopted for each of the watercourse crossings is provided below. In addition, reference is to be made to the design approach adopted to develop the larger bridge crossings i.e. non culvert crossings (12 of which exist within the proposed scheme) as identified in Section 3 of this appendix.

**Culvert Watercourse Crossings**

2.1.5 The majority of watercourses crossed by the existing A9 are conveyed by means of a culvert. The proposed scheme retains the same general approach to these watercourse crossings by following the design process defined below.

2.1.6 The decision making hierarchy adopted with regards to the design of culverted watercourse crossings is presented below in order of preference:

- Retain the existing watercourse crossing infrastructure unchanged.
- Retain the existing watercourse crossing infrastructure, but extended to accommodate the proposed scheme.
- Replace the existing watercourse crossing infrastructure with new infrastructure.

2.1.7 All watercourse crossings have been assessed against the design flood event[1] i.e. 0.5% AEP (200-year) plus an allowance for long term sustainability and resilience (e.g. an allowance for climate change and a minimum of 600mm freeboard to road level) such that the proposed scheme remains operational and safe for users during times of flood and flood risk is not compromised elsewhere, as reported in Appendix A11.3 (Flood Risk Assessment). Additionally, and where existing flood risk is not compromised, all new

[1] The 'design flood event' is the estimated peak flow associated with the 0.5% AEP (200-year) plus an allowance for climate change flood event. The 'design fluvial event' is used to define the fluvial event used in the design of watercourse crossings and the magnitude of the event will be given as appropriate.

replacement watercourse crossings (i.e. where it is proposed that an existing culvert is fully removed and replaced with a new culvert) have been sized as a minimum to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel, meeting the requirements of the Design Manual for Roads and Bridges (DMRB) HA107/04 (The Highways Agency et al. 2004) to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel.

**Cascades**

2.1.8 There are a number of locations where the proposed scheme will result in an earthworks 'cut' into the adjacent hillside or the invert of the new watercourse crossing will be lowered to pass beneath the proposed road drainage system. In both cases this will result in a steepened watercourse requiring a 'cascade' to safely convey the design flood event without compromising the integrity of the hillside and/or operation of the proposed scheme.

2.1.9 From a hydraulic perspective, the flow of water within a cascade is complex and characterised by two different flow types – 'nappe flow' and 'skimming flow'. 'Nappe flow' is characterised by a succession of free falling drops at each step with water depth recovering before the next step. 'Skimming flow' occurs when each step is submerged, typically occurring during larger magnitude discharges and/or longer cascades and requiring a stilling basin at the toe of the cascade to dissipate energy and allow water depth recovery. Both flow types are acceptable, as long as the proposed cascade geometry safely contains the flow of water.

2.1.10 The design approach taken has been to design a hydraulic cascade to typically follow the proposed hillside topography without significant additional excavation to form the cascade steps, which have been limited to a maximum height of 0.5m where possible.

2.1.11 Where a cascade is considered necessary at each watercourse, this is identified in Section 3. The nature of the cascade may take one of the following forms:

- bedrock channel cascade;
- natural cascade with natural gravel, cobbles and rock forming individual steps; and
- concrete cascade with stone pitching.

2.1.12 The nature of the cascade will be determined at detailed design stage taking into account hydraulic requirements, topography, fluvial morphology and nature of the underlying strata and its susceptibility to fluvial erosion. Similarly, the geometry of the proposed cascades provided in this report is indicative and may be subject to further development at detail design stage.

**Scour Protection Measures**

2.1.13 Fluvial scour of highway structure foundations is a major cause of failure. Consequently, it is critical that attention is given to the design of new watercourse crossings to prevent failure due to fluvial scour.

2.1.14 For each proposed watercourse crossings, an assessment has been made regarding the need to offer scour protection measures, in particular at bridge abutments, bridge piers, culvert exit and/or any other river training works required as part of the proposed scheme.

2.1.15 Where highways structures are founded directly onto sound bedrock and/or the watercourse local to the structure of formed by a bedrock channel with little or no alluvium mantling the risk of scour is considered to be low and hence no further scour protection measure is considered necessary at this stage.

2.1.16 Where highway structures are not founded directly onto sound bedrock and/or the channel local to the structure is not formed of bedrock, consideration has been given to estimating the maximum depth of scour such that structure foundations are set below this level and/or scour protection measures are provided to offer protection against scour and undermining of the structure foundations.

2.1.17 The extent of required scour protection measures for each watercourse is provided in Section 3 (Watercourse Crossing Information). The nature of any scour protection measure will be determined at detailed design stage taking into account hydraulic requirements, channel morphology and nature of the

underlying strata, however it could include stone (rip-rap) aprons and revetments forming the river bed and banks to limit the extent to which scour can occur.

2.1.18 The design of any scour protection measure will be in accordance with the relevant provision of the DMRB BD97/12 (The Highways Agency et al. 2012).

**Environmental Design**

2.1.19 In so far as practicable, all river engineering works associated with the scheme will be in accordance with SEPA good practice guidance, particularly with respect to river crossings (SEPA and Natural Scotland 2010a), sediment management (SEPA and Natural Scotland 2010b) and bank protection (SEPA and Natural Scotland 2008).

2.1.20 Particular consideration has been given in this report to the provision of mammal and fish passage, and culvert embedment.

Mammal Passage

2.1.21 The provision of mammal passage within watercourse crossings has been considered alongside geometric constraints, hydraulic performance requirements and other aspects of design in developing the watercourse crossing proposals outlined in this report.

2.1.22 Where existing watercourse crossing culverts are being replaced with a new culvert, consideration has been given to provide integral mammal passage where an ecological need has been identified. Mammal ledges have been designed in accordance with DMRB HA81/99 (The Highways Agency et al. 2001) and as shown in Figure 5.4 of the ES.

2.1.23 Where an existing watercourse crossing culvert has been confirmed to provide a mammal corridor but is being retained and extended to accommodate the proposed scheme, it is proposed to provide an adjacent dry mammal underpass to maintain and/or improve habitat connectivity.

2.1.24 The provision of mammal passage by means of dry mammal underpass rather than provision of mammal ledges within an enlarged watercourse culvert has been selected to avoid the need to significantly enlarge the culvert cross-section in order to meet DMRB requirements presented in Figure 5.2 of the ES.

2.1.25 Consequently, the use of dry mammal underpasses in such a situation reduces the need to increase clearance between the proposed scheme road level and the watercourse bed level. Raising proposed scheme road levels can have potentially significant impacts in terms of increasing the footprint of the road, drainage design, visual impact and increased capital cost; whereas the alternative option of lowering the watercourse potentially requires significant engineering intervention in the channel, with possible further ecological and geomorphological impacts. Avoiding, or minimising an increase in culvert size also has the benefit of reducing changes to flow conveyance capacity through the culvert, with consequent reduction in changes to both the hydraulic regime and flood risk associated with the watercourse.

2.1.26 Where required details relating to the provision of mammal passage within culvert structures is provided in Section 3. Dry mammal underpasses are not detailed within this report, but their presence is noted in Section 3 (Watercourse Crossing Information) where the dry mammal underpass is associated with an adjacent watercourse.

2.1.27 No provision is made for mammal passage through culverts proposed as part of the proposed scheme to accommodate access tracks, non-motorised user tracks and other minor crossings. Due to the (infrequent, low speed and/or non-motorised user) nature of the traffic using such minor crossings the risk to mammals crossing overland in times of high river flow within the culvert barrel is not considered to be significant.

Fish Passage

2.1.28 The current accessibility of each watercourse for migratory fish is provided in Appendix 11.1 (Baseline), where data has been available.

2.1.29 In line with good practice guidance (SEPA and Natural Scotland 2010a), measures to provide fish passage will be developed for each watercourse crossing, as determined where necessary through consultation with SEPA and the Tay District Salmon Fisheries Board, at the detailed design stage for applications made under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended).

Culvert Embedment

2.1.30 To provide continuity of river bed, maintain sediment transport and provide energy dissipation through the proposed structures where possible consideration has been given to burying the culvert invert below the natural bed level to allow for a naturalised culvert bed. This approach has been taken where a new culvert is proposed of moderate gradient and generally where the natural river bed level and bed slope is maintained through the culvert.

2.1.31 Where the channel upstream is relatively steep and where the design incorporates a hydraulic feature such as a cascade culvert embedment has not been indicated at this stage pending further development of the cascade design. In cases where the existing culvert is being retained and extended, it is necessary for the new section of culvert to match the existing cross-section; therefore, no culvert embedment is proposed.

2.1.32 The amount of embedment will vary depending on the size of culvert and hydraulic requirements. Typically, the depth of embedment will meet the following criteria, as suggested in 'Engineering in the Water Environment: Good Practice Guide, River Crossings', (Scottish Environment Protection Agency and Natural Scotland 2010a):

- for culverts less than 1.2m diameter, the invert should be buried at least 150mm below natural bed level;
- for culverts between 1.2 and 1.8m diameter, the invert should be buried at least 200mm below natural bed level; and
- for culverts greater than 1.8m diameter, the invert should be buried at least 300mm below natural bed level.

2.1.33 In addition, and where possible all new proposed scheme culverts should maintain the existing natural channel width.

2.1.34 The depth of embedment at each watercourse crossing is provided in Section 3 (Watercourse Crossing Information).

# 3 Watercourse Crossing Information

3.1.1 Table 1 provides information for each watercourse crossing which would be affected by the proposed scheme. This includes identification of the waterbody affected (together with predicted flood flows at the point of interest), details of the proposed works and broad justification for the engineering solution.

**Table 1: Watercourse crossings additional information**

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| **WF84 Allt Eachainn**<br><br>Approximate channel bed width at mainline culvert inlet: 2.8m<br><br>Flow data:<br>50% AEP: 3.03m$^3$/s<br>1% AEP: 8.27m$^3$/s<br>0.5% AEP + CC: 11.59m$^3$/s | WC84/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(291901,762498) | No change to existing structure:<br>Concrete box culvert with stepped invert.<br>Existing width (span) = 2.8m<br>Existing height = 3.4m<br>Existing length = 83m<br><br>Refer Figure A.11.8.1 | The watercourse is culverted beneath the existing A9.<br>The footprint of the A9 at this location is unchanged and therefore it is proposed to retain the existing structure unchanged. |
| **WF86**<br><br>Approximate channel bed width at mainline culvert inlet: n/a (no channel)<br><br>Flow data:<br>50% AEP: 0.02m$^3$/s<br>1% AEP: 0.06m$^3$/s<br>0.5% AEP + CC: 0.08m$^3$/s | WC86/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(291861,762711) | No change to existing structure:<br>250mm diameter plastic pipe, approximately 60m in length. | This watercourse and culvert is associated with pre-earthworks drainage located upstream of the existing A9.<br>The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway.<br>The preferred approach at this location is to retain the existing culvert unchanged - the existing culvert is sufficiently long to accommodate the proposed scheme at this location, hence there is no need to modify or replace the existing culvert. |
| **WF87**<br><br>Approximate channel bed width at mainline culvert inlet: 1.5m<br><br>Flow data:<br>50% AEP: 1.16m$^3$/s<br>1% AEP: 3.24m$^3$/s<br>0.5% AEP + CC: 4.42m$^3$/s | WC87/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(291722,762870) | Downstream extension of existing box culvert.<br>Approximately 70m long channel diversion downstream.<br><br>Existing width (span) = 2.5m<br>Existing height = 2.5m<br>Existing length = 62m<br><br>Proposed extension = 24m | The existing watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and widening of the mainline at this location.<br>• Extension of existing culvert:<br>The existing crossing infrastructure does not conflict with the proposed scheme, in particular the road box design and road drainage, hence the preferred option is to retain the existing culvert and extend it downstream to accommodate the widened mainline.<br>**Proposed Scheme** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | Proposed total length = 86m<br><br>Refer Figure A.11.8.2 | The preferred solution is to retain the existing culvert and extend it downstream.<br>A new channel will be required downstream of the culvert exit to tie-in with the existing channel and accommodate an adjacent realigned side road. A short section of existing channel adjacent to the new channel will be abandoned and infilled.<br>The alignment of the culvert extension will incorporate a bend and graded to improve the transition from the existing culvert alignment to the downstream channel. The cross-sectional geometry of the new culvert will equal the existing structure.<br>A scour protection system will be required within the channel for a short distance downstream to offer protection to the river banks and bed. The scour protection system will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a mammal corridor, therefore it is proposed to incorporate appropriately located mammal ledges within the new culvert section and retrofit a mammal ledge within the retained culvert section.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert.<br>**Flood Risk**<br>The existing culvert has sufficient capacity to freely convey flows up to the design flood event. However, hydraulic assessment predicts out of bank flooding upstream of the existing A9.<br>Numerical modelling of this watercourse indicates that extending the culvert downstream will result in a negligible (3mm) decrease in upstream water level with downstream water level increasing by 8mm. As the proposed scheme is not at risk of flooding during the design flood event and the impact on water level is considered to be negligible, no flood mitigation measures are considered necessary. |
| **WF89 (Lower Allt Girnaig)**<br><br>Approximate channel bed width at crossing: 7.5m<br><br>Flow data:<br>50% AEP: 21.6m$^3$/s<br>1% AEP: 52.4m$^3$/s<br>0.5% AEP + CC: 71.5m$^3$/s | Grid Reference:<br>(291558,763104) | Existing bridge (to be retained):<br>Existing length = 13.2m<br>Existing width (span) = 83.0m<br><br>New bridge dimensions (alongside and parallel to existing structure):<br>Proposed length = 19.5m<br>Proposed width (span) = 83.0m<br><br>Refer Figure A.11.8.3 | The existing A9 crosses the watercourse by means of a bridge comprising a three span raking leg steel portal structure with composite steel and concrete slab deck. The inclined intermediate supports are also steel and are supported on reinforced concrete spread footings. The end supports comprise reinforced concrete abutments on spread footings, founded on bedrock. The existing bridge superstructure is not subjected to flowing water during the design flood event and is located outwith the existing river corridor.<br>**Proposed Scheme**<br>The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway. To accommodate the proposed scheme, it is proposed to retain the existing structure, and provide a new parallel structure of the same form on the downstream side to accommodate the new northbound carriageway. The new bridge structure will not be subject to flowing water during the design flood event and will also be founded on sound bedrock.<br>**Environmental**<br>The existing river corridor will not be impacted by the proposed scheme; hence no environmental measures are considered necessary at this location.<br>**Flood Risk**<br>The existing river corridor will not be impacted by the proposed scheme, hence the impact on flood risk is considered to be negligible. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| **WF92**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.82m$^3$/s<br>1% AEP: 2.38m$^3$/s<br>0.5% AEP + CC: 3.26m$^3$/s | WC92/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(290985,763537) | New upstream cascade feature.<br>New flow diversion chamber.<br>New concrete pipe culvert.<br>New flood bypass pipe draining to WF89.<br><br>Existing diameter = 0.9m<br>Existing length = 36m<br><br>Proposed diameter = 1.6m<br>Proposed length = 50.1m<br><br>Refer Figure A.11.8.4 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 footprint at this location being widened to accommodate a new northbound carriageway and an adjacent NMU path. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme<br>• Extension of the existing culvert:<br>The existing culvert infrastructure conflicts with the proposed scheme design, in particular the road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme road surface and drainage level to accommodate the existing culvert infrastructure. This will increase the footprint of the proposed scheme and changes to drainage design. Extending the existing culvert also does not mitigate the flood risk to the proposed scheme.<br>• Replace the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme design, and the need to mitigate flood risk to the proposed scheme, the preferred option is to replace the existing culvert and also provide flood bypass.<br><br>**Proposed Scheme**<br>The preferred approach for this crossing taking account of engineering and environmental design criteria is to replace the existing culvert and to also provide flood bypass.<br>The new culvert and associated features has been designed to match the hydraulic performance of the existing culvert, in order to provide a neutral downstream flood risk impact (see flood risk discussion below). The culvert will also incorporate new concrete inlet and exit structures including headwalls, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance. At the culvert inlet, a flood diversion chamber is proposed which will limit the pass-forward flow through the culvert to match the existing culvert capacity and divert excess flood water via a bypass pipe to the Allt Girnaig (WF89). Low flows will continue to pass forward to WF92 downstream of the A9.<br>Upstream of the culvert inlet, a new cascade feature is required to link the upstream channel with the culvert entrance invert level. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system may be required for a short distance downstream of the culvert exit. If required, this will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a possible mammal corridor; however this will require a larger culvert barrel and due to the hydraulic control at the culvert entrance it may prove difficult to provide a continuous passage. Therefore it is proposed that an adjacent dry mammal pass is provided with appropriate fencing.<br>**Flood Risk**<br>Flooding is predicted both upstream and downstream of the existing culvert during the 0.5% AEP (200-year) design flood event plus allowance for climate change. The peak flow at the entrance to the existing culvert during the design flood |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | | event is 3.26m$^3$/s. In the existing situation, the peak pass forward flow downstream is 2.09m$^3$/s, whereas 1.17m$^3$/s spills from the channel upstream of the culvert entrance and travels overland in an easterly direction along the edge of the existing A9 road embankment.<br><br>Approximately 500m to the east of WF92, floodwater overtops the existing A9 road and flow in a south westerly direction through woodland towards a residential property at Druimuan. At this location the flow path is relatively wide and shallow (less than 100mm depth). Once floodwater reaches the B8079 road, it is intercepted and conveyed south-east along the road towards another residential property before overtopping the Highland Main Line (HML) railway and thereafter draining into the River Garry.<br><br>Downstream of the existing culvert, flood water spills from the existing channel to travel overland until its impounded by topography and the B8079 road. Floodwater then overtops the B8079 road to the east at the location of the WF92 culvert beneath the B8079 and to the west floodwater overtops Urrard House access road, flows across the B8079 road and passes beneath the HML railway via an underpass. A residential property at this location is also at flood risk.<br><br>To maintain a neutral flood risk impact downstream but also mitigate the flood risk to the proposed scheme resulting from the upstream flooding, it is proposed to limit the pass forward flow through the new WF92 culvert to the baseline value of 2.09m$^3$/s, and divert excess flood water at the culvert entrance to WF89 Allt Girnaig.<br><br>The magnitude of the flood flow to be diverted to Allt Girnaig (WF89) is 1.17m$^3$/s for the 0.5% AEP (200-year) design flood event plus an allowance for climate change. It is recognised that passing water from one catchment to another increases flow in the receiving watercourse. The predicted peak flow in the Allt Girnaig during the design flood event is 70m$^3$/s. Assuming concurrent peak flows in both watercourses, diverting 1.17m$^3$/s represents a 1.7% uplift in peak flows in the Allt Girnaig watercourse.<br><br>It is also recognised that the timing of the peak flow in both WF92 and Allt Girnaig (WF89) catchments at their respective crossings of the A9 will not occur at the same time. During the design flood event in each catchment; the time to peak for WF92 at the A9 crossing is 1.3 hours, whereas the time to peak for the Allt Girnaig is 5.6 hours. Notwithstanding the small amount of time associated with water flowing from WF92 to the Allt Girnaig, it is very likely that the impact of the peak flow associated with WF92 will occur during the rising limb of the Allt Girnaig flood hydrograph and be passed downstream prior to the peak flow occurring in the Allt Girnaig.<br><br>It is therefore considered that the flood risk impact of diverting excess floodwater from WF92 to the Allt Girnaig (WF89) is of 'negligible' magnitude and 'neutral' significance. This preferred option also alleviates the existing flooding occurring to the east of WF92 and in particular the existing flood risk to the residential property at Druimuan, whilst maintaining a 'neutral' impact to the existing flood risk in the downstream reach of WF92. |
| **WF95**<br><br>Approximate channel bed width at mainline culvert inlet: 0.8m<br><br>Flow data:<br>50% AEP: 0.09m$^3$/s | WC95/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(291206,763429) | New culvert.<br>Approximately 40m of channel realignment both upstream and downstream of the culvert.<br><br>Existing diameter = 0.6m<br>Existing length = 39m | The watercourse is culverted beneath the existing A9. The route of the watercourse as it meets the existing A9 follows the toe of the road embankment for a short distance before turning 90° into the existing culvert. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and an adjacent NMU path. A number of alternative options have been considered, as follows:<br><br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br><br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| 1% AEP: 0.26m$^3$/s<br>0.5% AEP + CC: 0.36m$^3$/s | | Proposed diameter = 1.05m<br>Proposed length = 57m<br>Proposed embedment depth = 0.25m<br><br>Refer Figure A.11.8.5 | An extension of the existing culvert will locate the culvert inlet and outlet at inappropriate locations and levels which relate poorly to the existing watercourse. Currently the existing culvert is located 'offline' to general alignment of the upstream and downstream watercourse. Extending the existing culvert to accommodate the proposed scheme will exacerbate the misalignment and may require significant channel diversion<br>• Replace the existing culvert:<br>Due to the poor correlation between the existing culvert infrastructure and the existing watercourse, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing culvert with a new culvert with a revised alignment.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The new culvert inlet will be located at a 'low' topographic point on the upstream earthworks boundary, allowing surface water runoff to freely drain to this point. Realignment of the upstream channel will be required to connect with the existing channel over a distance of 40m. Development of the channel design will be undertaken at detail design stage, but will typically mirror the geomorphological regime found in the channel immediately upstream. Similarly, a realignment of the channel will be required downstream of the culvert to link with the existing downstream channel.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a potential mammal corridor therefore no provision for mammal passage is proposed.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert.<br>**Flood Risk**<br>The new culvert geometry will result in a 0.32m increase in upstream water level during the design flood event.<br>However, the predicted freeboard to the proposed scheme road level is 3.81m at this location, hence the proposed scheme is not at flood risk during the design flood event and no other sensitive receptors have been identified upstream that are likely to be impacted by an increase in water level. Therefore, no further mitigation measures are considered necessary. |
| **WF96**<br><br>Approximate channel bed width at mainline culvert inlet: 0.4m | WC96/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(290464,763805) | No change to existing structure:<br>Existing diameter = 0.65m<br>Existing length = 44.2m<br><br>Refer Figure A.11.8.6 | The watercourse is culverted beneath the existing A9. The route of the watercourse follows a minor road towards an underpass, and then diverges into a separate culvert running parallel to the underpass. The watercourse is also culverted for short section immediately upstream and downstream of the A9 culvert which allows agricultural vehicular access into the adjacent fields.<br>**Proposed Scheme** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| Flow data:<br>50% AEP: 0.21m$^3$/s<br>1% AEP: 0.60m$^3$/s<br>0.5% AEP + CC: 0.82m$^3$/s | | | The existing culvert is adequate to accommodate the proposed scheme at this location. A proposed new side road on the downstream side of the A9 will provide access to a new SuDS feature; this will be accommodated using the existing downstream culvert which presently allows vehicular access to the adjacent fields.<br>**Environmental**<br>No change to the existing culvert and local watercourse is proposed.<br>**Flood risk**<br>No change to existing flood risk is anticipated. |
| **WF97**<br><br>Approximate channel bed width at mainline culvert inlet: n/a (no defined channel)<br><br>Flow data:<br>50% AEP: 0.33m$^3$/s<br>1% AEP: 0.97m$^3$/s<br>0.5% AEP + CC: 1.38m$^3$/s | WC97/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(290097,764034) | Removal of existing culvert and diversion of the watercourse to its confluence with Allt Chluain upstream of A9.<br>Abandonment of existing culvert beneath A9.<br>Abandonment of existing pipe downstream of the existing A9 culvert to its confluence with the Allt Chluain.<br><br>Existing A9 culvert:<br>Diameter = 0.85m<br>Length = 31.1m<br><br>Existing downstream pipe to be abandoned:<br>Diameter = 0.38m<br>Length = 65.7m<br><br>Refer Figure A.11.8.7 | The existing watercourse issues from springs approximately 40m upstream of the existing A9. Thereafter the watercourse is culverted beneath the existing A9 and then piped to its confluence with the Allt Chluain approximately 100m downstream. The watercourse is considered to be of low geomorphological and environmental status.<br>The proposed scheme will result in the mainline being widened to accommodate a new northbound carriageway and a new northbound diverge slip for the Aldclune junction. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Downstream extension of the existing culvert would conflict with the proposed scheme road drainage and road box depth, and would not pass beneath the proposed junction slip road level.<br>• Replacement of the existing culvert:<br>A replacement culvert could be arranged to pass beneath the proposed mainline and slip road. This will require re-grading the culvert invert level along its full length, including the pipe section traversing the adjacent fields to its confluence with the Allt Chluain watercourse, requiring significant excavation works.<br>• Diversion of watercourse:<br>Given the low sensitivity of the watercourse and to avoid the conflict with the proposed scheme design, the preferred solution is to divert the alignment of the watercourse to run parallel to the proposed scheme in a northerly direction to a new confluence with the Allt Chluain.<br>**Proposed Scheme**<br>The preferred approach for this crossing taking account of engineering and environmental design criteria is to abandon the existing culvert and divert the watercourse to a new confluence with the Allt Chluain approximately 120m upstream of the existing confluence location.<br>The watercourse will be piped along this length (approximately 100m). The existing culvert and downstream pipe will be abandoned and removed as part of the proposed scheme.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a mammal corridor; hence the provision for mammal passage is not required. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | **Flood Risk**<br>Relocating the confluence of the watercourse with the Allt Chluain 120m upstream will result in an increase in flood risk to a short reach of the Allt Chluain watercourse. Given that no flood risk sensitive receptors exist along this short reach; no further mitigation measures are being considered. Downstream of the existing confluence location the flood risk impact is considered to be negligible. |
| **WF98 (Allt Chluain)**<br><br>Approximate channel bed width at crossing: 4.3m<br><br>Flow data:<br>50% AEP: 2.36m$^3$/s<br>1% AEP: 5.82m$^3$/s<br>0.5% AEP + CC: 7.88m$^3$/s<br><br>(Note - Flows are quoted for baseline conditions (i.e. excluding the proposed upstream diversion of WF97 into this watercourse) | Grid Reference:<br>(290016,764065) | Existing Bridge dimensions:<br>Existing length = 13.2m<br>Existing width (span) = 26.5m<br><br>New Bridge dimensions:<br>Proposed length = 18m<br>Proposed width (span) = 26.4m<br><br>Refer Figure A.11.8.8 | The existing A9 crosses the watercourse by means of a single span bridge consisting of precast pre-stressed concrete 'M' beams composite with a reinforced concrete deck slab. The end supports comprise full height reinforced concrete cantilever abutments on spread footings. It is anticipated that the existing abutment footings are founded on bedrock, and this is based on exposed bedrock forming the left hand channel bank with outcrops observed on the right hand bank upstream of the existing bridge<br>The right hank beneath the existing bridge is formed by a gabion basket wall which supports an access track located between the right bank top and right abutment face. A section of this gabion wall has collapsed exposing the fill material founding the track which has slumped into the channel, thereby compromising the integrity of the track.<br>**Proposed Scheme**<br>The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and a northbound slip road associated with Aldclune Junction.<br>It is proposed to retain the existing bridge and provide two new parallel bridges, one immediately downstream of the existing A9 bridge to accommodate the new northbound carriageway and the second bridge a little further downstream to accommodate the proposed slip road.<br>The nature of both new bridges is proposed to be similar in construction to the existing A9 bridge, with abutments founded on sound bedrock.<br>The existing gabion wall will be repaired together with reinstatement of the existing track beneath the existing A9 bridge. Additionally, the gabion wall forming the right hand bank will be extended downstream to offer support and protection to the track as it passes beneath the two new proposed bridges. The nature of the gabion wall will be designed at detail design stage in accordance with DMRB requirements.<br>**Environmental**<br>Other than the reinstatement and extension of the existing gabion wall forming the right hand bank, no further in channel works are proposed.<br>**Flood Risk**<br>As the proposed works will not constrict the design flow, flood risk impact is considered to be negligible. |
| **WF100**<br>River Garry (ch4300)<br><br>Approximate channel bed width at crossing: 53m | Grid Reference:<br>(298107,764269) | Existing Bridge dimensions:<br>Existing length = 13.2m<br>Existing width (span) = 166.5m<br><br>New Bridge dimensions: | The existing A9 crosses the River Garry by means of the Essangal Underbridge. The existing structure is a four span structure with the superstructure comprising continuous steel 'I' girders with a composite concrete slab deck. The intermediate supports are concrete piers on either spread footings or piled foundations and the end supports comprise reinforced concrete cantilever abutments on spread footings. A gabion mattress scour protection system surrounds the existing bridge piers.<br>**Proposed Scheme** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| Flow data:<br>50% AEP: 402m$^3$/s<br>1% AEP: 852m$^3$/s<br>0.5% AEP + CC: 1155m$^3$/s | | Proposed length = 26.7m*<br>Proposed width (span) = 171.5m<br><br>* measured perpendicular to carriageway<br><br>Refer Figure A.11.8.9 | The proposed scheme will retain the existing bridge unchanged to carry the southbound carriageway together with the provision of a new bridge located immediately downstream of the existing bridge to carry the northbound carriageway. It is proposed that the new bridge mirrors the existing bridge, such that it will comprise of three bridge piers (two in the main channel and one on the adjacent floodplain) and two bridge abutments set back from the river. The principal axis (alignment) of the new bridge piers and abutments will follow the alignment of the existing bridge features.<br>The existing and proposed bridge piers will be subjected to flowing water during the design flood event i.e.0.5% AEP (200-year) plus an allowance for climate change, and consequently they will be subjected to fluvial scour. Its noted that the existing bridge piers and river bank local to the existing bridge crossing is afforded protection against erosion, via the use of gabion mattresses and boxes.<br>Combining the impact of both the existing pier and adjacent new pier on fluvial scour results in a predicted total scour depth of between 3.2m and 6.0m, following the methodology presented in the 'Manual on scour at bridges and other hydraulic structures', CIRIA C742. The wide range is principally attributed to the angle of flow relative to the pier axis, which due to the presence of a deep upstream pool and rock outcrop may be up to 20 degrees. To prevent undermining and loss of support to both the exiting bridge pier foundations and proposed bridge pier foundations, it is proposed to provide a scour protection system.<br>The scour protection system will be designed in accordance with DMRB BD97/12 and guidance provided in CIRIA C742 and will consist of rock armour placed on an appropriate filter layer. The scour protection system will circumnavigate each pier and also form part of the river bank at the bridge crossing. This will require the removal of the existing gabion mattresses and boxes, as these are considered to be inadequate and to also allow for a homogeneous and continuous scour protection system. In addition, the scour protection system will be located 0.9m below 'natural' river bed level, so as to minimise the obstruction to flow. Further detail is provided on the Drawing.<br>**Environment**<br>Where the scour protection system is located beneath water level, it will be overlain by natural river deposits, whilst maintaining the existing channel geometry.<br>The provision of specific features to facilitate mammal passage at this bridge crossing is not required, due to the open nature of the bridge.<br>**Flood Risk**<br>In summary, the overall impact of the proposed scheme and Essangal Underbridge at this location is considered to be negligible, however given the complex hydraulic interaction between the River Garry and its floodplain at this location, this reach of the River Garry has been subjected to numerical modelling, the results of which and flood risk impact have been assessed and reported in further detail in the Flood Risk Assessment (Jacobs 2017b). |
| **WF101**<br><br>Approximate channel bed width at mainline culvert inlet: 1.5m<br><br>50% AEP: 0.26m$^3$/s<br>1% AEP: 0.74m$^3$/s | WC101/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(288383,764321) | Downstream extension of the existing culvert, including replacement of existing access track culvert.<br><br>Existing diameter = 1.0m<br>Existing length = 31m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to predominately accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| 0.5% AEP + CC: 1.01m$^3$/s | | Proposed diameter = 1.0m<br>Proposed length = 48m<br><br>Refer Figure A.11.8.10 | The existing crossing infrastructure does not conflict with the proposed scheme, in particular the road box design and road drainage, hence the preferred option is to retain the existing culvert and extend it downstream to accommodate the widened mainline.<br>**Proposed Scheme**<br>The preferred approach for this crossing taking account of engineering and environmental design criteria is to extend the existing culvert downstream to accommodate the proposed scheme.<br>Extending the culvert will encompass both the widened A9 and also replace the existing (currently separate) culvert carrying an existing adjacent access track which will be retained as part of the proposed scheme<br>The size and geometry of the extended culvert will match the geometry of the existing culvert. The existing upstream inlet arrangement will be retained unchanged, however a new culvert exit will be provide including concrete headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance. A scour protection system will be required at the culvert exit to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>The provision to accommodate natural river bed deposits to form the culvert invert by oversizing the proposed culvert is not possible at this location, given the need to match the geometry of the existing culvert.<br>**Flood Risk**<br>The existing culvert has sufficient capacity to freely pass the design flood event. With the proposed scheme in place, the headwater level upstream of the culvert is predicted to increase by 0.04m. However, there is sufficient freeboard between the proposed scheme road level and headwater level i.e. greater than 0.6m; hence, the proposed scheme is not considered to be at flood risk during the design flood event. Given that there is no loss in existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further flood mitigation measures are considered necessary. |
| **WF102**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.19m$^3$/s<br>1% AEP: 0.55m$^3$/s<br>0.5% AEP + CC: 0.76m$^3$/s | WC102/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(287288,764736) | Extension both upstream and downstream of existing culvert.<br><br>Existing diameter = 1.0m<br>Existing length = 46.5m<br><br>Proposed diameter = 1.0m<br>Proposed length = 110m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and adjacent access tracks. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure does not conflict with the proposed scheme, hence the preferred option is to retain the existing culvert and extend it at each end to accommodate the proposed scheme.<br>• Replacement of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | Refer Figure A.11.8.11 | Consideration was given to a new replacement culvert at this location. However; this would require further upstream channel regrading or would mirror the gradients and length of the current proposal hence it is considered that there would be little/no benefit in a culvert replacement at this location.<br>**Proposed Scheme**<br>The preferred approach is to retain and extend the existing culvert to accommodate the proposed scheme including the adjacent access tracks in a single culvert.<br>The existing upstream watercourse follows a steep gradient to the entrance of the existing culvert. Extending the existing culvert upstream at the same gradient, will result in the culvert entrance being significantly lower than the existing channel bed level. To overcome this, the upstream extended culvert section is set at a slightly steeper gradient, such that the invert level at the culvert entrance meets the existing upstream channel bed level. A short section of channel regrading will also be required. This will introduce an 'elbow' within the culvert profile requiring manhole access for maintenance and inspection purposes. The manhole is proposed to be located at a position set back from the carriageway to the rear of the road verge. The downstream culvert extension is proposed to match the gradient of the existing culvert being retained.<br>The cross section of the new culvert sections will equal the existing culvert cross section.<br>A scour protection system will be required at the culvert exit to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location due to the retention (and extension) of the existing culvert which cannot accommodate mammal ledges, designed to DMRB specification to be included in the culvert, Mammal habitat connectivity shall be maintained at alternative, nearby watercourses and use shall be encouraged using mammal fencing.<br>Instead, mammal habitat connectivity is possible at alternative nearby watercourses.<br>As this is an extension of an existing culvert, no allowance has been made to provide a continuous natural river bed, as this would result in difference sized culverts which would be undesirable from a hydraulic performance perspective.<br>**Flood Risk**<br>The existing culvert has sufficient capacity to freely pass the design flood event. With the proposed scheme in place, headwater water level is predicted to increase by 0.19m. However, the design flood flow is predicted to remain in-bank and will not pose a flood risk to the proposed scheme with sufficient freeboard. No other upstream flood sensitive receptors have been identified, therefore, no further mitigation measures are considered necessary. |
| **WF103**<br><br>Approximate channel bed width at mainline culvert inlet: 1.2m<br><br>Flow data: | WC103/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(287074,764858) | 17m of upstream channel regrading and realignment.<br>Replacement of existing culvert with a new alignment.<br><br>Existing diameter = 1.0m<br>Existing length = 39.5m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| 50% AEP: 0.24m$^3$/s<br>1% AEP: 0.66m$^3$/s<br>0.5% AEP + CC: 0.95m$^3$/s | | Proposed diameter = 1.05m<br>Proposed length = 49m<br>Proposed Embedment = 0m<br><br>Refer Figure A.11.8.12 | Linear extension of the existing culvert infrastructure would conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing with a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>Realignment of the upstream channel is required to both lower the river bed level to meet the culvert entrance and also to avoid the proposed earthworks associated with the adjacent Tulach Hill NMU underpass. Additional new culverts will be required both upstream and downstream to convey adjacent side roads.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Instead, consideration has been given for the provision of mammal passage at the location via the adjacent 'dry' NMU underpass. Furthermore, mammal habitat connectivity is possible at an alternative structure.<br>No allowance has been made to provide a continuous natural river bed within the new culvert sections.<br>**Flood Risk**<br>The existing culvert and upstream channel has sufficient capacity to freely pass the design flood event.<br>With the proposed scheme in place upstream headwater level will rise by 0.22m, however, 0.6m of freeboard is available between the design flood water level and the proposed scheme road level, hence the proposed scheme is not at risk of flooding during the design flood event. Given that there is no loss in existing floodplain storage as the design flood event is contained within the channel and that there are no other local flood sensitive receptors, no further mitigation measures are considered necessary. |
| | WC103/NMU/US<br>(side road culvert)<br><br>Grid Reference: | New culvert:<br>Proposed diameter = 0.9m<br>Proposed length = 7m | A new culvert is required upstream of the A9 crossing to accommodate a proposed access track to the south of the A9. There is no existing watercourse crossing at this location.<br>The proposed new circular pipe culvert has been designed to freely pass the 2% AEP (50-year) design fluvial event with appropriate freeboard. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | (287055,764820) | Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.12 | |
| | WC103/ACC/DS<br>(side road culvert)<br><br>Grid Reference:<br>(287091,764922) | New culvert:<br>Proposed diameter = 0.9m<br>Proposed length = 7m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.12 | A new culvert is required downstream of the A9 crossing to accommodate a proposed track providing access to riverside properties, agricultural land and a proposed new SuDS feature required as part of the proposed scheme. The existing ford at this location is unsuitable due to the higher elevation of the proposed track.<br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard. |
| **WF104**<br><br>Approximate channel bed width at mainline culvert inlet: 1.2m<br><br>Flow data:<br>50% AEP: 0.04m$^3$/s<br>1% AEP: 0.11m$^3$/s<br>0.5% AEP + CC: 0.15m$^3$/s | WC104/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(286942,764928) | Replace the existing culvert with a new culvert.<br><br>Existing diameter = 0.6m<br>Existing length = 54m<br><br>Proposed diameter = 0.6 m<br>Proposed length = 59m<br>Proposed embedment = 0m<br><br>Refer Figure A.11.8.13 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and adjacent access tracks and NMU path. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>• Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design. Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution taking into account engineering and environmental design criteria is to replace the existing culvert with a new culvert along a revised plan alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit. Additional new culverts will be required further upstream and downstream to convey proposed side roads.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | **Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location due to the availability of mammal habitat connectivity via the adjacent Tualch Hill NMU underpass.<br>Due to the steepness of the proposed new culvert, no allowance has been made to provide a continuous natural river bed within the new culvert section.<br>**Flood Risk**<br>The proposed new culvert will freely pass the peak flow associated with the design flood event; however, the headwater level at the culvert entrance is predicted to increase by 0.70m. The available freeboard between the proposed mainline road level and headwater level is0.68m; hence, the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary. |
| | WC104/NMU/US<br>(side road culvert)<br><br>Grid Reference:<br>(286943,764868) | New culvert:<br>Proposed diameter = 0.6m<br>Proposed length = 9m<br>Proposed embedment = 0m<br><br>Refer Figure A.11.8.13 | A new culvert is required upstream of the A9 crossing to accommodate a proposed access track/NMU path to the south of the A9. There is no existing watercourse crossing at this location.<br>The proposed new circular culvert has been designed to pass the 2% AEP (50-year) design fluvial event with appropriate freeboard. |
| | WC104/ACC/DS<br>(side road culvert)<br><br>Grid Reference:<br>(287011,764980) | New culvert:<br>Proposed diameter = 0.6m<br>Proposed length = 28m<br>Proposed embedment = 0m<br><br>Refer Figure A.11.8.13 | A new culvert is required downstream of the A9 crossing to accommodate a proposed track providing access to agricultural land, woodland and a proposed new SuDS feature required as part of the proposed scheme. There is no existing watercourse crossing at this location.<br>The proposed new circular culvert has been designed to pass the 2% AEP (50-year) design fluvial event with appropriate freeboard. |
| **WF105**<br><br>Approximate channel bed width at mainline culvert inlet: 0.3m<br><br>Flow data:<br>50% AEP: 0.03m$^3$/s<br>1% AEP: 0.10m$^3$/s<br>0.5% AEP + CC: 0.13m$^3$/s | WC105/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(286919,764953) | New upstream cascade feature.<br>Replace existing culvert with a new culvert with new alignment.<br><br>Existing diameter = 0.44m<br>Existing length = 30.3m<br><br>Proposed diameter = 0.6m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and an adjacent access track/NMU path. A number of alternative options have been considered, as follows;<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | Proposed length = 59m<br>Proposed Embedment = 0m<br><br>Refer Figure A.11.8.14 | • Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred approach for this crossing taking account of engineering and environmental design criteria is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>Crossing the proposed mainline and adjacent access track/NMU will be accommodated via a single culvert crossing. The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit<br>To avoid the proposed scheme road box and drainage system, the new culvert requires to be set at a lower invert level, in particular at its entrance and hence its gradient will be reduced compared to the existing culvert. The lower culvert entrance invert level will require an upstream cascade feature to link the culvert entrance with the upstream natural channel. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a mammal corridor; hence the provision for mammal passage is not required.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The proposed new culvert will freely pass the peak flow associated with the design flood event. Headwater level at the culvert entrance is predicted to increase by 0.35m, however 1.69m freeboard is available between the headwater level and proposed mainline road level, hence the proposed scheme is not considered to be at flood risk associated with the design flood event. Given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert, no further mitigation measures are considered necessary. |
| **WF106**<br><br>Approximate channel bed width at mainline culvert inlet: 0.3m<br><br>Flow data:<br>50% AEP: 0.09m$^3$/s | WC106/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(286698,765063) | Realignment of approximately 30m of channel upstream incorporating a new cascade feature and pre-earthworks drainage channel.<br>Replace existing culvert with a new culvert with new alignment.<br><br>Existing diameter = 0.65m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and adjacent access track/NMU track. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure would conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure This would |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| 1% AEP: 0.25m$^3$/s<br>0.5% AEP + CC: 0.35m$^3$/s | | Existing length = 27m<br><br>Proposed diameter = 1.05m<br>Proposed length = 59.4m<br>Proposed embedment = 0m<br><br>Refer Figure A.11.8.15 | have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution taking account of engineering and environmental design criteria is to replace the existing culvert with a new culvert following a revised alignment to accommodate the proposed scheme. Crossing the proposed mainline and adjacent access track/NMU will be accommodated via a single culvert.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>Upstream of the cascade approximately 30m of new channel will be required to tie-in with the existing channel upstream, this will be formed by part of the proposed scheme pre-earthworks drainage.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The proposed culvert will freely pass the peak flow associated with the design flood event. Headwater level at the culvert entrance is predicted to increase by 0.2m, however greater than 0.6m freeboard is available between the proposed scheme road level and headwater level, hence the proposed scheme is not considered to be at flood risk associated with the design flood event. Given that there is no loss in floodplain storage and that there are no other flood sensitive receptors local to the culvert, no further mitigation measures are considered necessary. |
| **WF107** | WC107/A9<br>(mainline culvert) | Replacement of existing twin barrel culvert with a single culvert with new alignment. | The watercourse is culverted beneath the existing A9 from a catch pit in pre-earthworks drainage upstream of the existing A9 carriageway. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| Approximate channel bed width at mainline culvert inlet: n/a (no channel)<br><br>Flow data:<br>50% AEP: 0.11m$^3$/s<br>1% AEP: 0.32m$^3$/s<br>0.5% AEP + CC: 0.44m$^3$/s | Grid Reference:<br>(286523,765151) | Existing diameter = 0.45m (each)<br>Existing length = 40m<br><br>Proposed diameter = 1.35m (single)<br>Proposed length = 57m<br>Proposed embedment = 0.55m<br><br>Refer Figure A.11.8.16 | The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and also includes an adjacent access track/NMU path. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert (i.e. assuming no bends or elbows in the pipe) would locate the culvert inlet and outlet at inappropriate positions and invert levels which relate poorly to the existing downstream watercourse and the proposed topographic low point in upstream pre-earthworks drainage system.<br>• Replacement of the existing culvert:<br>Due to the poor correlation between an extended culvert and the existing watercourse alignment, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing with a revised alignment to accommodate the proposed scheme. Both the proposed mainline and adjacent access track will be crossed via a single culvert.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>The proposed culvert has been sized to accommodate a continuous natural river bed through the culvert length.<br>**Flood Risk**<br>The proposed culvert will freely pass the peak flow associated with the design flood event. Headwater level at the culvert entrance is predicted to increase by 0.97m, however greater than 0.6m freeboard is available between the proposed mainline road level and headwater level, hence the proposed scheme is not considered to be at flood risk associated with the design flood event. Given that there is no loss in existing floodplain storage and that there are no other flood sensitive receptors local to the culvert, no further mitigation measures are considered necessary. |
| **WF108** | WC108/A9<br>(mainline culvert) | New upstream cascade feature. | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| Approximate channel bed width at mainline culvert inlet: 0.75m.<br><br>Flow data:<br>50% AEP: 0.16m$^3$/s<br>1% AEP: 0.48m$^3$/s<br>0.5% AEP + CC: 0.66m$^3$/s | Grid Reference:<br>(286122,765234) | Replace existing culvert with a new culvert with new alignment.<br><br>Existing diameter = 0.49m<br>Existing length = 29.2m<br><br>Proposed diameter = 1.05m<br>Proposed length = 52.1m<br>Proposed embedment = 0m<br><br>Refer Figure A.11.8.17 | • Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure would conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert would require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing with a new crossing following a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The proposed new culvert will reduce upstream water level when compared to the existing situation, and freeboard between the headwater level at the culvert entrance and proposed mainline road level is 0.74m, hence the proposed scheme is not at risk of flooding during the design flood event.<br>Due to the new culvert being larger than the existing culvert, the peak pass forward flow will increase however given the magnitude of the peak design flood flow is small (0.66m$^3$/s), no loss in existing floodplain storage and that there are no |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | | flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry no further mitigation measures are considered necessary. |
| **WF109**<br><br>Approximate channel bed width at mainline culvert inlet: 0.4m<br><br>Flow data:<br>50% AEP: 0.14m$^3$/s<br>1% AEP: 0.42m$^3$/s<br>0.5% AEP + CC: 0.58m$^3$/s | WC109/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(285962,765237) | New upstream cascade feature.<br>Replace existing culvert with a new culvert with new alignment.<br><br>Existing diameter = 0.66m<br>Existing length = 40m<br><br>Proposed diameter = 0.9m<br>Proposed length = 46.3m<br>Embedment depth = 0m<br><br>Refer Figure A.11.8.18 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure would conflict with the proposed scheme design, in particular the road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred approach for this crossing, taking account of engineering and environmental design criteria, is to replace the existing culvert with a new culvert following a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at an alternative, nearby structure and use shall be encouraged using mammal fencing. Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | | The proposed new culvert will reduce upstream water level when compared to the existing situation, and freeboard between the headwater level at the culvert entrance and proposed mainline road level is 0.95m, hence the proposed scheme is not at risk of flooding during the design flood event.<br><br>Due to the new culvert being larger than the existing culvert, the peak pass forward flow will increase however given the magnitude of the peak design flood flow is small (0.58m$^3$/s), no loss in existing floodplain storage and that there are no flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry no further mitigation measures are considered necessary. |
| **WF110**<br><br>Approximate channel bed width at mainline culvert inlet: 0.4m<br><br>Flow data:<br>50% AEP: 0.10m$^3$/s<br>1% AEP: 0.30m$^3$/s<br>0.5% AEP + CC: 0.42m$^3$/s | WC110/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(285574,765241) | New 10m upstream channel diversion.<br><br>New upstream cascade feature<br><br>Replace the existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 0.6m<br>Existing length = 45m<br><br>Proposed diameter = 0.9m<br>Proposed length = 46.6m<br>Embedment depth = 0m<br><br>Refer Figure A.11.8.19 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and an access track/NMU path. A number of alternative options have been considered as follows:<br><br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br><br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure could conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br><br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br><br>**Proposed Scheme**<br><br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br><br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br><br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br><br>In addition, a new culvert is required further upstream to carry a new side road and this will also require upstream cascade feature to negotiate the steel topography and link with the upstream channel.<br><br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | | **Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The proposed new A9 culvert will result in a negligible impact on upstream headwater level with a predicted increase of 0.01m. The available freeboard between the headwater level and proposed mainline road level is 0.79m, hence the proposed scheme is not at flood risk during the design flood event.<br>There is no loss of existing floodplain storage and no other flood sensitive receptors local to the culvert, hence no further flood mitigation measures are considered necessary. |
| | WC110/NMU/US<br>(side road culvert)<br><br>Grid Reference:<br>(285581,765194) | New upstream cascade feature<br>New culvert:<br>Proposed diameter = 0.75m<br>Proposed length = 6m<br><br>Refer Figure A.11.8.19 | A new culvert is required upstream of the A9 crossing to accommodate a proposed access track/NMU path. There is no existing watercourse crossing at this location.<br>The proposed new culvert has been designed to pass the 2% AEP (50-year) design fluvial event with appropriate freeboard. |
| **WF111**<br><br>Approximate channel bed width at mainline culvert inlet: 0.8m<br><br>Flow data:<br>50% AEP: 0.26m$^3$/s<br>1% AEP: 0.76m$^3$/s<br>0.5% AEP + CC: 1.06m$^3$/s | WC111/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(285438,765245) | New upstream cascade feature<br>Replace existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 0.65m<br>Existing length = 48m<br><br>Proposed diameter = 1.05m<br>Proposed length = 50.1m<br><br>Refer Figure A.11.8.20 | The watercourse is culverted beneath the existing A9. The proposed scheme would result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and a proposed access track/NMU path. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and the existing culvert infrastructure would conflict with the vertical alignment of the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure would conflict with the proposed scheme design, in particular the road box and road drainage design. Retaining and extending the existing culvert would require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | | The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br><br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br><br>In addition, a new culvert is required further upstream to carry a new side road.<br><br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br><br>**Environmental**<br><br>Ecological assessment has identified this watercourse as a potential mammal corridor. Mammal habitat connectivity shall be maintained at an alternative, nearby structure and use shall be encouraged using mammal fencing. Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br><br>**Flood Risk**<br><br>The proposed new A9 culvert will result in a slight reduction in upstream headwater level compared to the existing situation. The available freeboard between the headwater level and proposed mainline road level is 0.84m, hence the proposed scheme is not at flood risk during the design flood event.<br><br>Due to the new culvert being larger than the existing culvert, the peak pass forward flow will increase however given the magnitude of the peak design flood flow is small (1.06$m^3$/s), no loss in existing floodplain storage and that there are no flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry no further mitigation measures are considered necessary. |
| | WC111/NMU/US<br>(side road culvert)<br><br>Grid Reference:<br>(285431,765201) | New culvert:<br>Proposed diameter = 1.05m<br>Proposed length = 5m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.20 | A new culvert is required upstream of the A9 crossing to accommodate a proposed access track/NMU path. There is no existing watercourse crossing at this location.<br><br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard. |
| **WF112**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m | WC112/A9<br>(mainline culvert)<br><br>Grid Reference: | New upstream cascade feature.<br>Replace the existing circular culvert with a new box culvert. | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and an access track/NMU path. A number of alternative options have been considered, as follows:<br><br>• Retain the existing culvert unchanged:<br><br>The existing culvert is not long enough to accommodate the proposed scheme. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| Flow data:<br>50% AEP: 0.22m$^3$/s<br>1% AEP: 0.64m$^3$/s<br>0.5% AEP + CC: 0.88m$^3$/s | (286122,765234) | Existing diameter = 0.66m<br>Existing length = 58m<br><br>Proposed height = 1.2m<br>Proposed width = 2.1m<br>Proposed length = 65m<br><br>Refer Figure A.11.8.21 | • Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing culvert.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>In addition, a new culvert is required further upstream to carry a new side road.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as being an active mammal corridor and consequently there is a requirement to provide mammal passage. To facilitate this, a box culvert is proposed to be provided with mammal ledges set at the appropriate level.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The proposed new A9 culvert will result in a slight reduction in upstream headwater level compared to the existing situation. The available freeboard between the headwater level and proposed mainline road level is 1.22m; hence, the proposed scheme is not at flood risk during the design flood event.<br>Due to the new culvert being larger than the existing culvert, the peak pass forward flow will increase however given the magnitude of the peak design flood flow is small (1.06m$^3$/s), no loss in existing floodplain storage and that there are no flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry no further mitigation measures are considered necessary. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | WC112/NMU/US<br>(side road culvert)<br><br>Grid Reference:<br>(285184,765186) | New culvert:<br>Proposed diameter = 0.9m<br>Proposed length = 5m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.21 | A new culvert is required upstream of the A9 crossing to accommodate a proposed access track/NMU path. There is no existing watercourse crossing at this location.<br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard. |
| **WF113**<br><br>Approximate channel bed width at mainline culvert inlet: 1.2m<br><br>Flow data:<br>50% AEP: 0.25$m^3/s$<br>1% AEP: 0.72$m^3/s$<br>0.5% AEP + CC: 0.99$m^3/s$ | WC113/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(285023,765270) | New upstream cascade feature.<br>Replace the existing culvert with a new culvert following a revised alignment.<br><br>Existing diameter = 0.6m<br>Existing length = 37.2m<br><br>Proposed diameter = 1.05m<br>Proposed length = 56m<br><br>Refer Figure A.11.8.22 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and an access track/NMU path. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>In addition, a new culvert is required further upstream to carry a new side road. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. Mammal habitat connectivity shall be maintained at alternative, nearby structures and use shall be encouraged using mammal fencing. Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The proposed new A9 culvert will result in a slight reduction in upstream headwater level compared to the existing situation. The available freeboard between the headwater level and proposed mainline road level is 0.94m; hence, the proposed scheme is not at flood risk during the design flood event.<br>Due to the new culvert being larger than the existing culvert, the peak pass forward flow will increase however given the magnitude of the peak design flood flow is small (1.06m$^3$/s), no loss in existing floodplain storage and that there are no flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry no further mitigation measures are considered necessary. |
| | WC113/NMU/US<br>(side road culvert)<br><br>Grid Reference:<br>(285023,765239) | New culvert:<br>Proposed diameter = 1.05m<br>Proposed length = 8m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.22 | A new culvert is required upstream of the A9 crossing to accommodate a proposed access track/NMU path. There is no existing watercourse crossing at this location.<br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert. |
| **WF114**<br><br>Approximate channel bed width at mainline culvert inlet: 0.8m<br><br>50% AEP: 0.19m$^3$/s<br>1% AEP: 0.57m$^3$/s<br>0.5% AEP + CC: 0.79m$^3$/s | WC114/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(284927,765300) | New upstream cascade feature.<br>Replace the existing circular culvert with a new box culvert.<br>Regrade downstream channel for approximately 10m.<br><br>Existing diameter = 0.6m<br>Existing length = 27.4m<br><br>Proposed height = 1.2m<br>Proposed width = 1.5m<br>Proposed length = 42.9m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>• Linear extension of the existing culvert infrastructure could conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design. Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | Refer Figure A.11.8.23 | The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing culvert with a new culvert.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as being an active mammal corridor and consequently there is a requirement to provide mammal passage. To facilitate this, a box culvert is proposed to be provided with mammal ledges set at the appropriate level.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The proposed new A9 culvert will result in a slight reduction in upstream headwater level compared to the existing situation. The available freeboard between the headwater level and proposed mainline road level is 2.81m; hence, the proposed scheme is not at flood risk during the design flood event.<br>Due to the new culvert being larger than the existing culvert, the peak pass forward flow will increase however given the magnitude of the peak design flood flow is small (0.79m$^3$/s), no loss in existing floodplain storage and that there are no flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry no further mitigation measures are considered necessary. |
| **WF115 (Allt Bhaic)**<br><br>Approximate channel bed width at crossing: 9.25m<br><br>50% AEP: 4.6m$^3$/s<br>1% AEP: 10.7m$^3$/s<br>0.5% AEP + CC: 14.4m$^3$/s | Grid Reference:<br>(284531,765611) | Bridge<br><br>Existing length = 13.2m<br>Existing width (span) = 11.5m<br><br>Proposed length = 42.4m<br>Proposed width (span) = 11.2m<br><br>Refer Figure A.11.8.24 | The existing A9 crosses this watercourse by means of an underbridge. The existing structure is a single span structure with the superstructure comprising a reinforced concrete slab deck. The end supports comprise full height reinforced concrete cantilever abutments on spread footings.<br>**Proposed Scheme**<br>The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway.<br>At this location it is proposed to demolish and replace the existing structure. A new single span bridge is proposed which consists of a concrete beam and infill deck supported by full height concrete abutments. To accommodate an access track sharing the same structure it is proposed to modify the existing channel through the structure, which will require some associated river training.<br>The level of the bridge abutment foundation will be set in accordance with DMRB i.e. i) the top of the spread footing is positioned below the calculated scour depth and ii) the bottom of the spread footing is located 2m below river bed level. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | In addition, to maintain the cross sectional profile of the channel beneath the bridge and also provide support and scour protection to the proposed track, a rock armour (rip-rap) revetment system is proposed. On the river bed the rock armour will be overlain with natural river bed deposits.<br>**Environmental**<br>The provision of specific features to facilitate mammal passage at this bridge crossing is not required, due to the open nature of the bridge.<br>**Flood Risk**<br>The Allt Bhaic watercourse and its floodplain at this location are subject to flooding during the design flood event. The proposed bridge superstructure itself is unlikely to impact on flood water levels, however the approach road embankments built on active flood plain will impact flood water levels. Given the complex hydraulic interaction between the Allt Bhaic and its downstream confluence with the River Garry and associated floodplain at this location, this reach of the Allt Bhaic has been subjected to numerical modelling, the results of which and flood risk impact have been assessed and reported in the Flood Risk Assessment (Appendix 11.3). |
| **WF116**<br><br>Approximate channel bed width at mainline culvert inlet: 0.4m<br><br>50% AEP: 0.28m$^3$/s<br>1% AEP: 0.80m$^3$/s<br>0.5% AEP + CC: 1.10m$^3$/s | WC116/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(284222,765724) | Regrade channel upstream for approximately 15m.<br>Replace the existing culvert with a new culvert.<br>Regrade channel downstream for approximately 45m.<br><br>Existing diameter = 0.6m<br>Existing length = 28.6m<br><br>Proposed diameter = 1.35m<br>Proposed length = 81.6m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.25 | The watercourse is culverted beneath the existing A9. The proposed scheme consists of an offline dual carriageway at this location, resulting in a widened A9 mainline. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design. Additionally, to avoid a bend in the culvert and access manhole located within the live carriageway which is undesirable in terms of operation of the A9; linear extension of the existing culvert will require the upstream channel to be realigned to tie-in to a new culvert inlet located approximately 30m to the west of the existing channel alignment.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred approach for this crossing taking account of engineering and environmental design criteria is to replace the existing culvert with a new culvert following a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed new culvert follows a new alignment with the culvert's inlet and outlet located where the existing watercourse crosses the proposed scheme earthworks boundary. To avoid conflict with the road box and drainage design, it is proposed to lower the culvert invert (by approximately 0.75m relative to existing culvert invert levels) which will also require |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | some regrading of the upstream and downstream channel. Development of the channel design will be undertaken at detail design stage, but will typically mirror the geomorphological regime found in the channel local to the culvert.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. Mammal habitat connectivity shall be maintained at an alternative, nearby structure and use shall be encouraged using mammal fencing.<br>The proposed culvert has been sized to accommodate a continuous natural river bed through the culvert length.<br>**Flood Risk**<br>The proposed new A9 culvert will result in a slight reduction in upstream headwater level compared to the existing situation. The available freeboard between the headwater level and proposed mainline road level is 2.79m; hence; the proposed scheme is not at flood risk during the design flood event.<br>Due to the new culvert being larger than the existing culvert, the peak pass forward flow will increase however given the magnitude of the peak design flood flow is small (1.1m$^3$/s) and that there are no flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry no further mitigation measures are considered necessary. |
| **WF117**<br><br>Approximate channel bed width at mainline culvert inlet: 0.3m<br><br>Flow data:<br>50% AEP: 0.60m$^3$/s<br>1% AEP: 1.77m$^3$/s<br>0.5% AEP + CC: 2.52m$^3$/s | WC117/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(283814,765651) | Replace existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 0.6m<br>Existing length = 24m<br><br>Proposed diameter = 0.9m<br>Proposed length = 58.2m<br>Proposed embedment = 0.3m<br><br>Refer Figure A.11.8.26 | The watercourse is culverted beneath the existing A9. The proposed scheme consists of an offline dual carriageway at this location, resulting in a widened A9 mainline. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>The proposed mainline is offline at this location. Linear extension of the existing culvert infrastructure will result in a culvert longer than is otherwise necessary. It will also result in a culvert inlet level lower than the existing channel bed level necessitating the introduction of regrading or a cascade upstream.<br>• Replacement of the existing culvert:<br>Due to the poor correlation between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred approach for this crossing taking account of engineering and environmental design criteria is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The culvert design is constrained by existing channel geometry and proposed mainline road level. Due to the relatively flat channel gradient and predicted elevated downstream water level in the River Garry exerting an influence on culvert hydraulics, it is not possible to achieve the required freeboard for the size of culvert being considered at the design 1% AEP (100-year) design fluvial event i.e. the culvert is surcharged during this design event.<br>To accommodate a 'larger' culvert with appropriate freeboard will require raising the proposed road level and consequently increasing the road footprint which will likely extend closer to the River Garry at this location which is considered to be |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | undesirable given that the area is environmentally sensitive. Therefore, a 'like for like' (from a hydraulic perspective) culvert replacement has been adopted, albeit the new culvert is larger in section to accommodate proposed embedment. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. Mammal habitat connectivity shall be maintained at an alternative, nearby structure and use shall be encouraged using mammal fencing.<br>The proposed culvert has been sized to accommodate a continuous natural river bed through the culvert length.<br>**Flood Risk**<br>The existing A9 floods at this location during the design flood event. With the proposed scheme in place the A9 road level will be raised providing 1m freeboard between peak water level and proposed mainline road level during the design flood event.<br>The proposed scheme will increase water level within the River Garry flood plain at this location and water level on the Invervack and Balnansteuartach access road will increase by 0.015m compared to the existing situation.<br>However, this access road will flood during this flow event in the baseline scenario to a depth of approximately 0.16m and with the scheme in place, this minor adverse impact on flood depth would not be sufficient to prevent access to the properties in this location. The increases in flooding predicted upstream of the proposed mainline would have a negligible impact on overall flood risk in this area with the properties south of this area remaining accessible and no new sensitive receptors such as property becoming flooded. Also, there would be no increase in flood risk downstream. Therefore, no additional mitigation is recommended.<br>There would be no increase in flood risk downstream. |
| | WC117/ACC/US<br>(side road culvert)<br><br>Grid Reference:<br>(283731,765161) | New culvert:<br>Proposed diameter = 1.35m<br>Proposed length = 7.2m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.27 | A new culvert is required upstream of the A9 crossing at Invervack to accommodate a proposed new track providing access to Tomban. An existing ford at this location will be replaced by a new culvert to provide availability of access to properties in times of high flow.<br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert. |
| **WF118**<br><br>Approximate channel bed width at mainline culvert inlet: 0.8m | WC118/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(283596,765540) | Replace the existing culvert with a new box culvert.<br><br>Existing diameter = 1.0m<br>Existing length = 22m | The watercourse is culverted beneath the existing A9. The proposed scheme consists of an offline dual carriageway at this location, resulting in a widened A9 mainline. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| Flow data:<br>50% AEP: 0.07m$^3$/s<br>1% AEP: 0.22m$^3$/s<br>0.5% AEP + CC: 0.31m$^3$/s | | Proposed height = 1.35m<br>Proposed width = 1.5m<br>Proposed length = 43m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.28 | The proposed mainline alignment is 'offline' relative to the existing A9 alignment at this location. Linear extension of the existing culvert infrastructure will result in a culvert longer than is otherwise necessary. It will also result in a culvert inlet lower than the existing channel necessitating the introduction of regrading or a cascade feature upstream.<br>• Replacement of the existing culvert:<br>Due to the poor correlation between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing culvert.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as an active mammal corridor and consequently the proposed new crossing has been developed as a new box culvert incorporating appropriately designed mammal ledges.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert.<br>**Flood Risk**<br>The existing culvert freely passes the peak flow associated with the design flood event.<br>Similarly, the proposed culvert freely passes the design flood event, however upstream headwater level will rise by 0.18m. The increase in water level is predicted to be contained within the upstream channel and given that there is greater than 0.6m freeboard between headwater level and proposed mainline road level, the proposed scheme is not considered to be at flood risk during the design flood event. As there is no loss in existing floodplain storage and that there are no other flood sensitive receptors, no further mitigation measures are considered necessary at this location. |
| **WF119**<br><br>Approximate channel bed width at mainline culvert inlet: 0.75m<br><br>Flow data:<br>50% AEP: 0.26m$^3$/s<br>1% AEP: 0.77m$^3$/s<br>0.5% AEP + CC: 1.06m$^3$/s | WC119/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(283482,765495) | New upstream cascade feature.<br>Replace existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 1.0m<br>Existing length = 26m<br><br>Proposed diameter = 1.05m | The watercourse is culverted beneath the existing A9. The proposed scheme consists of an offline dual carriageway at this location, resulting in a widened A9 mainline. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>• Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design. Replacement of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | Proposed length = 49.5m<br>Embedment depth = 0m<br><br>Refer Figure A.11.8.29 | Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard.<br>The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit. The location of the proposed new culvert exit matches the existing culvert exit in order to minimise impact on the downstream channel and to minimise engineering works within the SAC. An existing downstream access track and associated culvert will remain unchanged.<br>To avoid the proposed scheme road box and drainage system, the new culvert requires to be set at a lower invert level, in particular at its entrance and hence its gradient will be reduced compared to the existing culvert. The lower culvert entrance invert level will require an upstream cascade feature to link the culvert entrance with the upstream natural channel. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at an alternative, nearby structure and use shall be encouraged using mammal fencing.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The existing culvert freely passes the peak flow associated with the design flood event.<br>Similarly, the proposed culvert freely passes the design flood event, however upstream headwater level will rise by 0.03m. The increase in water level is predicted to be contained within the upstream channel and given that there is greater than 0.6m freeboard between headwater level and proposed mainline road level, the proposed scheme is not considered to be at flood risk during the design flood event. As there in no loss in existing floodplain storage and that there are no other flood sensitive receptors, no further mitigation measures are considered necessary at this location. |
| **WF120**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m | WC120/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(283184,765485) | New upstream cascade feature.<br>Replace the existing culvert with a new culvert following a new alignment.<br>Realign channel for approximately 70m downstream of culvert exit to | The watercourse is culverted beneath the existing A9. The proposed scheme consists of an offline dual carriageway at this location, resulting in a widened A9 mainline. Also a proposed SuDS pond encroaches on the existing downstream watercourse, necessitating realignment. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| Flow data:<br>50% AEP: 0.30m$^3$/s<br>1% AEP: 0.86m$^3$/s<br>0.5% AEP + CC: 1.20m$^3$/s | | its confluence with the River Garry.<br><br>Existing diameter = 1.2m<br>Existing length = 61m<br><br>Proposed diameter = 1.2m<br>Proposed length = 85m<br>Embedment depth =0m<br><br>Refer Figure A.11.8.30 | Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage (including SuDS) design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br><br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert to a new alignment.<br><br>**Proposed Scheme**<br><br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme. The proposed road drainage network has been severed at this location to minimise the road box depth and consequent impact on culvert and/or carriageway levels.<br><br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br><br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br><br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br><br>Realignment of the downstream watercourse will be required to avoid a proposed SuDS pond. The position of the pond is restricted by the River Garry channel and floodplain preventing the pond being positioned further north or west, and levels of the proposed scheme preventing the pond being positioned further east. The proposed road levels prevent the road drainage network crossing the watercourse culvert without elevating the proposed scheme road surface and drainage level for a significant distance on either side of this watercourse. This would have potential impacts resulting from an increased footprint of the proposed scheme. The channel realignment will be developed to minimise impact to the watercourse geomorphology of both WF120 and the River Garry.<br><br>**Environmental**<br><br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at an alternative, nearby structure and use shall be encouraged using mammal deterrent fencing.<br><br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br><br>**Flood Risk** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | The proposed new culvert will reduce upstream headwater levels by 0.1m during the design flood event. The available freeboard between predicted upstream headwater level and proposed mainline road level is 1.29m, hence the proposed scheme is not considered to be at flood risk during the design flood event.<br>Pass forward flow is not predicted to increase and therefore, downstream flood will remain unchanged, hence no further mitigation measures are considered necessary at this location. |
| | WC120/ACC/DS<br><br>Grid Reference:<br>(283289,765551) | New culvert:<br>Proposed diameter = 1.2m<br>Proposed length = 5m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.30 | A new culvert is required downstream of the A9 crossing to maintain an existing access track over the proposed realignment of the watercourse.<br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard. The culvert passes the design flood event with free flow, with the upstream headwater level contained in bank.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert. |
| **WF121**<br><br>Approximate channel bed width at mainline culvert inlet: 1.5m<br><br>Flow data:<br>50% AEP: 0.38m$^3$/s<br>1% AEP: 1.11m$^3$/s<br>0.5% AEP + CC: 1.57m$^3$/s | WC121/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(283090,765506) | New upstream cascade feature.<br>Replace the existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 1.0m<br>Existing length = 24.5m<br><br>Proposed diameter = 1.5m<br>Proposed length = 57.1m<br>Embedment = 0m<br><br>Refer Figure A.11.8.31 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and includes an adjacent access track on the downstream side. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme. Both the proposed mainline crossing and adjacent access track crossing will be accommodated via a single culvert.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new northbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The proposed new culvert arrangement will result in a reduction in upstream headwater level by 0.1m during the design flood event.<br>The available freeboard between the predicted upstream headwater level and the proposed mainline road level is 1.28m, hence the proposed scheme is not considered to be at flood risk during the design flood event.<br>Downstream flood risk may increase due to the new culvert geometry, however given that there is no loss of existing floodplain storage, no flood sensitive receptors located downstream of the culvert between the culvert exit and watercourse confluence with the River Garry and the small magnitude of the design flow (1.57$m^3$/s), no further mitigation measures are considered necessary. |
| | WC121/ACC/US<br>(side road culvert)<br><br>Grid Reference:<br>(283033,765328) | New culvert:<br>Proposed diameter = 1.2m<br>Proposed length = 20m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.32 | A new culvert is required upstream of the A9 crossing at Tomban to accommodate a proposed new access track. There is no existing watercourse crossing at this location.<br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert. |
| **WF122**<br><br>Approximate channel bed width at mainline culvert inlet: n/a (no defined channel)<br><br>Flow data: | WC122/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(282932,765610) | Replacement of existing culvert.<br>Realignment of downstream channel from new outlet to relocated confluence with WF121.<br><br>Existing diameter = 0.38m<br>Existing length = 35m | The existing watercourse forms part of the earthworks drainage system upstream of the existing A9 carriageway. It is culverted beneath the existing A9 into a ditch leading to its confluence with an unnamed watercourse (WF121). The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway and includes an adjacent access track. The A9 will also be elevated as part of the southern approach earthworks to the River Garry Underbridge. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| 50% AEP: 0.11m$^3$/s<br>1% AEP: 0.33m$^3$/s<br>0.5% AEP + CC: 0.47m$^3$/s | | Proposed diameter = 1.05m<br>Proposed length = 64.6m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.33 | Linear extension of the existing culvert would locate the inlet and outlet at inappropriate locations and levels which relate poorly to the existing downstream watercourse and the proposed low point in upstream pre-earthworks drainage.<br>• Replacement of the existing culvert:<br>Due to the poor correlation between the existing culvert infrastructure and the watercourse, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme. Both the proposed mainline and adjacent access track will be accommodated via a single culvert.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at alternative, nearby watercourses and use shall be encouraged using mammal deterrent fencing. The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert.<br>**Flood Risk**<br>This culvert is located within the River Garry flood plain, which has been subjected to detailed numerical modelling. For further detail, reference should be made to the Flood Risk Assessment (Jacobs 2017b). |
| **WF100**<br>River Garry (Ch11350)<br><br>Approximate channel bed width at crossing: 47m<br><br>Flow data:<br>50% AEP: 184m$^3$/s<br>1% AEP: 390m$^3$/s<br>0.5% AEP + CC: 517m$^3$/s | Grid Reference:<br>(282540,765781) | River Garry Underbridge<br><br>Baseline structure (to be retained):<br>Existing length = 13.2m<br>Existing width (span) = 79.6m<br><br>Additional structure:<br>Proposed length = 41.4m<br>Proposed width (span) = 76m | The existing A9 crosses the River Garry at Pitaldonich by means of the Pitaldonich Underbridge. The existing structure is a three span structure with a concrete superstructure supported by reinforced concrete piers on spread footings and reinforced concrete bank seat abutments on spread footings. Existing scour protection measures have been provided surrounding the existing piers and a gabion basket wall forms both the left and right channel bank as it passes beneath the existing Pitaldonich Underbridge.<br>**Proposed Scheme**<br>The proposed scheme will result in the A9 following a new, offline dual carriageway alignment and the existing single carriageway structure being retained as the southbound merge. It is proposed that the River Garry Underbridge is provided on the upstream side of the existing Pitaldonich to accommodate the new A9 road. The new structure is proposed to consist of a single span structure with steel beams and concrete deck slab supported on concrete abutments set back from the watercourse. The approach roach roads will be set on an embankment and in particular the southern approach roach will be located on the River Garry flood plain.<br>The alignment and cross section of the existing river channel beneath the new bridge will remain unchanged, however, the existing gabion wall system currently training the river beneath the existing A9 bridge will be extended upstream to train the |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | Refer Figure A.11.8.34(a) and (b) | river beneath the proposed new bridge. The nature of the gabion wall system will be further developed at detail design stage in accordance with DMRB requirements.<br>**Environmental**<br>The provision of specific features to facilitate mammal passage at this bridge crossing is not required, due to the open nature of the River Garry Underbridge.<br>**Flood Risk**<br>The River Garry and its floodplain at this location are subject to flooding during the design flood event. The proposed bridge superstructure itself is unlikely to impact on flood water levels, however the approach road embankments built on active flood plain will impact flood water levels. Given the complex hydraulic interaction between the River Garry and its floodplain at this location, this reach of the River Garry has been subjected to numerical modelling, the results of which and flood risk impact have been assessed and reported in the Flood Risk Assessment (Appendix 11.3). |
| **WF125**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.20m$^3$/s<br>1% AEP: 0.61m$^3$/s<br>0.5% AEP + CC: 0.87m$^3$/s | WC125/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(281975,765837) | Replace the existing culvert with a new culvert.<br>Realign the downstream channel.<br><br>Existing diameter = 0.57m<br>Existing length = 20m<br><br>Proposed diameter = 1.35m<br>Proposed length = 158.7m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.35 | This watercourse is culverted beneath the existing A9. The proposed scheme will result in realignment and widening of the A9 at this location. It is proposed that the A9 mainline is realigned to the south (downstream with respect to WF125) of the existing A9 carriageway, and the proposed Bruar/Calvine Junction extending further south, conflicting with the existing watercourse alignment.<br>A number of alternative options have been considered for this watercourse crossing:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert along the same alignment could involve the lengthening of the culvert from approximately 20m to approximately 330m to a culvert outlet at the downstream edge of the proposed scheme earthworks. This length of culvert is undesirable, given the impact on the culvert's hydraulic performance and impact on upstream water level, the need to incorporate appropriately spaced inspection chambers (including safe access) and to avoid culvert bends.<br>• Replacement of the existing culvert:<br>To maintain the existing hydraulic regime and avoid an increase in upstream water level due to increased culvert head losses, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>It is proposed to abandon and remove the existing culvert, and replace it with a new culvert with an inlet at the upstream boundary of the proposed earthworks. The outlet of the proposed culvert is located to the west of the existing watercourse to minimise the culvert length. Accordingly, it is proposed to divert the downstream channel to a new alignment between the new culvert exit and the confluence of the watercourse with the River Garry. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified a requirement to provide features to facilitate the passage of mammals at this location, however to accommodate mammal ledges within the culvert will result in a larger culvert section which cannot be accommodated within the headroom available, without raising the proposed road level. Therefore, it is proposed to provide an adjacent 'dry' mammal passage.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert.<br>**Flood Risk**<br>The proposed culvert will freely pass the design flood event. The available freeboard between the headwater level and proposed mainline road level is 5.88m, hence the proposed scheme is not considered to be at flood risk during the design flood event.<br>Downstream flood risk may increase due to the new culvert geometry, however given that there is no loss of existing floodplain storage, the small magnitude of the peak design flow (0.87m$^3$/s) and that there are no flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry, no further mitigation measures are considered necessary. |
| **WF127**<br><br>Approximate channel bed width at mainline culvert inlet: 1.5m<br><br>Flow data:<br>50% AEP: 0.68m$^3$/s<br>1% AEP: 2.04 m$^3$/s<br>0.5% AEP + CC: 2.93m$^3$/s | WC127/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(281661,765781) | Replace the existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 0.65m<br>Existing length = 30m<br><br>Proposed diameter = 2.0m<br>Proposed length = 119m<br>Proposed embedment = 0.2m<br><br>Refer Figure A.11.8.36 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the realignment and widening of the A9 at this location. It is proposed that the dualled A9 mainline is aligned offline to the south (downstream with respect to WF127) of the existing A9 single carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>This option was not adopted as such a culvert would be likely to constrain flows and pose adverse flood risk impacts upstream.<br>• Replacement of the existing culvert:<br>To maintain the existing hydraulic regime and avoid negative upstream flood risk impacts, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to accommodate the proposed scheme.<br>It is proposed to replace the existing culvert with a new culvert with its entrance at the same location as the existing culvert entrance. The culvert exit will be positioned where the proposed scheme earthworks boundary intercepts the existing downstream watercourse. This is to avoid the need to realign the watercourse. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert.<br>**Flood Risk**<br>The new culvert arrangement will freely pass the design flood event. The available freeboard between headwater level and the proposed mainline road level is 3.3m, hence the proposed scheme is not considered to be at flood risk during the design flood event.<br>Downstream flood risk may increase due to the new culvert geometry, however given that there is no loss of flood plain storage and there are no flood sensitive receptors located downstream between the culvert exit and the watercourse's confluence with the River Garry, no further mitigation measures are considered necessary. |
| **WF128**<br><br>Approximate channel bed width at mainline culvert inlet: 0.3m<br><br>Flow data:<br>50% AEP: 0.19m$^3$/s<br>1% AEP: 0.57m$^3$/s<br>0.5% AEP + CC: 0.82m$^3$/s | WC128/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(281255,765779) | Downstream extension of the existing culvert.<br>Realign approximately 50m of downstream channel.<br><br>Existing diameter = 0.6m<br>Existing length (approximately) = 68m<br><br>Proposed diameter = 0.6m<br>Proposed extension = 11m<br>Proposed embedment = 0m<br><br>Refer Figure A.11.8.37 | The existing watercourse is culverted beneath both the Highland Main Line railway and the existing A9. Downstream of the A9, there is a short reach of artificial channel before the watercourse again is culverted beneath fields and the B847 to the River Garry.<br>At this location, the proposed scheme will result in the widening of the A9 mainline to accommodate a new northbound carriageway on approach to a widened structure over of the A9 and railway. A new SUDS basin is proposed on the site of the existing watercourse immediately downstream of the culvert outlet.<br>A number of alternative options have been considered for the A9 crossing, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>To avoid possible impacts on the railway and the railway bridge arising from culvert replacement, it is proposed to extend the existing culvert downstream to accommodate the proposed scheme.<br>• Replacement of existing culvert:<br>Replacement of the existing culvert has been considered unnecessary given the suitability of the extension option.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to extend the existing A9 watercourse crossing to accommodate the proposed scheme. The existing culvert will be extended downstream with no proposed change to the existing 0.6m diameter circular pipe culvert and existing culvert inlet |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | arrangements. To avoid conflicts with Scheme drainage design, it is proposed to replace the downstream B847 culvert to a new alignment.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a mammal corridor; hence the provision for mammal passage is not required.<br>The provision to accommodate natural river bed deposits to form the culvert invert by oversizing the proposed culvert is not possible at this location, given the need to match the geometry of the existing culvert.<br>**Flood Risk**<br>The existing culvert is considered to have sufficient capacity to freely convey the design flood event. Extending the culvert will not impact existing flood risk and the proposed scheme is not considered to be at flood risk during the design flood event. |
| **WF129**<br><br>Approximate channel bed width at mainline culvert inlet: 0.3m<br><br>Flow data:<br>50% AEP: 0.19$m^3/s$<br>1% AEP: 0.59$m^3/s$<br>0.5% AEP + CC: 0.84$m^3/s$ | WC129/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(281068,765708) | No changes are proposed to existing A9 mainline and railway culvert. | The existing watercourse is culverted beneath both the Highland Main Line railway and the existing A9. At this location, the proposed scheme will not widen the earthworks beyond the existing culvert inlet and outlet, nor will the proposed scheme infrastructure conflict with the existing culvert.<br>Therefore, it is proposed to retain the existing culvert unchanged, hence the proposed scheme will not impact on the existing hydraulic regime and flood risk. |
| **WF131**<br><br>Approximate channel bed width at mainline culvert inlet: n/a (no channel)<br><br>Flow data:<br>50% AEP: 0.14$m^3/s$<br>1% AEP: 0.42$m^3/s$<br>0.5% AEP + CC: 0.60$m^3/s$ | WC131/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(280638,765878) | Replace the existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 0.45m<br>Existing length = 24.2m<br><br>Proposed diameter = 0.6m<br>Proposed length = 39.3m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.38 | The watercourse is culverted beneath the existing A9 from a catch pit in pre-earthworks drainage upstream of the existing carriageway. The proposed scheme will result in the A9 mainline at this location being widened to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>An extension of the existing culvert would locate the inlet and outlet at inappropriate locations and levels which relate poorly to the existing watercourse. Currently the existing culvert is located offline to the general alignment of the upstream and downstream watercourse. Extending the existing culvert to accommodate the proposed scheme will only exacerbate this misalignment. The option to insert a manhole chamber and introduce a change of direction within the extended culvert has been discounted as the manhole would need to be located part-way up a steep embankment resulting in maintenance access difficulties.<br>• Replacement of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | Due to the poor correlation between the existing culvert infrastructure and the general alignment of the watercourse, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing following a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location.<br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>Both the existing and proposed culverts freely pass the design flood event. Due to the geometry of the culvert inlet with the presence of a catchpit, an estimation of upstream headwater depths was not possible through the hydraulic performance assessment. However, with free flow conditions predicted in the culvert and a bank height of 0.79m at the catchpit location the A9 is not considered to be at risk.<br>Given that there is no predicted change in pass forward flow as a result of the proposed scheme and no loss of existing flood storage, the impact on flood risk is considered to be negligible. |
| **WF132**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.41m$^3$/s<br>1% AEP: 1.25m$^3$/s<br>0.5% AEP + CC: 1.79m$^3$/s | WC132/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(280535,765899) | Partial replacement of an existing culvert<br>Local regrading of channel downstream of the culvert exit.<br><br>Existing diameter = 1.0m<br>Existing length = 67m<br><br>Proposed diameter = 1.4m<br>Proposed length = 72m<br><br>Refer Figure A.11.8.39 | The watercourse is culverted beneath an access track and the existing A9. The existing culvert falls steeply from an inlet upstream of the access track to a manhole located in the existing A9 verge. Thereafter the culvert adopts a shallower gradient beneath the A9 to its exit.<br>The proposed scheme will result in the widening of the A9 mainline to both northbound and southbound carriageways. Proposed road levels are constrained in this area due to the proximity of properties in the village of Calvine to the south (downstream) and associated environmental impacts. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure would conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme road surface and drainage levels to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Extension of the existing culvert:<br>The existing culvert is sufficient in length to extend beyond the proposed mainline; hence extending the culvert alone will not resolve the conflict in vertical geometry between the proposed scheme and existing culvert infrastructure. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | An alternative to realigning the proposed scheme in a downstream direction to remove the conflict with the existing culvert (which would then require to be extended) has been considered, however this would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to partially replace the existing culvert, where the conflict between the existing culvert and proposed scheme infrastructure arises.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>It is proposed to retain the existing culvert inlet and the steep upstream section of existing culvert (approximately 30m). The existing culvert will be intercepted with a new manhole chamber downstream of the proposed new retaining wall and thereafter the existing culvert will be removed and replaced with a new culvert set with a vertical profile which avoids the proposed scheme infrastructure.<br>To accommodate the proposed scheme culvert invert levels, it is proposed to regrade the downstream watercourse locally to allow the channel bed to be lowered by approximately 0.45m at the culvert outlet. The design of the downstream channel will be undertaken at detail design stage, but will typically be geomorphologically similar to the channel immediately downstream.<br>The new culvert section has been designed to freely pass the 1% AEP (100-year) flood event with appropriate freeboard. In addition, a new culvert exit structure will be required incorporating concrete headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance. Thereafter, a scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location.<br>As an upstream section of the existing culvert is being retained, no provision has been made to allow for a continuous river bed invert within the culvert.<br>**Flood Risk**<br>Numerical modelling of the proposed culvert arrangement suggests that there is no increase in downstream peak flow during the design flood event. Therefore, the proposed scheme is considered to have a neutral impact on flood risk. Further detail is provided in the Flood Risk Assessment (Appendix 11.3). |
| **WF134**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m | WC134/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(280426,765915) | Replace the existing culvert with a new culvert following a new alignment.<br>Regrade channel over approximately 10m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the A9 mainline to both northbound and southbound carriageways. Proposed road levels are constrained in this area due to the proximity of properties in the village of Calvine to the south (downstream) and the associated environmental impacts. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| Flow data:<br>50% AEP: 0.41m$^3$/s<br>1% AEP: 1.25m$^3$/s<br>0.5% AEP + CC: 1.79m$^3$/s | | downstream of proposed new culvert outlet.<br><br>Existing diameter = 1.0m<br>Existing length = 24m<br><br>Proposed diameter = 1.4m<br>Proposed length = 67m<br><br>Refer Figure A.11.8.40 | The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. An alternative to realigning the proposed scheme in a downstream direction is to remove the conflict with the existing culvert, which would then require the culvert to be extended, however This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing following a revised alignment to accommodate the proposed scheme. It is proposed to intercept the upstream watercourse where it meets the earthworks, and then culvert the watercourse down the steep slope to a manhole chamber located at the southbound (upstream) verge. Thereafter it is proposed that the watercourse is culverted beneath the A9 to a new, lower outlet at the same location as the existing.<br>The new culvert section has been designed to freely pass the 1% AEP (100-year) flood event with appropriate freeboard. In addition, a new culvert exit structure will be required incorporating concrete headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance. Thereafter, a scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>To accommodate the proposed culvert invert levels, it is proposed to regrade the downstream watercourse over approximately 10m from the culvert outlet to tie-in to existing downstream river bed level. The design of the downstream channel will be undertaken at detail design stage, but will typically be geomorphologically similar to the channel immediately downstream.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a potential mammal corridor therefore no provision has been made for mammal passage.<br>**Flood Risk**<br>Hydraulic modelling of the proposed culvert arrangement suggests that there is a negligible increase in downstream flood levels during the design flood event. Therefore, the proposed scheme is considered to have a neutral impact on flood risk. Further detail is provided in the Flood Risk Assessment (Appendix 11.3). |
| **WF136**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m | WC136/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(280301,765926) | New upstream cascade feature.<br>Replace the existing concrete culvert with a new culvert following a new alignment. | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| Flow data:<br>50% AEP: 0.38m$^3$/s<br>1% AEP: 1.15m$^3$/s<br>0.5% AEP + CC: 1.65m$^3$/s | | Regrade approximately 30m of downstream channel.<br><br>Existing diameter = 0.675m<br>Existing length = 28m<br><br>Proposed diameter = 1.2m<br>Proposed length = 33.7m<br>Embedment depth = 0m<br><br>Refer Figure A.11.8.41 | Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>To accommodate the proposed culvert invert levels, it is proposed to regrade the downstream watercourse over approximately 30m from the culvert outlet to accommodate a 0.8m lower culvert exit invert level relative to existing river bed level. This will be tapered out downstream with channel regrading.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at alternative, nearby watercourses. Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>Due to the existing flood risk to the properties at Calvine, this watercourse has been subjected to numerical modelling. Modelling suggests that the proposed scheme and properties are not at flood risk due to the design flood event, however increased flood risk to the downstream B847 road is likely. Further detail regarding this assessment is provided in the Flood Risk Assessment (Appendix 11.3). |
| **WF137** | WC137/A9<br>(mainline culvert) | New upstream cascade feature. | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| Approximate channel bed width at mainline culvert inlet: 0.2m<br><br>Flow data:<br>50% AEP: 0.26m$^3$/s<br>1% AEP: 0.80m$^3$/s<br>0.5% AEP + CC: 1.15m$^3$/s | Grid Reference:<br>(280156,765926) | Replace the existing culvert with a new culvert.<br><br>Existing diameter = 1.3m<br>Existing length = 85m<br><br>Proposed diameter = 1.3m<br>Proposed length = 85m<br>Proposed embedment = 0m<br><br>Refer Figure A.11.8.42 | The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The existing A9 culvert freely passes the design flood event<br>Similarly, the new culvert arrangement will freely pass the design flood event. The head water level at the culvert entrance is predicted to increase by 0.24m, however the available freeboard between headwater level and the proposed mainline road level is 0.6m, hence the proposed scheme is not considered to be at flood risk during design flood event. As the increase in water level is contained within the upstream channel, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| **WF139**<br><br>Approximate channel bed width at mainline culvert inlet: 0.2m<br><br>Flow data:<br>50% AEP: 0.39m$^3$/s<br>1% AEP: 1.20m$^3$/s<br>0.5% AEP + CC: 1.71m$^3$/s | WC139/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(279711,766090) | Two new inlets at head of earthworks and carrier pipes down embankment to culvert inlet at road verge.<br>Replace existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 1.2m<br>Existing length = 22m<br><br>Proposed diameter = 1.2m<br>Proposed length = 56m<br>Proposed Embedment = 0m<br><br>Refer Figure A.11.8.43 | Two distinct watercourses have their confluence at the entrance to the existing A9 culvert. The proposed scheme will result in the widening of the earthworks to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>In addition, an adjacent watercourse (also labelled WF139) will be required to traverse across the slope fall line. This will be achieved by culverting the watercourse from the top of the cut slope to a manhole chamber located at the road verge. A single culvert will cross the proposed mainline.<br>The position of the culvert exit will tie-in to the existing channel with minimal impact on the downstream watercourse.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a mammal corridor; hence the provision for mammal passage is not required. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The existing A9 culvert freely passes the design flood event.<br>Similarly, the new culvert arrangement will freely pass the design flood event. The head water level at the culvert entrance is predicted to increase by 0.38m, however the available freeboard between headwater level and the proposed mainline road level is 0.6m, hence the proposed scheme is not considered to be at flood risk during the design flood event. As the increase in water level is contained within the upstream channel, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF140**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m<br><br>Flow data:<br>50% AEP: 0.64m$^3$/s<br>1% AEP: 1.93m$^3$/s<br>0.5% AEP + CC: 2.76m$^3$/s | WC140/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(297426,766212) | New upstream cascade feature.<br>Replace the existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 1.2m<br>Existing length = 35m<br><br>Proposed diameter = 1.5m<br>Proposed length = 36.6m<br>Proposed embedment =0m<br><br>Refer Figure A.11.8.44 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance. The proposed culvert exit will be located at the same location and invert level as the existing culvert outlet, avoiding the need for any regrading or realignment of the downstream channel.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at alternative, nearby watercourses. Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The existing A9 culvert is surcharged during the design flood event, with flood water overtopping the existing A9 and re-joining to the watercourse downstream.<br>The new culvert arrangement will freely pass the design flood event. The available freeboard between the headwater level and the proposed mainline road level is 0.82m, hence the proposed scheme is not considered to be at flood risk during the design flood event.<br>As the pass forward flow is unchanged and there is no loss of existing flood plain storage, flood risk is not affected by the proposed scheme., hence no further mitigation measured are considered necessary. |
| **WF141**<br><br>Approximate channel bed width at mainline culvert inlet: 0.35m<br><br>Flow data:<br>50% AEP: 0.64m$^3$/s<br>1% AEP: 1.96m$^3$/s<br>0.5% AEP + CC: 2.80m$^3$/s | WC141/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(279183,766363) | New upstream cascade feature<br>Replace the existing culvert with a new culvert following a new alignment.<br><br>Existing diameter = 1.5m<br>Existing length = 32m<br><br>Proposed diameter = 1.6m<br>Proposed length = 57.1m<br>Proposed embedment =0m<br><br>Refer Figure A.11.8.45 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork ‘cut’ into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The existing culvert will freely pass the design flood event.<br>Similarly, the new culvert arrangement will freely pass the design flood event. The head water level at the culvert entrance is predicted to increase by 0.06m, however the available freeboard between headwater level and the proposed mainline road level is 1.38m, hence the proposed scheme is not considered to be at flood risk during the design flood event. As the increase in water level is contained within the upstream channel and there is no loss in existing flood storage, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF142 (Allt a' Chrombaidh)**<br><br>Approximate channel bed width at crossing: 2.0m<br><br>Flow data:<br>50% AEP: 9.2m$^3$/s<br>1% AEP: 27.8m$^3$/s<br>0.5% AEP + CC: 39.9m$^3$/s | Grid Reference:<br>(278945,766589) | Bridge<br><br>Existing length = 13.5m<br>Existing width (span) = 9.9m<br><br>Proposed length = 28.8m<br>Proposed width (span) = 10.6m<br><br>Refer Figure A.11.8.46 | The existing A9 crosses this watercourse by means of an overbridge. The existing structure is a single span structure with a concrete deck and full height mass concrete gravity abutments on spread footings.<br>**Proposed Scheme**<br>The proposed scheme will result in the A9 being widened on the downstream side to accommodate a new northbound carriageway.<br>At this location it is proposed to demolish and replace the existing structure. A new single span bridge is proposed which consists of a concrete beam and infill deck supported by full height concrete abutments. The bridge will fully span the watercourse with its abutments located outwith the river corridor associated with the design flood event. The bridge abutments will be founded on sound bedrock.<br>**Environmental**<br>The existing river corridor will not be impacted by the proposed scheme; hence no environmental measures are considered necessary at this location.<br>**Flood Risk**<br>The proposed bridge will not impact existing flood risk due to it be located outwith the river corridor.<br>The proposed bridge will not impact on existing flood risk. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| **WF143**<br><br>Approximate channel bed width at mainline culvert inlet: 0.15m<br><br>Flow data:<br>50% AEP: 0.28m$^3$/s<br>1% AEP: 0.86m$^3$/s<br>0.5% AEP + CC: 1.23m$^3$/s | WC143/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(278849,766684) | Replace existing culvert with new culvert.<br>Regrade downstream channel for approximately 12m between proposed new culvert outlet and existing side road culvert entrance.<br><br>Existing diameter = 1.2m<br>Existing length = 19m<br><br>Proposed diameter = 1.35m<br>Proposed length = 30m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.47 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>Linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining and extending the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert section has been designed to freely pass the 1% AEP (100-year) flood event with appropriate freeboard. The location of the existing culvert inlet will be retained to minimise the impact on the upstream channel and the culvert exit will be located at the proposed retaining wall supporting the northbound carriageway where it intersects with the existing downstream watercourse. The culvert invert level will tie-in with the existing channel bed level. Thereafter, a scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at alternative, nearby watercourses and use shall be encouraged using mammal fencing.<br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>The existing A9 culvert will freely pass the design flood event.<br>Similarly, the proposed culvert will freely pass the peak flow associated with the design flood event. Headwater level at the culvert entrance is predicted to increase by 0.01m, however 0.77m freeboard is available between the proposed mainline road level and headwater level, hence the proposed scheme is not considered to be at flood risk associated with the design flood event. Given that there is no loss in existing floodplain storage and that there are no other flood sensitive receptors local to the culvert, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| **WF144**<br><br>Approximate channel bed width at mainline culvert inlet: 0.7m<br><br>Flow data:<br>50% AEP: 0.31m$^3$/s<br>1% AEP: 0.93m$^3$/s<br>0.5% AEP + CC: 1.33m$^3$/s | WC144/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(278568,766911) | Replace the existing concrete pipe culvert with a new culvert.<br>Regrade the downstream channel from the culvert exit over approximately 45m.<br><br>Existing diameter = 1.4m<br>Existing length = 40m<br><br>Proposed diameter = 1.6m<br>Proposed length = 40m<br>Proposed embedment = 0.2m<br><br>Refer Figure A.11.8.48 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>• The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design. Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing. It is proposed to retain the existing upstream rock cascade and culvert inlet location, however with a new inlet chamber deepened to suit the proposed culvert invert level.<br>The proposed location of the culvert exit will be in the same position as the existing culvert exit, but set at a lower invert level. This will require regrading approximately 45m of downstream channel from the culvert exit to tie in with the downstream channel. The design of the downstream channel will be undertaken at detail design stage, but will typically be geomorphologically similar to the channel immediately downstream.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at alternative, nearby watercourses and use shall be encouraged using mammal deterrent fencing. The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>The existing A9 culvert will freely pass the design flood event.<br>Similarly, the proposed culvert will freely pass the peak flow associated with the design flood event. Headwater level at the culvert entrance is predicted to increase by 0.17m, however 0.6m freeboard is available between the proposed mainline road level and headwater level, hence the proposed scheme is not considered to be at flood risk associated with the |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | design flood event. Given that there is no loss in existing floodplain storage and that there are no other flood sensitive receptors local to the culvert, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF145**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m<br><br>Flow data:<br>50% AEP: 0.68m$^3$/s<br>1% AEP: 2.08m$^3$/s<br>0.5% AEP + CC: 2.98m$^3$/s<br><br>(Note - Flows are quoted for baseline conditions (i.e. excluding the proposed upstream diversion of WF146 into this watercourse) | WC145/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(278347,767085) | Replace the existing concrete culvert with a new culvert.<br>Regrade the downstream channel from the culvert exit over approximately 25m.<br><br>Existing diameter = 1.2m<br>Existing length = 29m<br><br>Proposed diameter = 1.5m<br>Proposed length = 37m<br><br>Refer Figure A.11.8.49 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme. It is proposed to retain the existing upstream natural bedrock cascade and culvert inlet position, with a new inlet chamber deepened to suit the proposed culvert invert level i.e. 2.36m below the existing bed level at the present culvert exit.<br>The proposed culvert exit will be relocated further downstream out with the footprint of the road embankments. As the culvert invert level at its exit will be lower than the existing channel bed approximately 25m of channel downstream of the culvert exit will be regraded. Design of new channel will be undertaken at detail design stage but the channel will typically be geomorphologically similar to the existing channel downstream.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>Modelling has been undertaken to assess the impact of the new enlarged culvert and the diversion of WF146 into WF145 of flooding. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | The baseline modelling shows that the existing A9 main road culvert has enough capacity to convey the peak flow associated with the design event and the existing A9 is not at risk of overtopping. Downstream of the A9, the modelling shows that the Clunes Lodge access road culvert (0.8m diameter) would surcharge resulting in the floodwater overtopping the road before entering the River Garry. The peak flood depths along the local access road reach approximately 0.125m.<br>The proposed scheme modelling shows that proposed alterations to the A9 main road culvert would accommodate the increase in peak flows from both WF145 and WF146. This increase in peak flow would also not impact Clunes Cottage, with flows remaining in-channel during the design event.<br>Downstream of the proposed scheme, the access road culvert would remain surcharged during the design flood event, with peak flood levels at the culvert inlet increasing by 0.04m. Peak flood depths would remain below 0.2m and the road would remain passable for road users. Modelling indicates that the access road culvert has the capacity to pass the peak flow associated with the 3.33% AEP (30-year) event and therefore the frequency of flooding to the road would remain low. As a result, no further mitigation measures are proposed. |
| | WC145/ACC/US<br>(side road culvert)<br><br>Grid Reference:<br>(278374,767159) | New culvert:<br>Proposed diameter = 1.5m<br>Proposed length = 12m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.49 | A new culvert is required upstream of the A9 crossing to accommodate a proposed access track. There is no existing crossing at this location.<br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert. |
| **WF146**<br><br>Flow data:<br>50% AEP: 0.07m$^3$/s<br>1% AEP: 0.22m$^3$/s<br>0.5% AEP + CC: 0.31m$^3$/s | No culvert<br><br>Grid Reference:<br>(278308,767220) | Channel diversion | The existing watercourse does not cross the A9. Water feature 146 is currently diverted via pre-earthworks drainage to WF147.<br>A proposed access track will cross WF146 upstream of the A9. A number of alternative options to pass the flow from WF146 downstream have been considered, as follows:<br>• Divert the watercourse upstream of the access track to WF147:<br>WF146 is not channelised upstream of the side road. Rising topography prevents a pre-earthworks ditch flowing to WF147 without significant excavation and re-profiling.<br>• Culvert the watercourse past the access track, to regain the present course to WF147:<br>This option has been discounted as impractical due to road levels. The access track is lower than the mainline of the proposed scheme, which would necessitate significant impact on WF147 and the associated culvert beneath the mainline. Watercourse WF146 will require to cross the access track for a second time before a possible confluence with WF147.<br>• Culvert the watercourse past the access track and A9 to regain WF147 downstream of the A9:<br>The side road is lower than the mainline of the proposed scheme, which would necessitate significant impact on WF147 and the associated culvert beneath the mainline.<br>• Culvert the watercourse past the side road, then divert to WF145: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | The access track is lower than the mainline of the proposed scheme, which would necessitate significant impact on WF145 and the associated culvert beneath the mainline.<br>• Divert the watercourse upstream of the side road to WF145:<br>This is the preferred option. The flow associated by WF146 will be intercepted by means of a pre-earthworks ditch and directed to WF145. This will increase flow in WF145 by approximately 10% during the plus climate change design event.<br>**Flood Risk**<br>Hydraulic modelling has been undertaken to assess the impacts of diverting flows from WF146 into WF145 – refer to WF145 for assessment of downstream impacts. |
| **WF147**<br><br>Approximate channel bed width at mainline culvert inlet: 0.4m<br><br>Flow data:<br>50% AEP: 0.26m$^3$/s<br>1% AEP: 0.81m$^3$/s<br>0.5% AEP + CC: 1.15m$^3$/s<br>(Note - Flows are quoted for baseline conditions (i.e. prior to the proposed upstream removal of WF146 contribution to flow in this watercourse) | WC147/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(278103,767276) | Diversion of upstream channel.<br>Replace the existing culvert with a new culvert.<br><br>Existing diameter = 1.2m<br>Existing length = 28m<br><br>Proposed diameter = 1.35m<br>Proposed length = 42m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.50 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A proposed new upstream diversion is necessary to allow the watercourse to skirt the earthworks associated with an adjacent track underpass.<br>A number of alternative options for the A9 crossing have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit. Additional new culverts will be required further upstream and downstream to convey proposed side roads.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | **Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at an alternative, nearby structure and use shall be encouraged using mammal fencing. The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>The existing A9 culvert will freely pass the design flood event.<br>The proposed new culvert will freely pass the peak flow associated with the design flood event, however headwater level at the culvert entrance is predicted to increase by 0.06m. The available freeboard between the proposed mainline road level and headwater level is 0.9m, hence the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF148**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m<br><br>Flow data:<br>50% AEP: 0.15m$^3$/s<br>1% AEP: 0.46m$^3$/s<br>0.5% AEP + CC: 0.65m$^3$/s | WC148/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(277931,767408) | New upstream cascade feature.<br>Replace the existing culvert with a new culvert.<br><br>Existing diameter = 1.2m<br>Existing length = 55m<br><br>Proposed diameter = 1.2m<br>Proposed length = 92.7m<br>Proposed embedment =0m<br><br>Refer Figure A.11.8.51 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new lay-by located on the southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at alternative, nearby watercourses and use shall be encouraged using mammal fencing. Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The existing culvert will freely pass the design flood event.<br>Similarly, the new culvert arrangement will freely pass the design flood event. The head water level at the culvert entrance is predicted to increase by 0.14m, however the available freeboard between headwater level and the proposed mainline road level is 0.6m, hence the proposed scheme is not considered to be at flood risk during the design flood event. As the increase in water level is contained within the upstream channel and there is no loss in existing flood storage, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF149 (Allt nan Cuinneag)**<br><br>Approximate channel bed width at crossing: 3.75m<br><br>Flow data:<br>50% AEP: 2.0m$^3$/s<br>1% AEP: 6.0m$^3$/s<br>0.5% AEP + CC: 8.6m$^3$/s | Grid Reference:<br>(277931,767408) | Arch bridge<br><br>Existing length = 40.3m<br>Existing width (span) = 5.8m<br><br>Proposed length = 57.3m<br>Proposed width (span) = 5.8m<br><br>Refer Figure A.11.8.52 | The existing A9 crosses this watercourse by means of a buried single span concrete segmental arch underbridge.<br>The proposed scheme will result in the A9 road being widened on the downstream side to accommodate a new northbound carriageway. To achieve this, it is proposed to extend the existing arch structure on the downstream side.<br>The proposals have been assessed to have a negligible impact on flood risk. |
| **WF150** | WC150/A9<br>(mainline culvert) | No culvert. | This watercourse does not cross the A9. Upstream, it is intercepted by the existing pre-earthworks drainage and transferred to WF149.<br>There is no requirement to modify the existing course of WF150. |
| **WF151** | WC151/A9<br>(mainline culvert) | Downstream extension of the existing culvert.<br>Realign downstream channel for approximately 25m. | The watercourse is culverted beneath the existing A9 from pre-earthworks drainage upstream of the existing carriageway. The proposed scheme will result in the A9 mainline at this location being widened on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| Approximate channel bed width at mainline culvert inlet: 1.5m<br><br>Flow data:<br>50% AEP: 0.33m$^3$/s<br>1% AEP: 0.99m$^3$/s<br>0.5% AEP + CC: 1.42m$^3$/s | Grid Reference:<br>(277213,768355) | Existing diameter = 1.2m<br>Existing length = 65m<br><br>Proposed diameter = 1.2m<br>Proposed length = 72.2m<br>Proposed embedment =0m<br><br>Refer Figure A.11.8.53 | The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure allows for direct extension of the existing culvert to a new culvert outlet at the toe of the proposed scheme earthworks. This is the preferred option.<br>• Replacement of existing culvert<br>Replacement of the existing culvert has been considered unnecessary given the suitability of the extension option.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to extend the existing crossing to accommodate the proposed scheme. The existing culvert inlet and upstream channel will be retained.<br>The existing culvert will be extended to a new outlet, where the culvert intersects the proposed scheme earthworks. As this point does not lie on the existing downstream channel it is proposed that the existing channel is realigned to tie-in to the culvert outlet over a length of approximately 25m.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor. In the absence of mammal ledges designed to DMRB specification to be included in the culvert, habitat connectivity shall be maintained by means of an adjacent dry mammal underpass.<br>As this is an extension of an existing culvert, no allowance has been made to provide a continuous natural river bed, as this would result in difference sized culverts which would be undesirable from a hydraulic performance perspective.<br>**Flood Risk**<br>The existing culvert has sufficient capacity to freely convey the design flood event.<br>With the proposed scheme in place, headwater water level is predicted to increase by 0.03m. However, the design flood flow is predicted to remain in-bank and will not pose a flood risk to the proposed scheme with sufficient freeboard. No other upstream flood sensitive receptors have been identified, therefore, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF152**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m<br><br>Flow data:<br>50% AEP: 0.07m$^3$/s | WC152/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(277107,768645) | Replace the existing culvert with a new culvert.<br><br>Existing diameter = 1.2m<br>Existing length = 29m<br><br>Proposed diameter = 1.35m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| 1% AEP: 0.21m$^3$/s<br>0.5% AEP + CC: 0.30m$^3$/s | | Proposed length = 60m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.54 | The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a mammal corridor; hence the provision of features to facilitate mammal passage is not required.<br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>The existing A9 culvert will freely pass the design flood event.<br>The proposed new culvert will freely pass the peak flow associated with the design flood event. However, headwater level at the culvert entrance is predicted to increase by 0.35m. The available freeboard between the proposed mainline road level and headwater level is 0.6m, hence the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF153**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m<br><br>Flow data: | WC153/A9 (mainline culvert)<br><br>Grid Reference: (277060,768766) | Downstream extension of the existing culvert.<br><br>Existing diameter = 1.2m<br>Existing length = 38m<br><br>Proposed diameter = 1.2m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| 50% AEP: 0.26m$^3$/s<br>1% AEP: 0.80m$^3$/s<br>0.5% AEP + CC: 1.14m$^3$/s | | Proposed length = 65m<br>Proposed embedment =0m<br><br>Refer Figure A.11.8.55 | The existing culvert infrastructure allows for direct extension of the culvert to a new culvert exit at the toe of the proposed scheme earthworks with no conflict with the proposed scheme infrastructure. This is the preferred option.<br>• Replacement of existing culvert<br>Replacement of the existing culvert has been considered unnecessary given the suitability of the extension option.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to extend the existing culvert to accommodate the proposed scheme. The existing upstream culvert inlet and channel will be retained. The existing culvert will be extended downstream to the extent of the proposed scheme earthworks embankment with a new culvert exit incorporating headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance, located in line with the downstream channel.<br>The cross-section of the culvert extension will equal the existing structure.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Instead, mammal habitat connectivity is possible at alternative nearby watercourses.<br>As this is an extension of an existing culvert, no allowance has been made to provide a continuous natural river bed, as this would result in difference sized culverts which would be undesirable from a hydraulic performance perspective.<br>**Flood Risk**<br>The proposed new culvert will freely pass the peak flow associated with the design flood event. However, headwater level at the culvert entrance is predicted to increase by 0.03m. The available freeboard between the proposed mainline road level and headwater level is 0.52m, which is lower than the recommended 0.6m. Although the estimated freeboard is lower than is recommended, flow would remain in bank and the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF88/167 (Allt Crom Bhruthaich)**<br><br>Approximate channel bed width at crossing: 2.0m<br><br>Flow data:<br>50% AEP: 3.8m$^3$/s<br>1% AEP: 11.6m$^3$/s | Grid Reference:<br>(276946,768889) | Bridge<br><br>Existing length = 13.5m<br>Existing width (span) = 8.0m<br><br>Proposed length = 46m<br>Proposed width (span) = 15.6m | The existing A9 crosses this watercourse by means of an underbridge. The existing structure is a single span structure with a concrete deck and full height mass concrete gravity abutments on spread footings.<br>**Proposed Scheme**<br>The proposed scheme will result in the A9 being widened on the downstream side to accommodate a new northbound carriageway.<br>At this location it is proposed to demolish and replace the existing structure with the proposed Allt Crom Bhruthaich Underbridge. The new single span bridge is proposed which consists of a concrete beam and infill deck supported by full height concrete abutments. The bridge will fully span the watercourse with its abutments located outwith the river corridor associated with the design flood event. The bridge abutments will be founded on sound bedrock.<br>**Environmental** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| 0.5% AEP + CC: 16.6m$^3$/s | | Refer Figure A.11.8.56 | The existing river corridor will not be impacted by the proposed scheme; hence no environmental measures are considered necessary at this location.<br>**Flood Risk**<br>The proposed bridge will not impact existing flood risk due to it being located outwith the river corridor. |
| **WF154**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.52m$^3$/s<br>1% AEP: 1.57m$^3$/s<br>0.5% AEP + CC: 2.25m$^3$/s | WC154/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(276662,769074) | New upstream cascade feature.<br>Replace the existing culvert with a new culvert.<br><br>Existing diameter = 1.5m<br>Existing length = 21m<br><br>Proposed diameter = 1.6m<br>Proposed length = 52m<br><br>Refer Figure A.11.8.57 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure could conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure would conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The new culvert arrangement will freely pass the design flood event. The available freeboard between the headwater level and the proposed mainline road level is 1.19m, hence the proposed scheme is not considered to be at flood risk during the design flood event. As the increase in water level is contained within the upstream channel and there is no loss in existing flood storage, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF155**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.15m$^3$/s<br>1% AEP: 0.47m$^3$/s<br>0.5% AEP + CC: 0.67m$^3$/s | WC155/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(276381,769212) | Replace the existing concrete culvert with a new culvert.<br><br>Existing diameter = 1.2m<br>Existing length = 28m<br><br>Proposed diameter = 1.35m<br>Proposed length = 52.4m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.58 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the downstream side to accommodate a new northbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and the existing culvert infrastructure would conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>An extension of the existing culvert would locate the culvert inlet and outlet at inappropriate locations and levels which relate poorly to the existing watercourse alignment. Currently the existing culvert is located offline to the general alignment of the upstream and downstream watercourse. Extending the existing culvert to accommodate the proposed scheme will only exacerbate the misalignment.<br>• Replacement of the existing culvert:<br>Due to the poor correlation between the alignment of the existing culvert and watercourse, the preferred option would be to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme. The existing culvert inlet location could be retained to minimise the impact on the upstream channel. The new culvert outlet will be located out with the footprint of the widened mainline at this location and the culvert outlet will tie-in with the downstream channel alignment and bed level.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | Ecological assessment has not identified this watercourse as a mammal corridor; hence the provision of features to facilitate mammal passage is not required.<br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>The existing A9 culvert will freely pass the design flood event.<br>The proposed new culvert will freely pass the peak flow associated with the design flood event, however headwater level at the culvert entrance is predicted to increase by 0.28m. The available freeboard between the proposed mainline road level and headwater level is 0.6m, hence the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF156**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.66m$^3$/s<br>1% AEP: 2.01m$^3$/s<br>0.5% AEP + CC: 2.89m$^3$/s | WC156/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(276089,769411) | New upstream cascade feature.<br>Replace existing concrete pipe with a new box culvert.<br>Regrade approximately 72m of downstream channel.<br><br>Existing pipe diameter = 0.675m<br>Existing length = 24.7m<br><br>Proposed height = 1.8m<br>Proposed width = 2.4m<br>Proposed length = 38m<br><br>Refer Figure A.11.8.59 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the upstream side to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing culvert.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>To accommodate the proposed lower culvert invert level at the culvert exit, it is proposed to regrade the downstream watercourse for a distance of 72m from the culvert outlet to tie-in with the existing channel downstream. The design of the downstream channel will be undertaken at detail design stage, but will be designed to be geomorphologically similar to the existing downstream channel.<br>A scour protection system will also be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as being an active mammal corridor and consequently there is a requirement to provide mammal passage. To facilitate this, a box culvert is proposed to be provided with mammal ledges set at the appropriate level.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>Numerical modelled been undertaken at this location due to the close proximity of a residential property to the watercourse. Detail of the flood risk assessment at this location is presented in the Flood Risk Assessment (Appendix 11.3), however a summary is provided below.<br>Under the existing situation, the existing A9 road is overtopped during the design flood event plus allowance for climate change with flood water re-joining the channel downstream of the of the existing A9 but then being restricted by the smallerU521 culvert which results in flooding of the adjacent fields and U521 road.<br>Site surveys identified the existing U521 culvert to be partially blocked with sediment. It is proposed that in conjunction with the regrading works upstream of the U521, the existing culvert here will be cleared of sediment and restored to its original design capacity.<br>The proposed new A9 culvert will freely pass the design flood event without flooding the proposed mainline, however flooding of the downstream U521 road and adjacent land will still occur, with increased water level of 0.03m. As the U521 road already floods and the increase in water level is not considered to be significant, with no loss of existing flood plain storage, no additional mitigation is recommended. |
| | WC156/ACC/US<br>(side road culvert)<br><br>Grid Reference:<br>(276112,769426) | New culvert:<br>Proposed diameter = 1.5m<br>Proposed length = 13.3m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.59 | A new culvert is required upstream of the A9 crossing to accommodate a proposed access track. There is no existing crossing at this location.<br>The proposed new circular pipe culvert has been designed to pass the 2% AEP (50-year) design flood event with appropriate freeboard.<br>The invert of the new culvert will be depressed to allow for a continuous natural river bed through the culvert. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| **WF157**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m<br><br>Flow data:<br>50% AEP: 0.15m$^3$/s<br>1% AEP: 0.44m$^3$/s<br>0.5% AEP + CC: 0.63m$^3$/s | WC157/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(275848,769514) | New diversion of the upstream channel for approximately 40m.<br>New upstream cascade feature.<br>Replace the existing culvert with a new culvert.<br><br>Existing diameter = 1.0m<br>Existing length = 36.1m<br><br>Proposed diameter = 1.0m<br>Proposed length = 48.5m<br><br>Refer Figure A.11.8.60 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the upstream side to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and the existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. To reduce the depth of 'cut' into the adjacent hillside the gradient of the upstream section of culvert has been steepened. This will require a new manhole positioned at the road side verge to gain access to the culvert where the change in gradient occurs.<br>In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will also be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at alternative, nearby watercourses. Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | The existing A9 culvert freely passes the peak flow associated with the design flood event.<br>Similarly, the new culvert arrangement will also freely pass the design flood event. The available freeboard between the headwater level and the proposed mainline road level is 0.6m, hence the proposed scheme is not considered to be at flood risk during the design flood event. As the increase in water level is contained within the upstream channel and there is no loss in existing flood storage, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF158 (Allt Anndeir)**<br><br>Approximate channel bed width at crossing: 6.0m<br><br>Flow data:<br>50% AEP: 45.9m$^3$/s<br>1% AEP: 101.8m$^3$/s<br>0.5% AEP + CC: 137.2m$^3$/s | Grid Reference:<br>(275511,769610) | Bridge<br><br>Existing length = 13.7m<br>Existing width (span) = 47.1m<br><br>Proposed length = 37.3m<br>Proposed width (span) = 51.5m<br><br>Refer Figure A.11.8.61 | The existing A9 crosses this watercourse by means of an overbridge. The existing structure is a three span structure with a concrete superstructure supported by intermediate concrete columns on spread footings and concrete bank seat abutments on spread footings.<br>**Proposed Scheme**<br>The proposed scheme will result in the A9 being widened to accommodate a new southbound carriageway and the new crossing is proposed also to accommodate new access tracks adjacent to both northbound and southbound carriageways.<br>At this location it is proposed to demolish and replace the existing structure with the proposed Allt Anndeir Underbridge. The new bridge will fully span the watercourse with its abutments located outwith the river corridor associated with the design flood event. The bridge abutments will be founded on sound bedrock.<br>**Environmental**<br>The existing river corridor will not be impacted by the proposed scheme; hence no environmental measures are considered necessary at this location.<br>**Flood Risk**<br>The proposed bridge will not impact existing flood risk due to it being located outwith the river corridor. |
| **WF159**<br><br>Approximate channel bed width at mainline culvert inlet: 1.8m<br><br>Flow data:<br>50% AEP: 0.56m$^3$/s<br>1% AEP: 1.62m$^3$/s<br>0.5% AEP + CC: 2.30m$^3$/s | WC159/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(274463,769810) | Replace the existing concrete pipe culvert with a new culvert.<br><br>Existing diameter = 1.68m<br>Existing length = 30.8m<br><br>Proposed diameter = 2.0m<br>Proposed length = 79.4m<br>Proposed embedment =0.32m<br><br>Refer Figure A.11.8.62 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the upstream side to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme.<br>• Extension of the existing culvert:<br>An extension of the existing culvert would locate the culvert inlet and outlet at inappropriate locations and levels which relate poorly to the existing watercourse alignment. Currently the existing culvert is located offline to general alignment of the upstream and downstream watercourse. Extending the existing culvert to accommodate the proposed scheme will only exacerbate the misalignment.<br>• Replacement of the existing culvert:<br>Due to the poor correlation between the existing culvert infrastructure and the watercourse, the preferred option is to replace the existing culvert.<br>**Proposed Scheme** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | | The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br><br>The new culvert inlet will be located upstream of the existing culvert inlet to accommodate the widened A9 mainline at this location. The new culvert outlet will be located at the same position as the existing culvert outlet.<br><br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br><br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br><br>**Environmental**<br><br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at an alternative, nearby structure.<br><br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br><br>**Flood Risk**<br><br>The existing A9 culvert will freely pass the design flood event.<br><br>The proposed new culvert will freely pass the peak flow associated with the design flood event, however headwater level at the culvert entrance is predicted to increase by 0.25m. The available freeboard between the proposed mainline road level and headwater level is 0.6m, hence the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br><br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF160**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.34m$^3$/s<br>1% AEP: 0.98m$^3$/s<br>0.5% AEP + CC: 1.40m$^3$/s | WC160/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(274840,769734) | Replace the existing concrete pipe culvert with a new slightly larger culvert.<br><br>Regrade approximately 25m of channel downstream of proposed new outlet.<br><br>Existing diameter = 1.1m<br>Existing length = 20.1m<br><br>Proposed diameter = 1.35m<br>Proposed length = 36.6m<br>Proposed embedment =0.15m | The existing watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the upstream side to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br><br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and the existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br><br>• Extension of the existing culvert:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br><br>• Replacement of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| | | Refer Figure A.11.8.63 | Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme. The new culvert inlet will be located upstream of the existing culvert inlet to accommodate the widened A9 mainline at this location. The new culvert outlet will be located at the same location as the existing culvert outlet; however, the culvert invert will be set at a lower level relative to the existing channel at this location i.e. 2m. To accommodate this lower culvert invert, approximately 35m of the channel downstream will be regraded. The design of the regraded channel will be undertaken at detail design stage, but will typically be designed to where possible be geomorphologically similar to the existing channel.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a mammal corridor; hence the provision of features to facilitate mammal passage is not required.<br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>The existing A9 culvert will freely pass the design flood event.<br>The proposed new culvert will freely pass the peak flow associated with the design flood event, however headwater level at the culvert entrance is predicted to increase by 0.03m. The available freeboard between the proposed mainline road level and headwater level is 0.6m, hence the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF161**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m<br><br>Flow data:<br>50% AEP: 0.32m$^3$/s | WC161/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(274733,769768) | Regrade approximately 10m of upstream channel.<br>Replace the existing culvert with a new culvert.<br>Regrade approximately 20m of downstream channel.<br><br>Existing diameter = 1.1m | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the upstream side to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and the existing culvert infrastructure could conflict with the proposed scheme design, in particular the proposed road box and road drainage design.<br>• Extension of the existing culvert: |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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| 1% AEP: 0.92m$^3$/s<br>0.5% AEP + CC: 1.31m$^3$/s | | Existing length = 22.6m<br><br>Proposed diameter = 1.35m<br>Proposed length = 35.0m<br>Proposed embedment =0.15m<br><br>Refer Figure A.11.8.64 | Direct linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert alignment will require elevating the proposed scheme, road surface and drainage level. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme. A new culvert inlet is proposed at the verge of the proposed scheme, at a location which is upstream of the existing inlet. To accommodate the proposed road level, the culvert invert level at the inlet is required to be approximately 0.8m lower than the existing channel bed level. To achieve this, it is proposed to regrade a 10m section of channel upstream.<br>The proposed culvert exit will be placed at the same position as the existing culvert exit, albeit at a lower invert level i.e. 0.6m. To accommodate this lower culvert invert level, it is proposed to regrade the downstream channel over a 20m reach to tie-in with the existing channel.<br>The design of the channel regarding both upstream and downstream will be undertaken at detail design stage, but will typically be designed to where possible be geomorphologically similar to the existing channel.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental**<br>Ecological assessment has not identified this watercourse as a mammal corridor; hence the provision of features to facilitate mammal passage is not required.<br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>The existing A9 culvert will freely pass the design flood event.<br>The proposed new culvert will freely pass the peak flow associated with the design flood event, however headwater level at the culvert entrance is predicted to increase by 0.02m. The available freeboard between the proposed mainline road level and headwater level is 0.6m, hence the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
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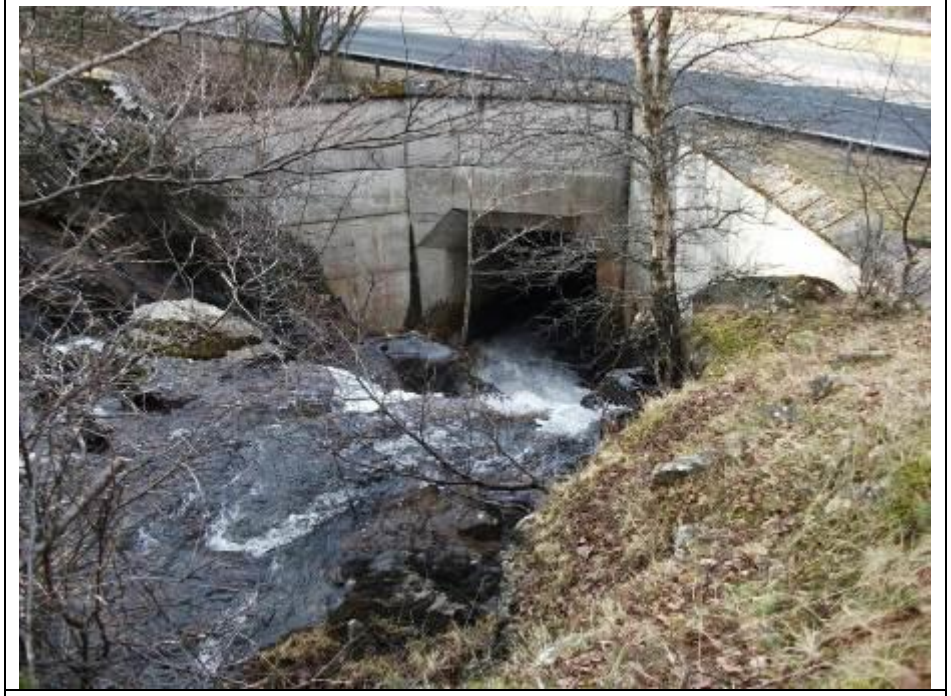
| **WF162**<br><br>Approximate channel bed width at mainline culvert inlet: 0.5m<br><br>Flow data:<br>50% AEP: 0.26m$^3$/s<br>1% AEP: 0.75m$^3$/s<br>0.5% AEP + CC: 1.06m$^3$/s | WC162/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(274681,769790) | Regrade approximately 10m of upstream channel.<br>Replace the existing culvert with a new culvert.<br>Regrade approximately 30m of downstream channel.<br><br>Existing diameter = 1.2m<br>Existing length = 20.4m<br><br>Proposed diameter = 1.35m<br>Proposed length = 31.7m<br>Proposed embedment =0.15m<br><br>Refer Figure A.11.8.65 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the upstream side to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and the existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>Direct linear extension of the existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design. Retaining the existing culvert alignment will require elevating the proposed scheme, road surface and drainage level. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing culvert infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>A new culvert inlet is proposed where the toe of the proposed scheme earthworks intersects with the watercourse. To accommodate proposed mainline road levels, the culvert invert level at the inlet is required to be approximately 1.0m lower than the existing channel bed level. To achieve this, it is proposed to regrade approximately 10m of upstream channel. The proposed culvert exit will be placed at the same location as the existing culvert exit albeit set at a lower invert level. To accommodate the lower culvert invert level (i.e. 0.8m), it is proposed to regrade the downstream watercourse. This will require regrading approximately 30m downstream of the culvert outlet. The design of the channel regarding both upstream and downstream will be undertaken at detail design stage, but will typically be designed to where possible be geomorphologically similar to the existing channel.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental**<br>Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location. Mammal habitat connectivity shall be maintained at alternative, nearby structures.<br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | | The existing A9 culvert will freely pass the design flood event.<br>The proposed new culvert will freely pass the peak flow associated with the design flood event, however headwater level at the culvert entrance is predicted to increase by 0.08m. The available freeboard between the proposed mainline road level and headwater level is 0.6m, hence the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF163**<br><br>Approximate channel bed width at mainline culvert inlet: 1.0m<br><br>Flow data:<br>50% AEP: 0.19m$^3$/s<br>1% AEP: 0.54m$^3$/s<br>0.5% AEP + CC: 0.77m$^3$/s | WC163/A9<br>(mainline culvert)<br><br>Grid Reference:<br>(273805,770055) | New upstream cascade feature.<br>Replace the existing culvert with a new culvert.<br><br>Existing diameter = 1.2m<br>Existing length = 26.3m<br><br>Proposed diameter = 1.2m<br>Proposed length = 42.8m<br>Proposed embedment =0m<br><br>Refer Figure A.11.8.66 | The watercourse is culverted beneath the existing A9. The proposed scheme will result in the widening of the earthworks on the upstream side to accommodate a new southbound carriageway. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert is not long enough to accommodate the proposed scheme and the existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design.<br>• Extension of the existing culvert:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the proposed road box and road drainage design. Retaining the existing culvert will require elevating the proposed scheme, road surface and drainage level to accommodate the existing culvert infrastructure. This would have potential impacts resulting from an increasing the footprint of the proposed scheme and changes to drainage design.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing crossing to a revised alignment to accommodate the proposed scheme.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance.<br>The proposed scheme will require an earthwork 'cut' into the adjacent hillside to win space to accommodate the new southbound carriageway. This will require the culvert invert level at its entrance to be set at a lower level than the present channel bed level at this location. In addition, the channel gradient immediately upstream of the culvert entrance will be steeper; hence a new cascade feature will be required to train the flow of water to the culvert entrance. The nature of the cascade will be further developed at detail design stage, but will likely be either a bedrock cascade, natural cascade or concrete (stone pitched) cascade.<br>A scour protection system will also be required for a short distance downstream of the culvert exit. This will be developed further at detail design stage, but will likely consist of a rock armour (rip-rap) revetment system.<br>**Environmental** |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | | Ecological assessment has identified this watercourse as a potential mammal corridor, however no provision is made at this location.<br>Given the presence of the new upstream cascade feature no provision has been made to accommodate a natural river bed invert with the new culvert section.<br>**Flood Risk**<br>The existing A9 culvert will freely pass the design flood event.<br>The proposed new culvert will freely pass the peak flow associated with the design flood event, however headwater level at the culvert entrance is predicted to increase by 0.01m. The available freeboard between the proposed mainline road level and headwater level is 0.6m, hence the proposed scheme is not considered to be at risk of flooding during the design flood event. Also, given that there is no loss of existing floodplain storage and that there are no other flood sensitive receptors local to the culvert entrance, no further mitigation measures are considered necessary.<br>Downstream flood risk is not impacted by the proposed scheme. |
| **WF164/166 (Allt Geallaidh)**<br>Approximate channel bed width at crossing: 2.8m<br><br>Flow data:<br>50% AEP: 11.6m$^3$/s<br>1% AEP: 33.8m$^3$/s<br>0.5% AEP + CC: 47.5m$^3$/s | Grid Reference:<br>(273483,770254) | Bridge<br><br>Existing length = 22.5m<br>Existing width (span) = 10.0m<br><br>Proposed length = 28.8m<br>Proposed width (span) = 10.6m<br><br>Refer Figure A.11.8.67 | The existing A9 crosses this watercourse by means of an overbridge. The existing structure is a single span structure with a concrete deck and full height mass concrete gravity abutments on spread footings.<br>**Proposed Scheme**<br>The proposed scheme will result in the A9 being widened on the downstream side to accommodate a new dualled carriageway.<br>At this location it is proposed to demolish and replace the existing structure with the proposed Allt Geallaidh Underbridge. A new single span bridge is proposed which consists of a concrete beam and infill deck supported by full height concrete abutments.<br>The new bridge will fully span the watercourse with its abutments located outwith the river corridor associated with the design flood event. The bridge abutments will be founded on sound bedrock.<br>**Environmental**<br>The existing river corridor will not be impacted by the proposed scheme; hence no environmental measures are considered necessary at this location.<br>**Flood Risk**<br>The proposed bridge will not impact existing flood risk due to it be located outwith the river corridor. |
| **WF178**<br><br>Flow data:<br>50% AEP: 0.33m$^3$/s<br>1% AEP: 0.93m$^3$/s<br>0.5% AEP + CC: 1.29m$^3$/s | WC178/JUNCTION<br>(side road culvert)<br><br>Grid Reference:<br>(289144,764417) | Replace the existing twin concrete pipe culvert with a new culvert.<br><br>Existing diameter = 0.45m + 0.37m<br>Existing length = 20m | The existing watercourse is culverted beneath the existing Aldclune junction. The existing inlet is buried, and likely to be formed within pre-earthworks drainage related to the present road network. The proposed scheme will result in the revision of the junction layout and an upgrade of the junction road drainage infrastructure. A number of alternative options have been considered, as follows:<br>• Retain the existing culvert unchanged:<br>The existing culvert infrastructure will conflict with the proposed scheme design, in particular the road box and road drainage design. Options which require raising the junction alignment to clear the culvert infrastructure have been discounted because of the need to tie-in with the B8079 close by the watercourse crossing location. |

| Water Feature | Culvert number & Location | Construction detail | Justifications for engineering solution |
|---|---|---|---|
| | | Proposed diameter = 2.0m<br>Proposed length = 20m<br>Proposed embedment = 0.15m<br><br>Refer Figure A.11.8.68 | • Extension of the existing culvert:<br>No options were identified whereby a culvert extension would resolve the geometric conflicts between the existing culvert and the proposed scheme.<br>• Replacement of the existing culvert:<br>Due to the conflict between the existing crossing infrastructure and the proposed scheme, the preferred option is to replace the existing culvert.<br>**Proposed Scheme**<br>The preferred solution for this crossing, taking account of engineering and environmental design criteria, is to replace the existing culvert with a revised, lower level to accommodate the proposed scheme.<br>A new culvert inlet will be formed within revised pre-earthworks drainage as part of the scheme, and the existing twin circular pipes shall be replaced by a single culvert barrel.<br>The new culvert has been designed to freely pass the 1% AEP (100-year) design fluvial event with appropriate freeboard within the culvert barrel in accordance with DMRB requirements. The culvert will also incorporate concrete inlet and exit structures including headwall, wingwalls and apron appropriately designed in accordance with SEPA good practice guidance and tie-in with the existing channel at its entrance and exit.<br>Scour protection systems will be required at all of the culvert exits to offer protection to the channel for a short distance downstream against fluvial erosion. The scour protection system will likely consist of a rock armour (rip-rap) revetment system, which will be further developed at detail design stage.<br>**Environmental**<br>Mammal passage is restricted by the Highland Mainline railway into the River Tay SAC, as a result it is considered of little / no benefit to mammals to provide a culvert to facilitate mammal passage under this side road.<br>The invert of the new culvert will be depressed to allow for a natural bed through the culvert.<br>**Flood Risk**<br>It has not been possible to fully assess the hydraulic performance of the existing culvert due to it being buried, hence at present the culvert offer little to no capacity to convey flow.<br>The proposed new culvert will freely pass the peak flow associated with the design flood event. This will increase flow downstream which may exceed the capacity of the downstream 0.6m dia. B8079 culvert. However, flow path analysis has indicated that that in the existing situation, flood water will overtop the side road and then flow along the B8079 towards the culvert inlet. Therefore, the flood risk downstream of the culvert is likely to remain unchanged and hence no additional mitigation is considered necessary. |

**Table 2: Watercourse photographs**



**Photograph 1**

WF84 Existing A9 culvert inlet and upstream channel

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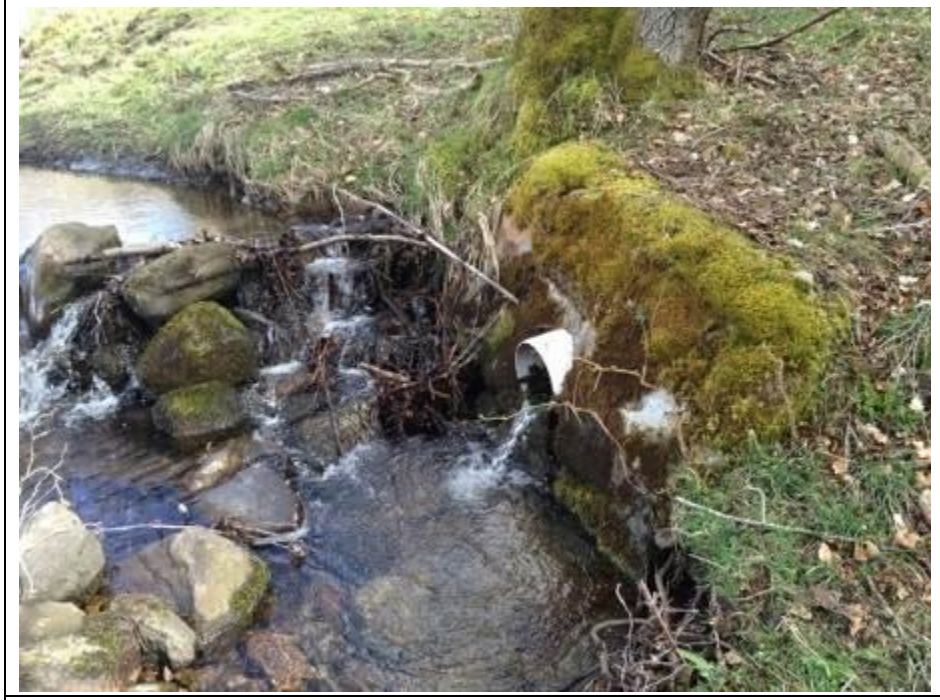
|  |  |
| **Photograph 2**<br><br>WF86 Existing A9 culvert outlet and downstream channel | **Photograph 3**<br><br>WF86 Existing A9 culvert inlet and upstream channel |

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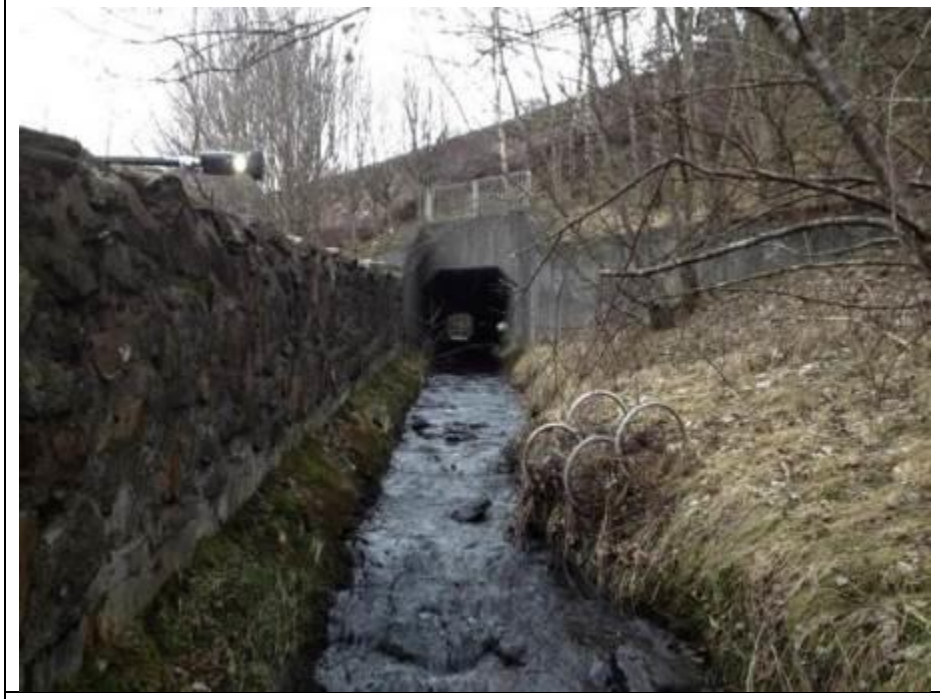
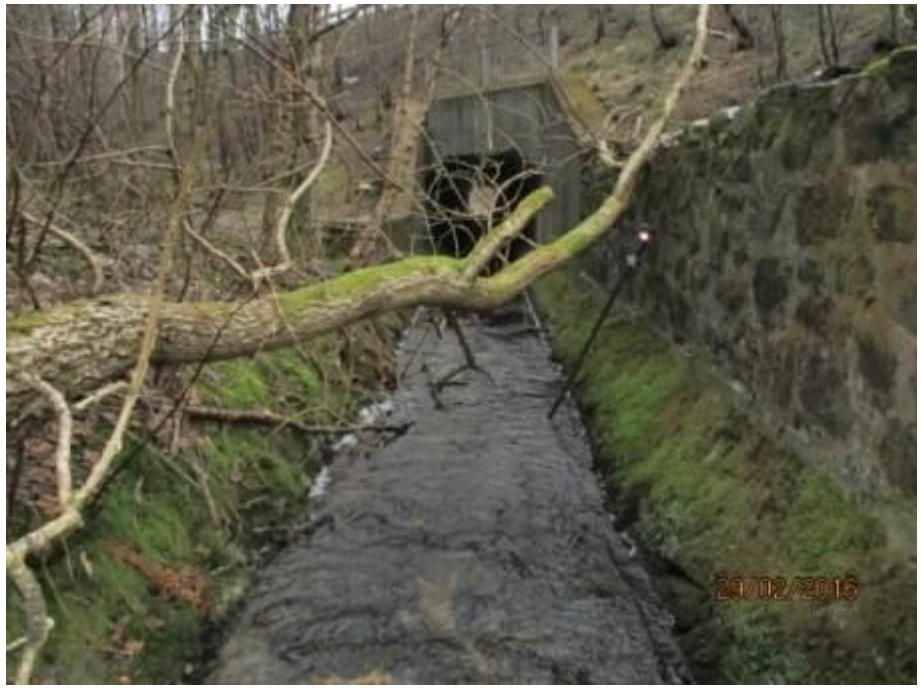
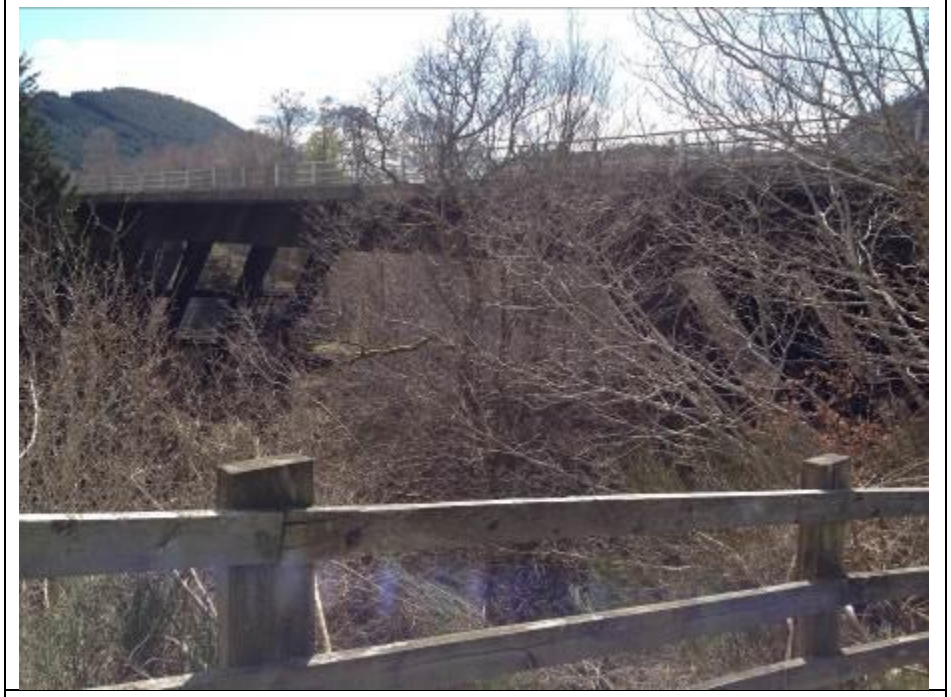
|  |  |
| **Photograph 4**<br><br>WF87 Existing A9 culvert outlet and downstream channel | **Photograph 5**<br><br>WF87 Existing A9 culvert inlet and upstream channel |

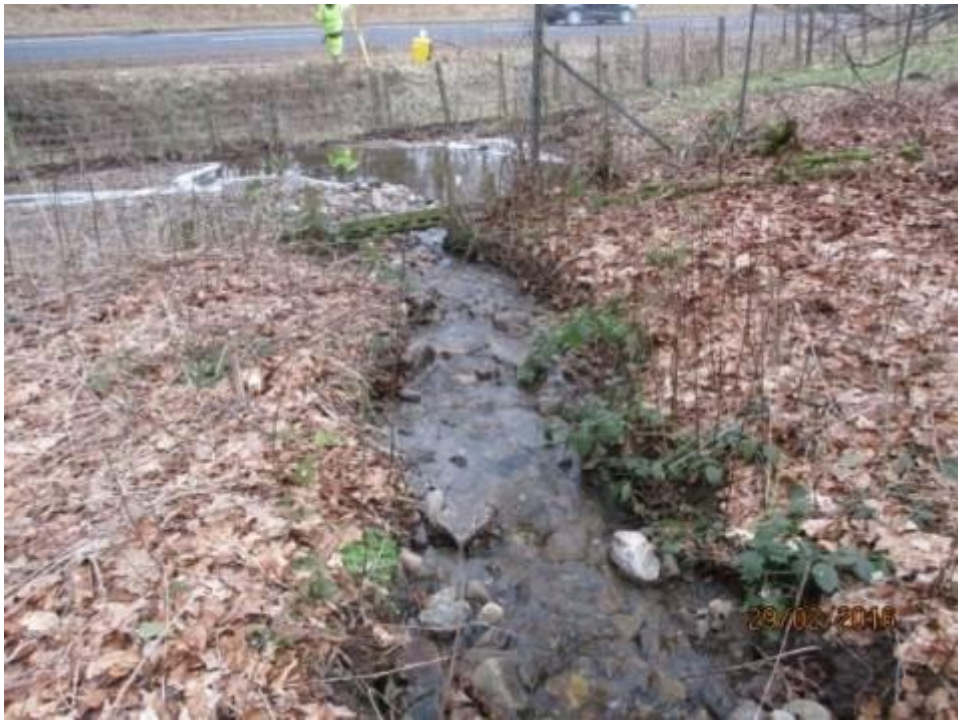


**Photograph 6**

WF89 Existing A9 bridge

**Photograph 7**

WF92 Existing A9 culvert outlet and downstream channel



**Photograph 8**

WF92 Existing A9 culvert inlet and upstream channel

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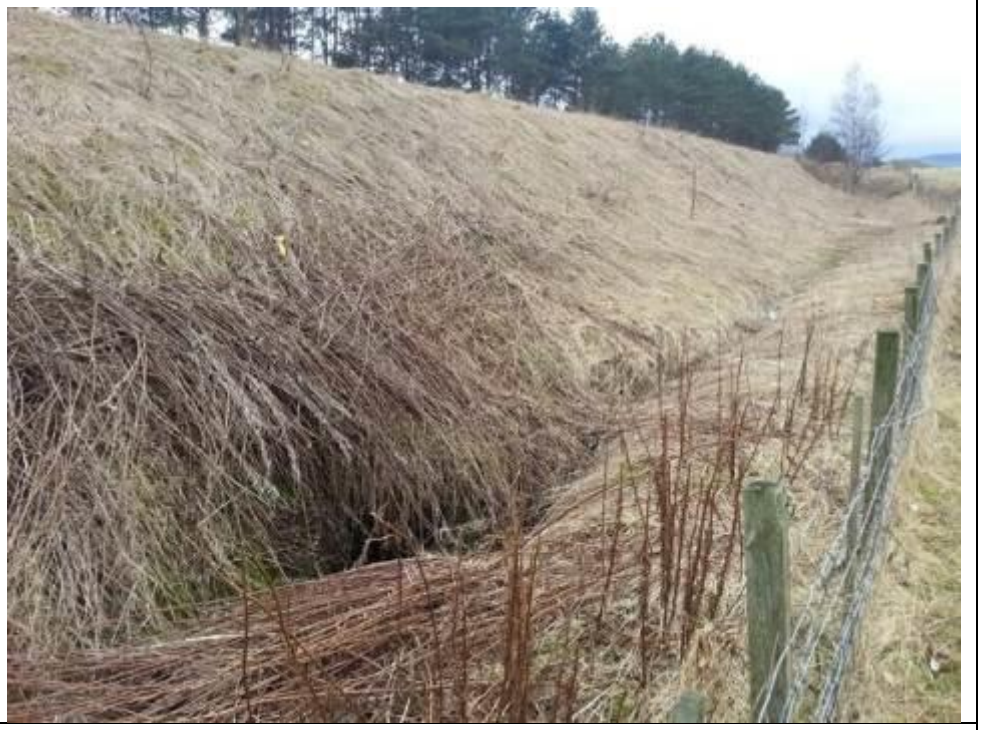
|---|---|
| (No image currently available) |  |
| **Photograph 9**<br><br>WF95 Existing A9 culvert outlet and downstream channel | **Photograph 10**<br><br>WF95 Existing A9 culvert inlet and upstream channel |

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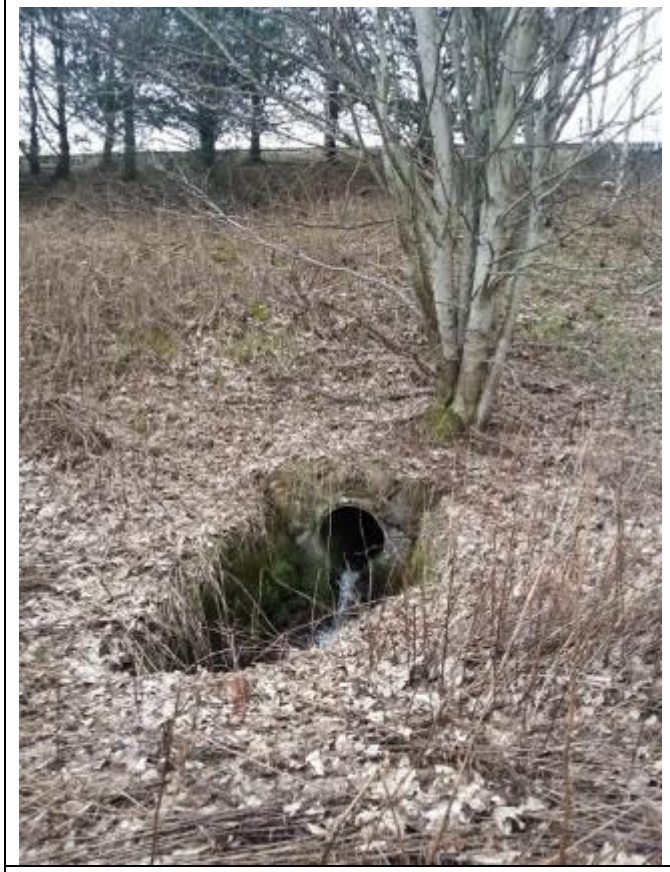
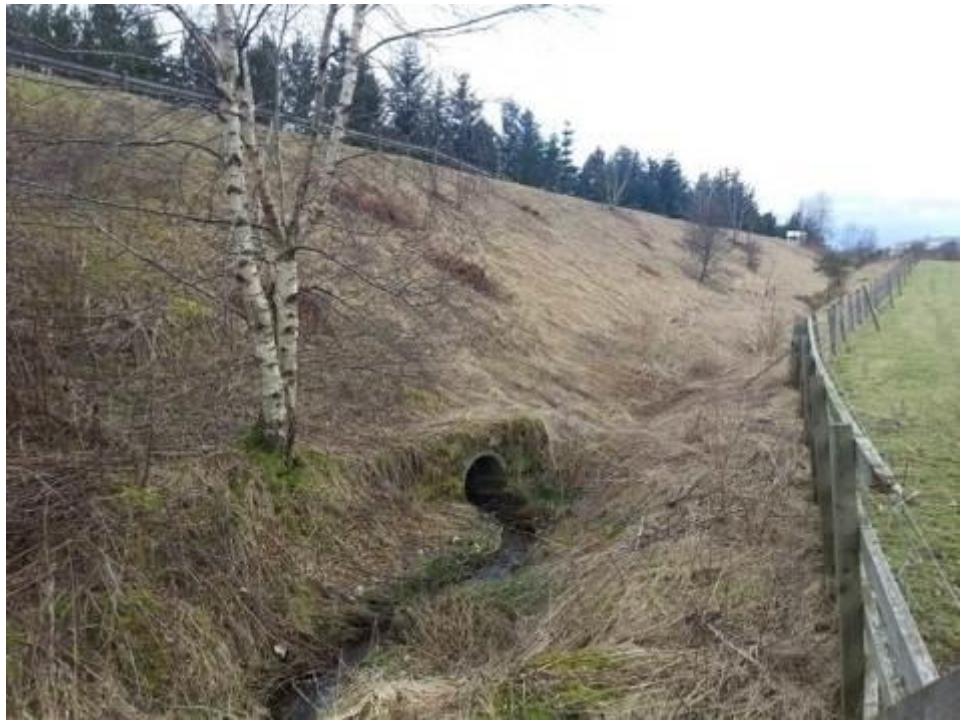
|---|---|
|  |  |
| **Photograph 11**<br><br>WF96 Existing A9 culvert outlet and downstream channel | **Photograph 12**<br><br>WF96 Existing A9 culvert inlet and upstream channel |

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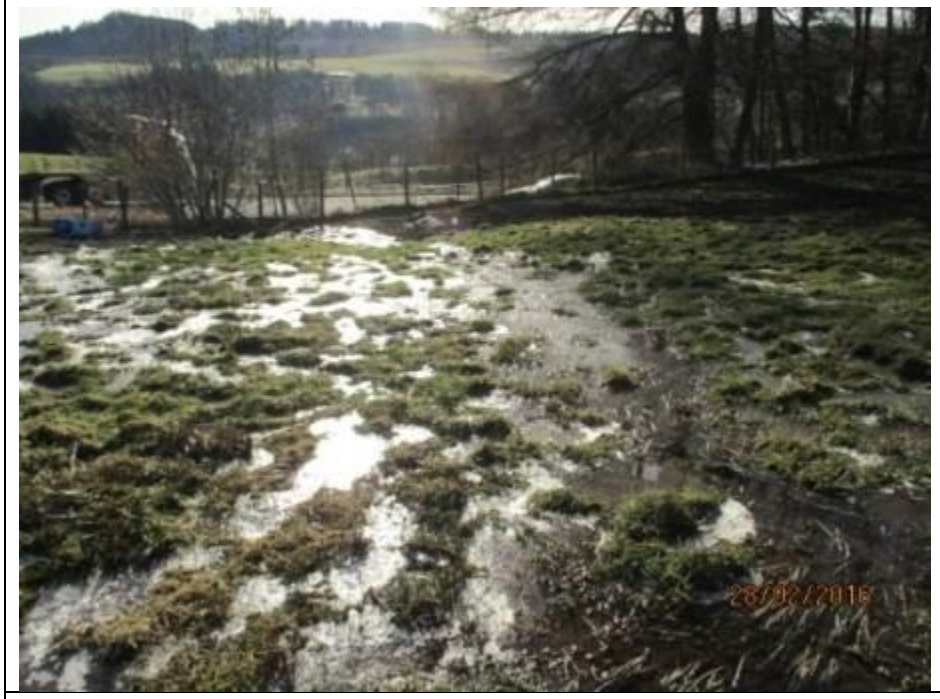
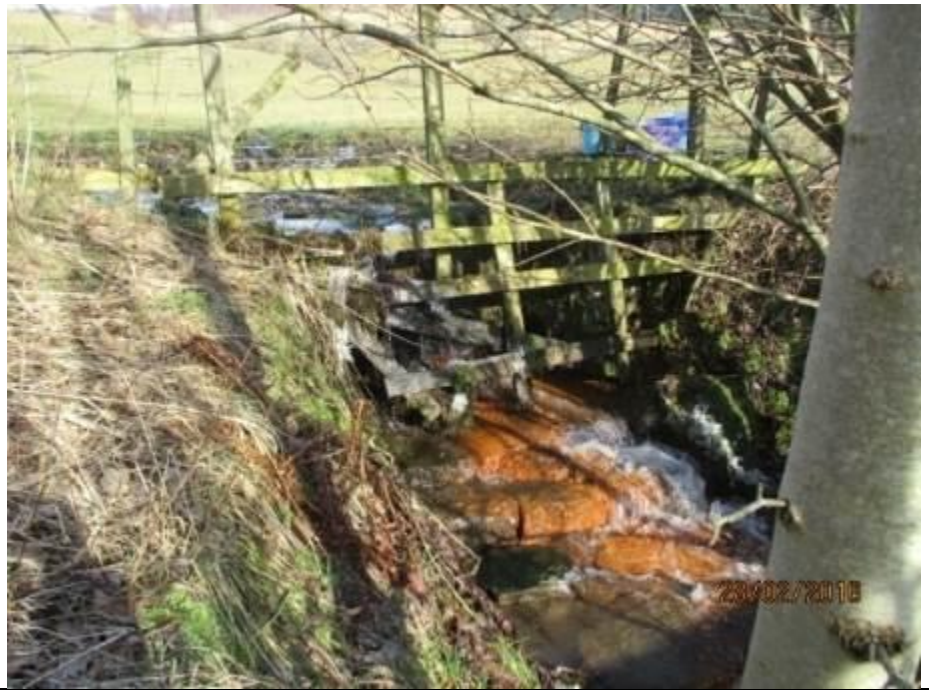
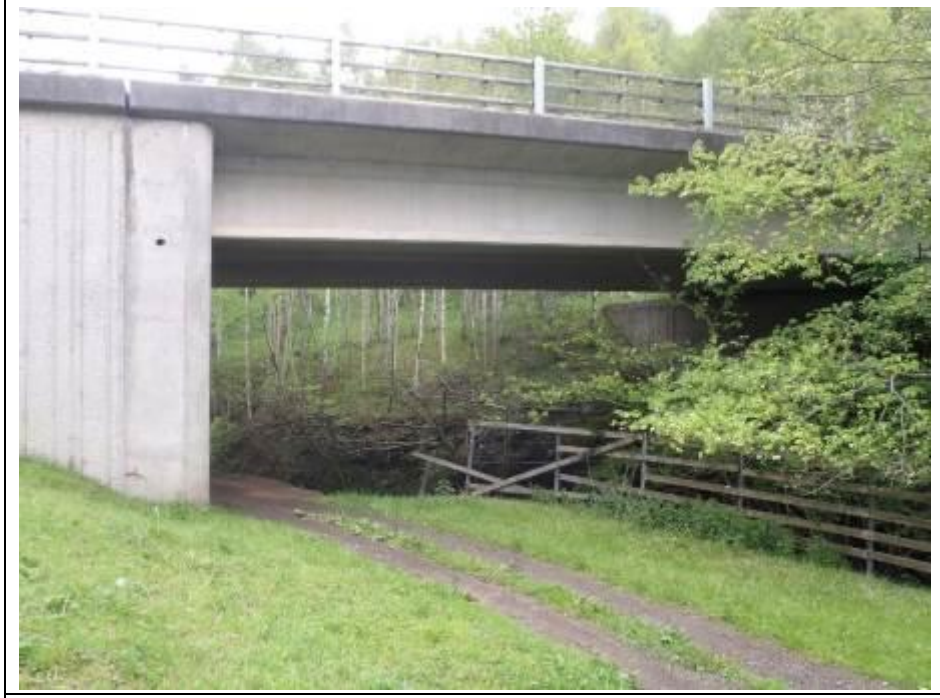
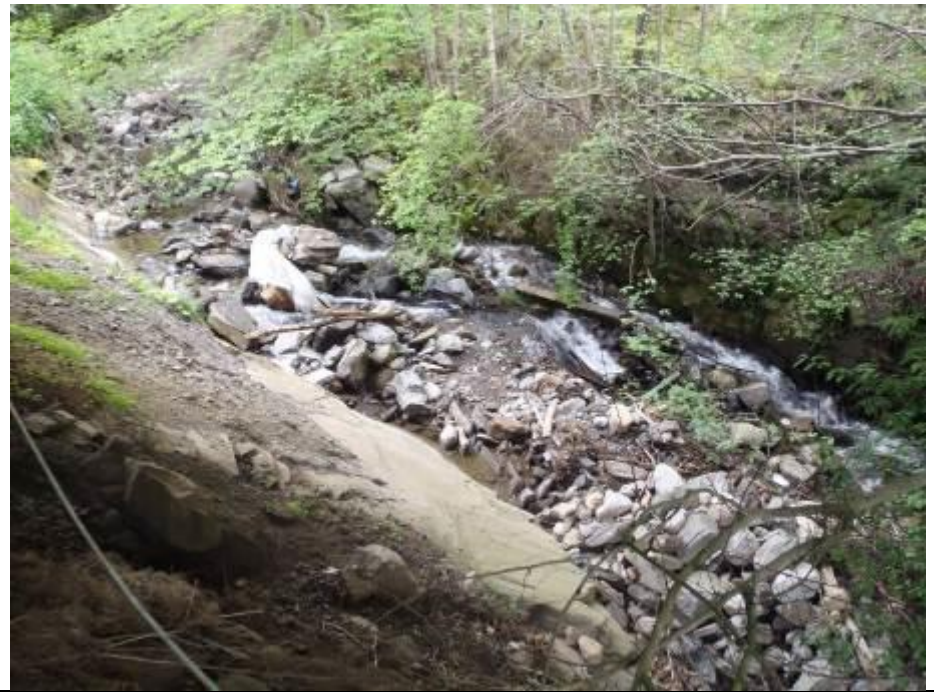
|  |  |
| **Photograph 13**<br><br>WF97 Existing overland flow upstream of the A9 | **Photograph 14**<br><br>WF97 Steps upstream of existing A9 culvert |



**Photograph 15**

WF98 Existing A9 bridge



**Photograph 16**

WF98 View of channel at existing A9 bridge

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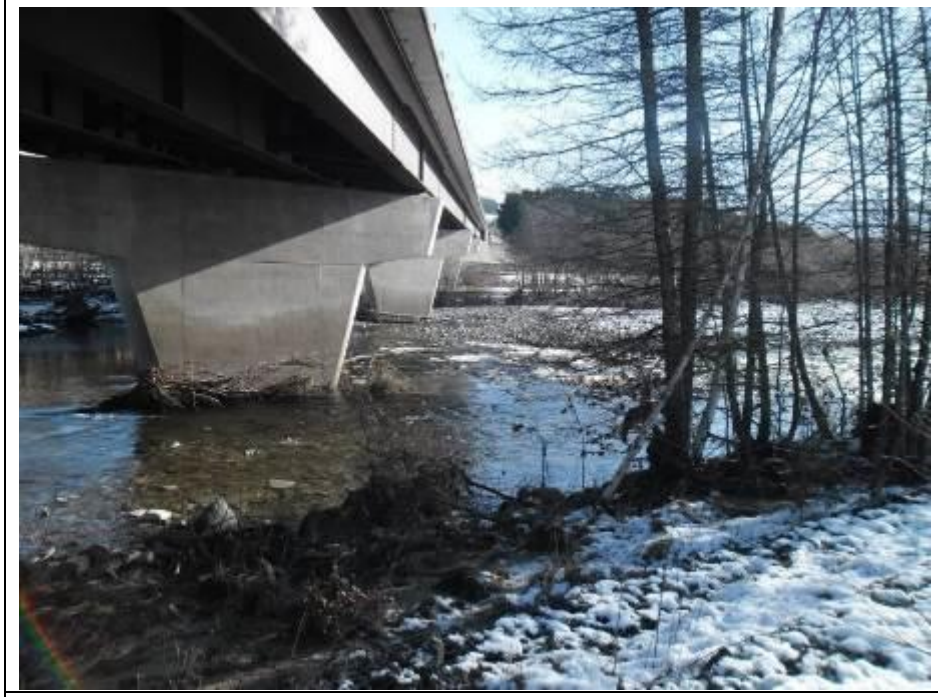
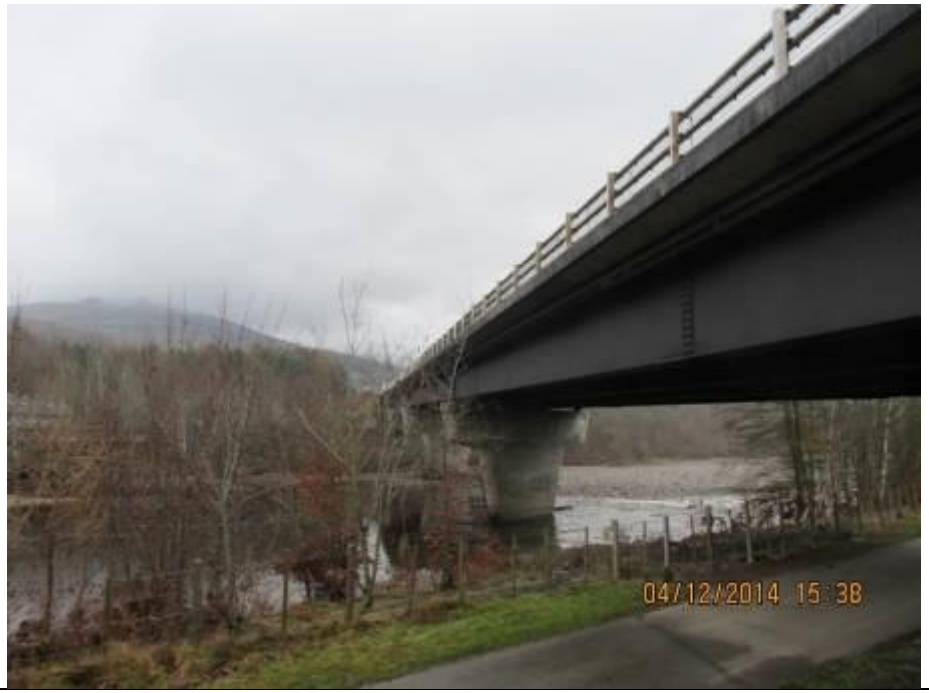
|  |  |
| **Photograph 17**<br><br>WF100 Existing A9 Essangal bridge over River Garry | **Photograph 18**<br><br>WF100 Existing A9 Essangal bridge over River Garry |

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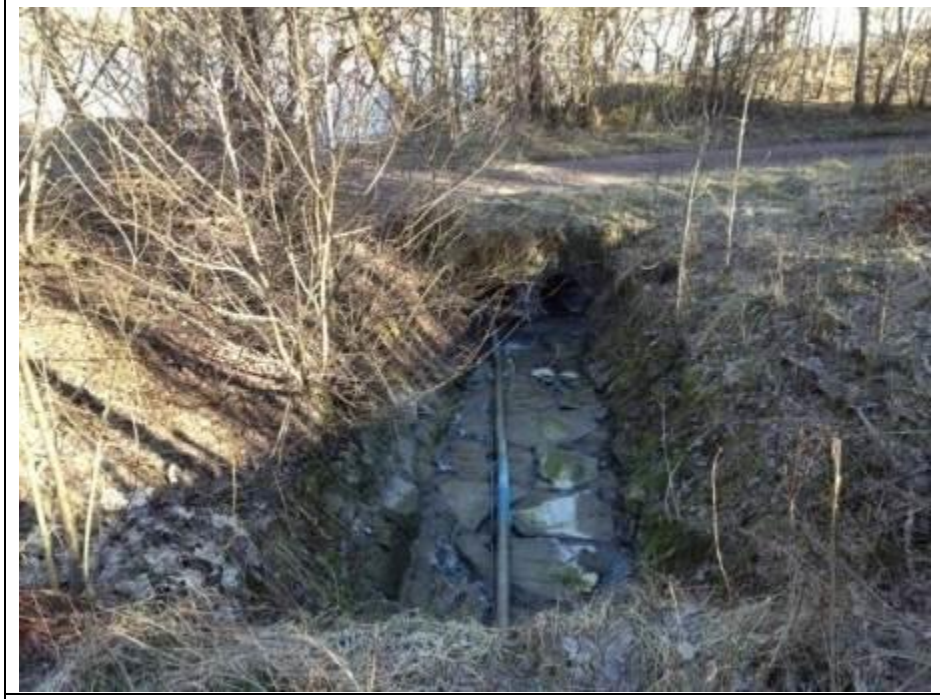
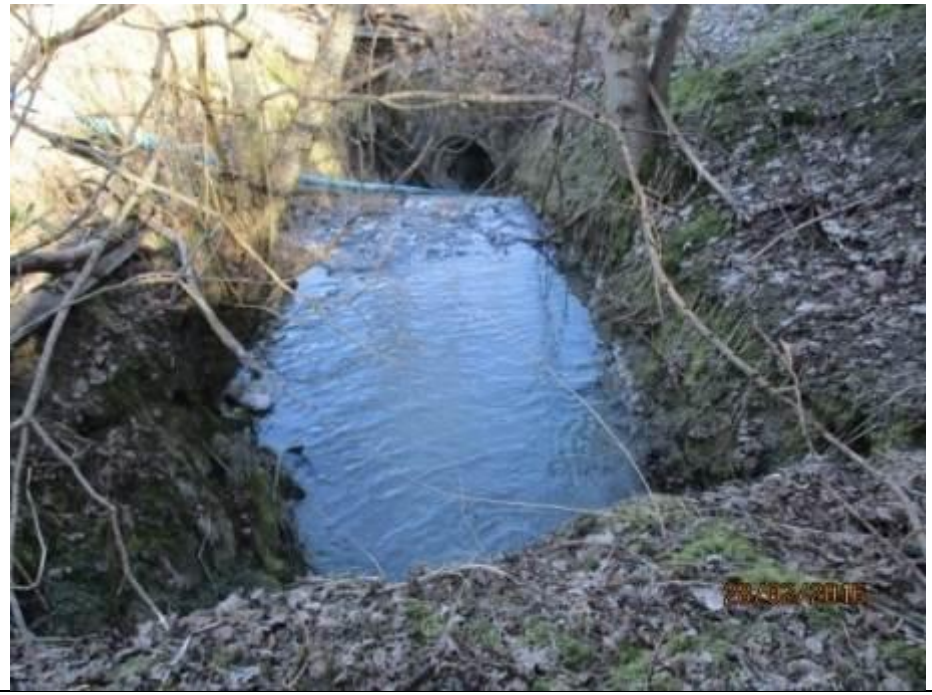
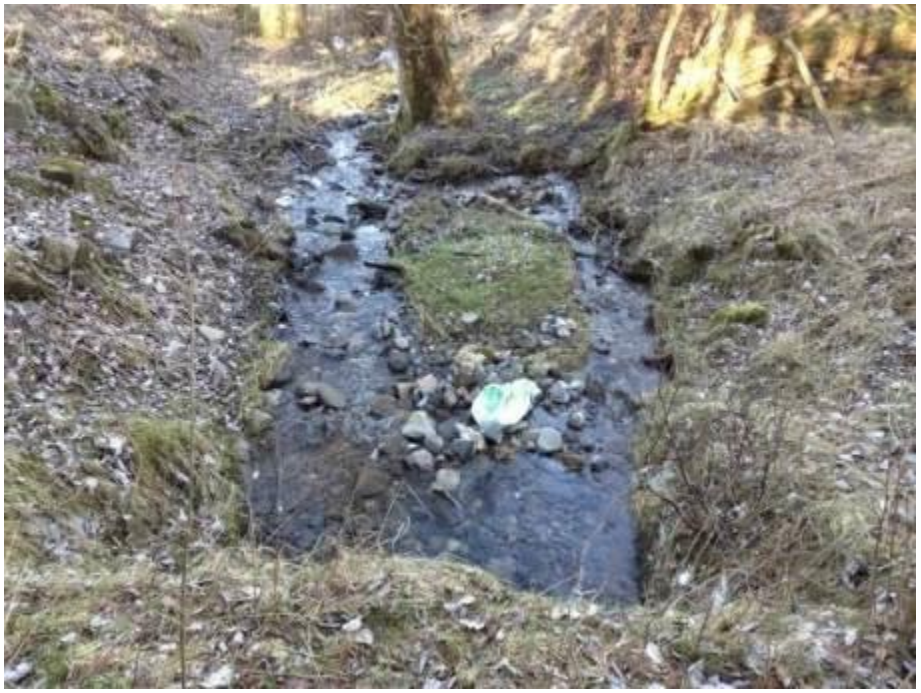
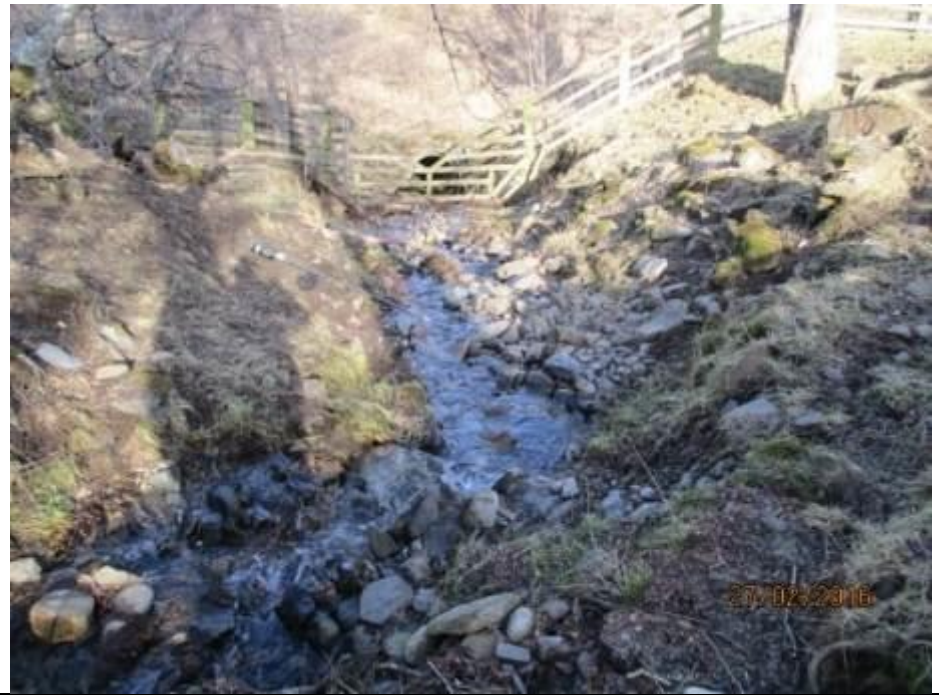
|  |  |
| **Photograph 19**<br><br>WF101 Existing A9 culvert downstream channel looking to existing access track culvert | **Photograph 20**<br><br>WF101 Existing A9 culvert inlet and upstream channel |



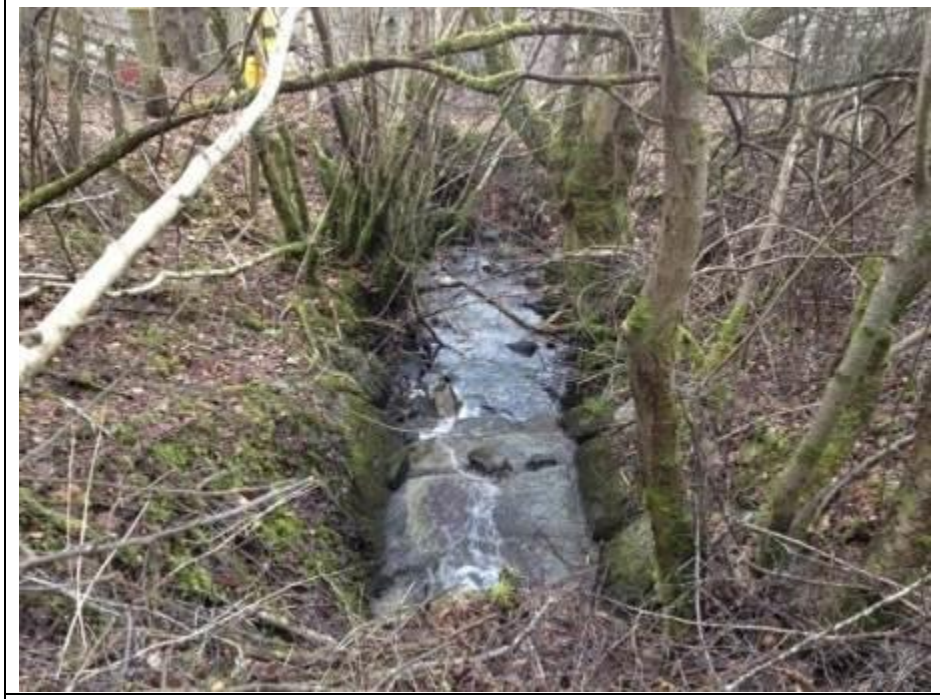
**Photograph 21**

WF102 Existing downstream channel viewed from A9 culvert outlet



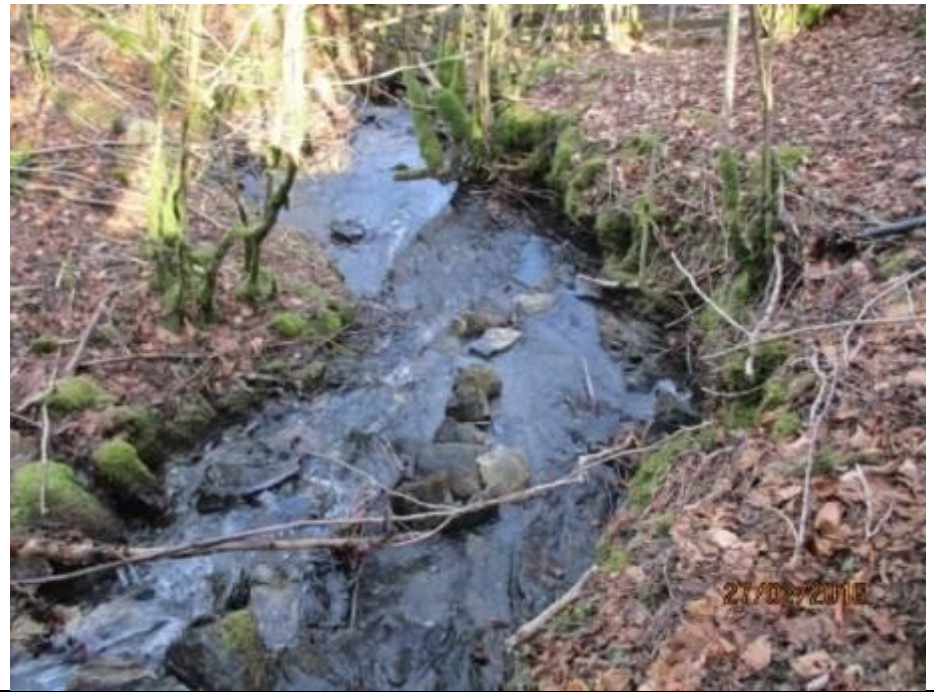
**Photograph 22**

WF102 Existing A9 culvert inlet and upstream channel



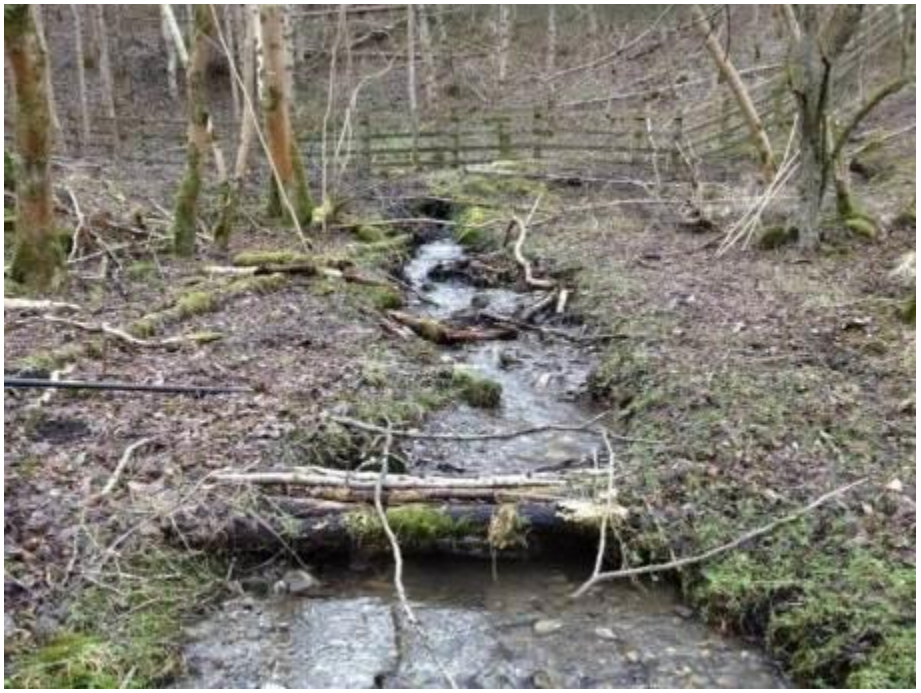
**Photograph 23**

WF103 Existing downstream channel viewed from A9 culvert outlet



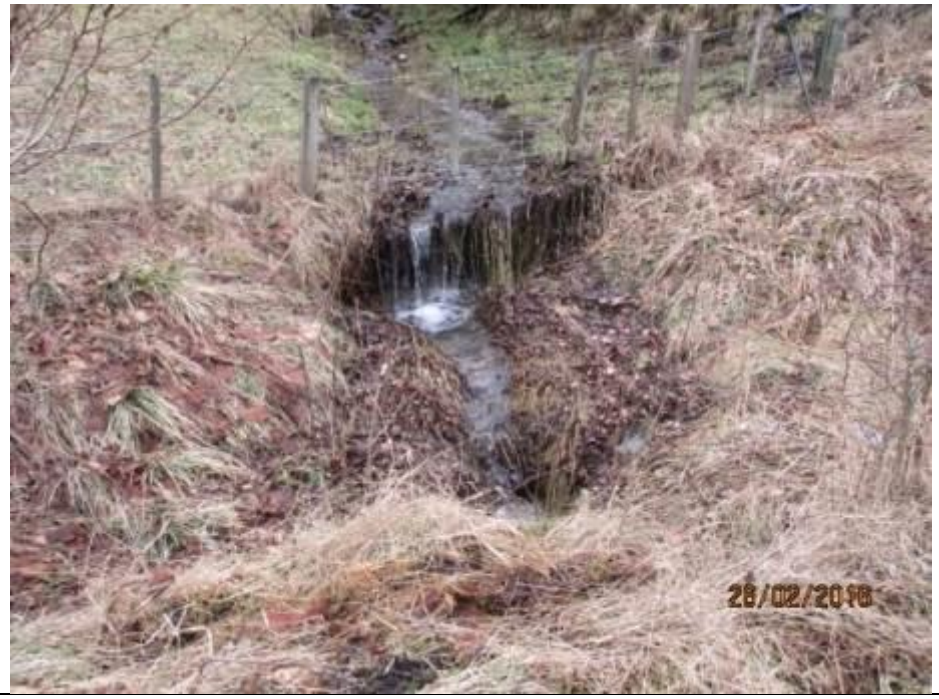
**Photograph 24**

WF103 Existing upstream channel viewed towards A9 culvert inlet



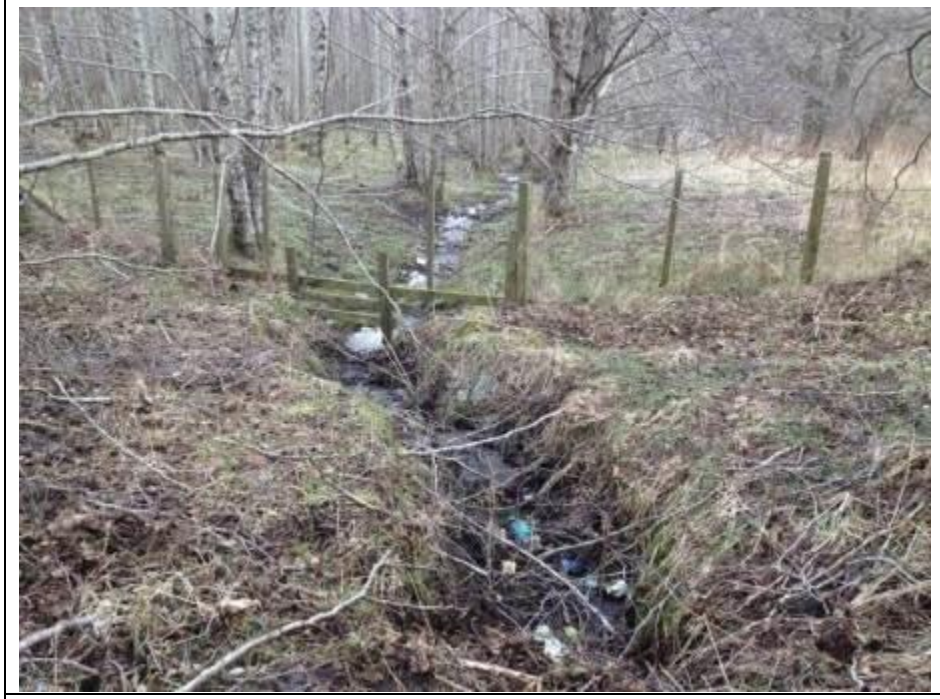
**Photograph 25**

WF104 Existing A9 culvert outlet and downstream channel



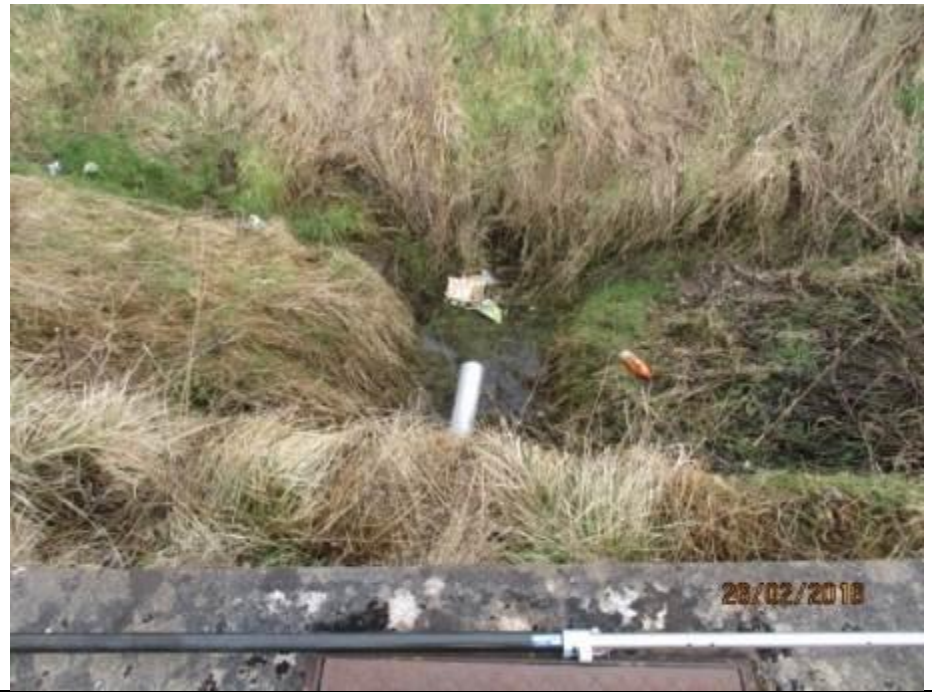

**Photograph 26**

WF104 Existing upstream channel viewed from A9 culvert inlet



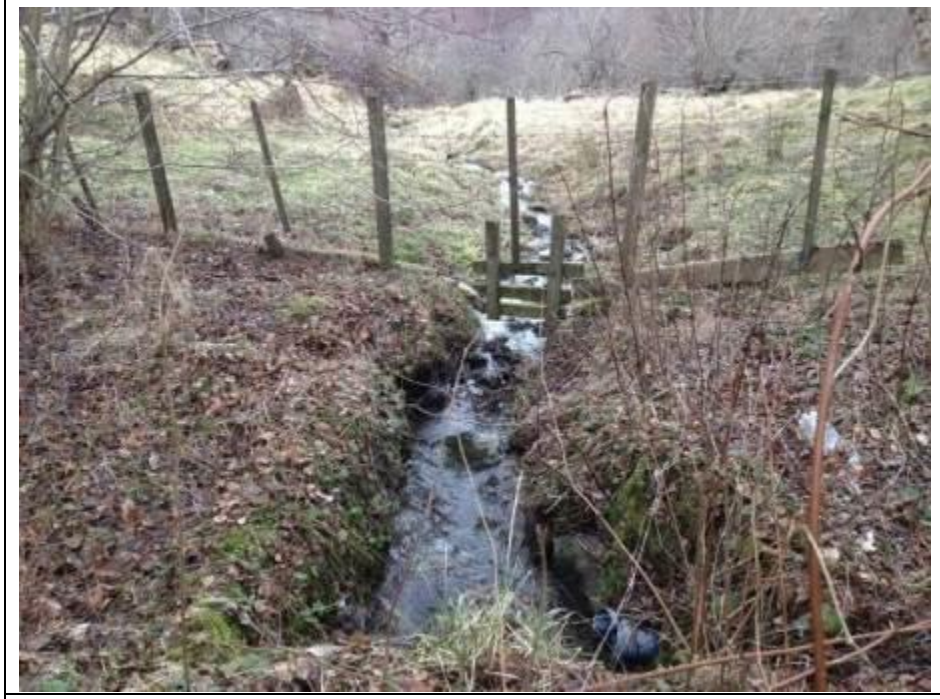
**Photograph 27**

WF105 Existing downstream channel viewed from A9 culvert outlet



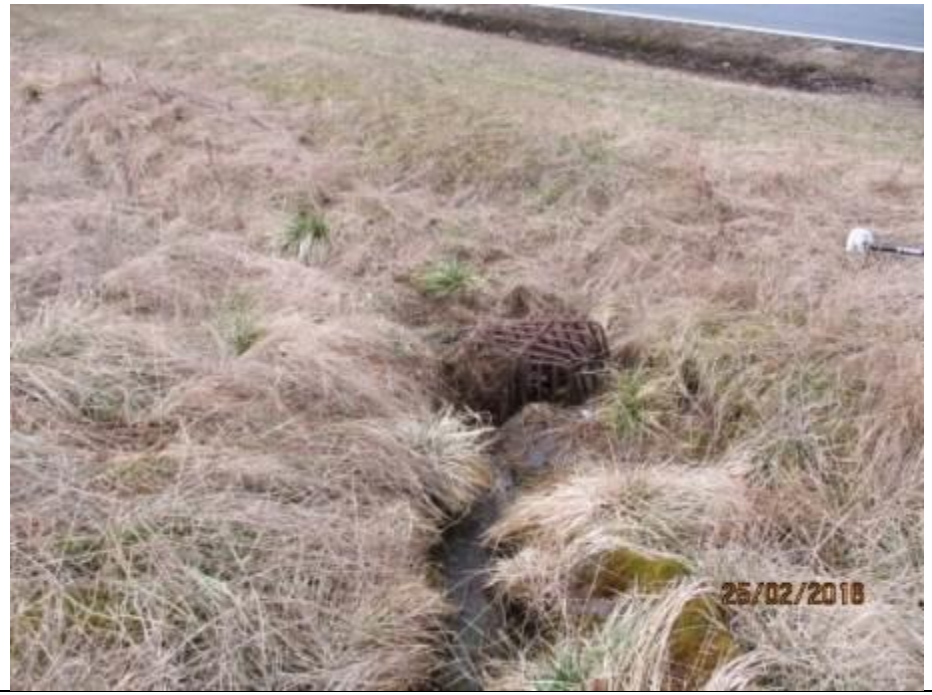

**Photograph 28**

WF105 Existing A9 culvert inlet (overgrown)



**Photograph 29**

WF106 Existing downstream channel viewed from A9 culvert outlet

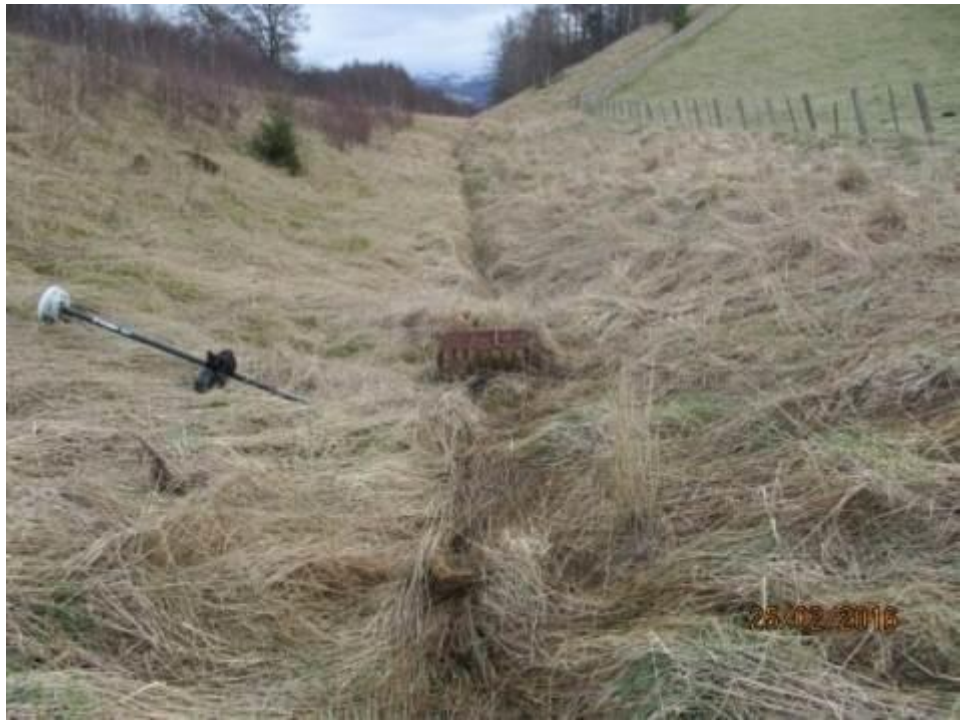



**Photograph 30**

WF106 Existing A9 culvert inlet and upstream channel

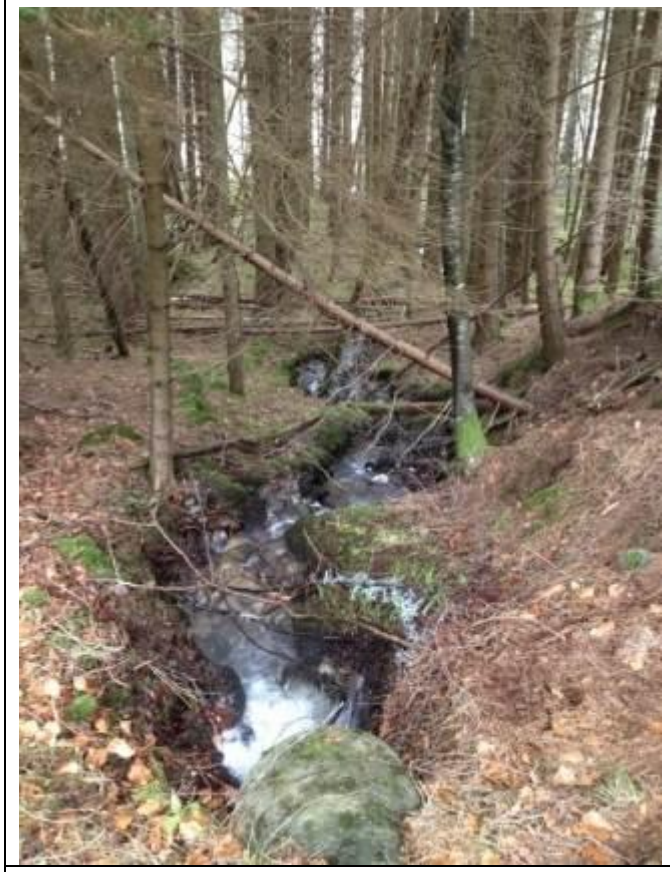
**Photograph 31**

WF107 Existing downstream channel viewed from A9 culvert outlet



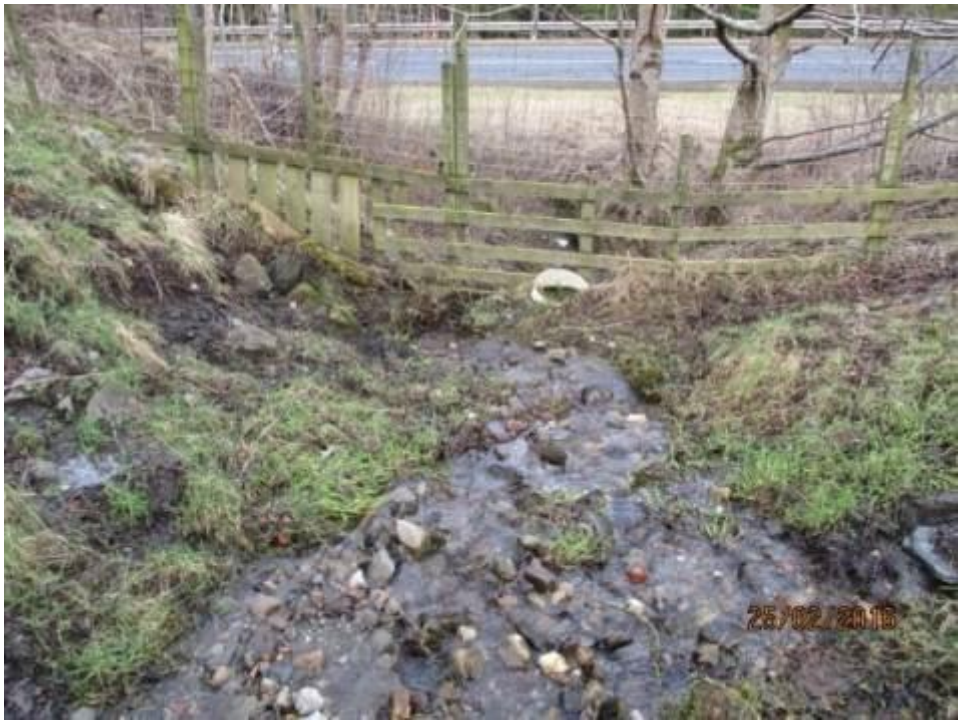
**Photograph 32**

WF107 Existing A9 culvert inlet and upstream channel



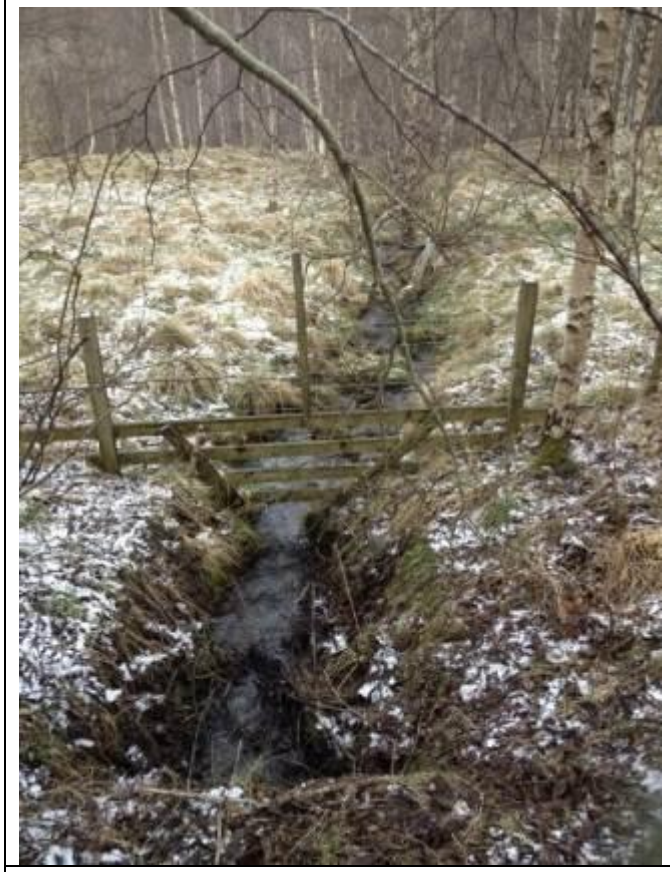
**Photograph 33**

WF108 Existing downstream channel viewed from access track culvert outlet



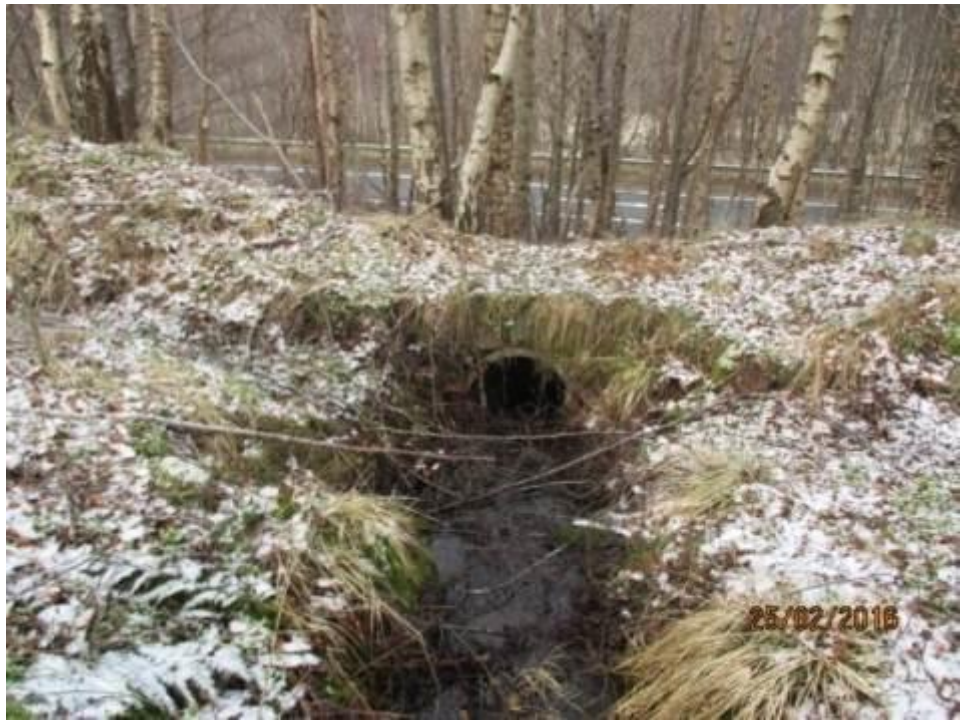
**Photograph 34**

WF108 Existing A9 culvert inlet and upstream channel



**Photograph 35**

WF109 Existing downstream channel viewed from A9 culvert outlet




**Photograph 36**

WF109 Existing A9 culvert inlet and upstream channel

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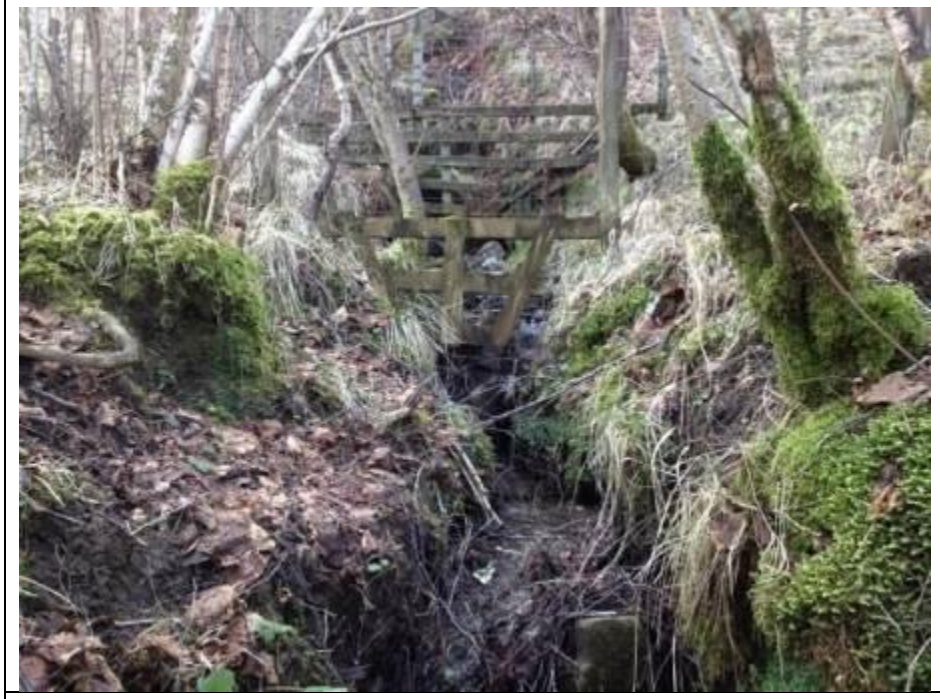
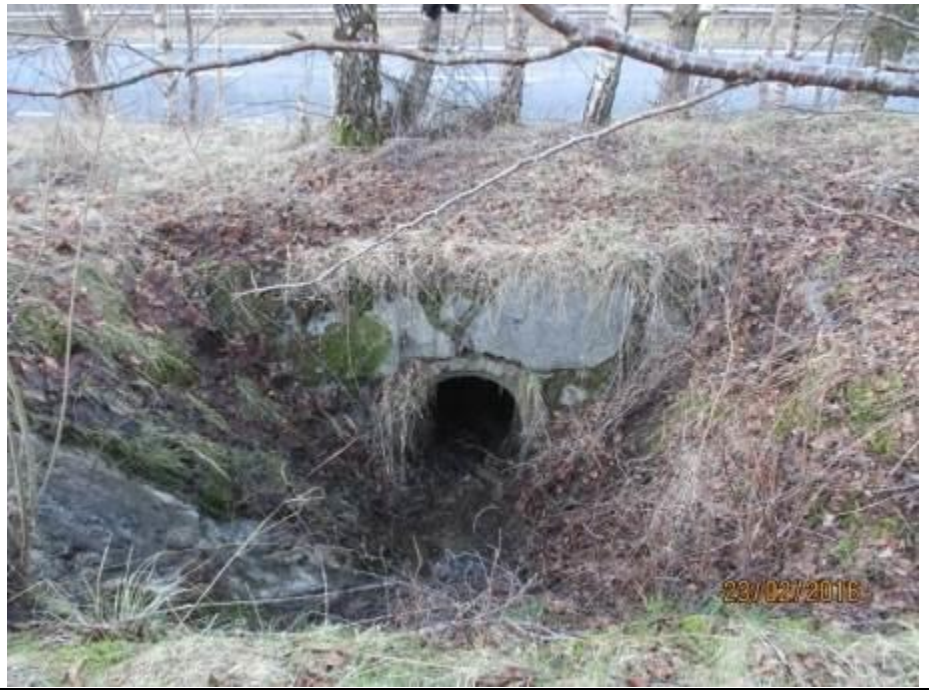
|---|---|
|  |  |
| **Photograph 37**<br><br>WF110 Existing A9 culvert outlet and downstream channel | **Photograph 38**<br><br>WF110 Existing A9 culvert inlet and upstream channel |

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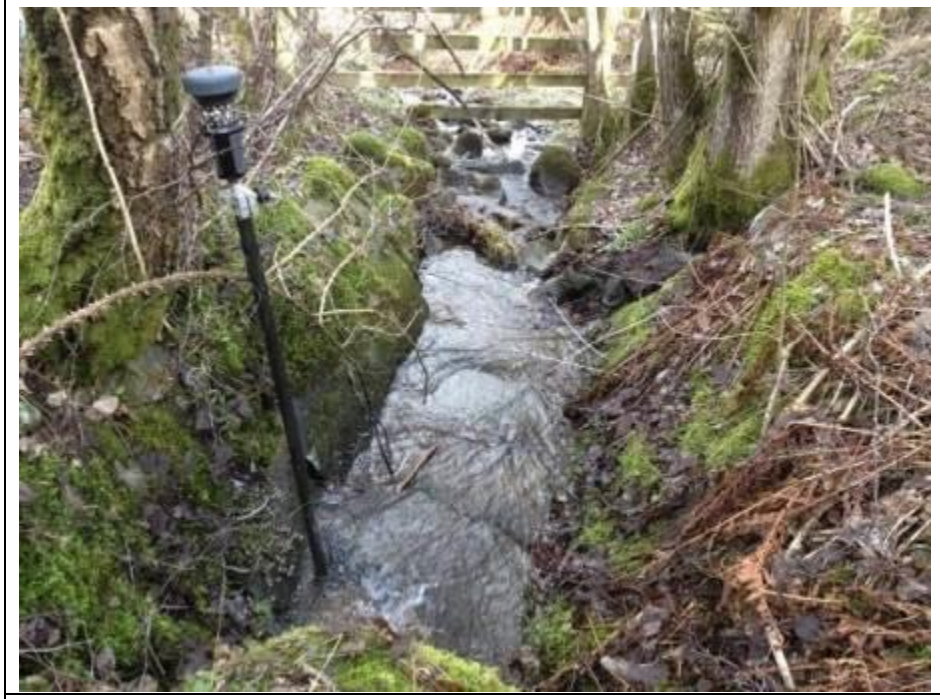
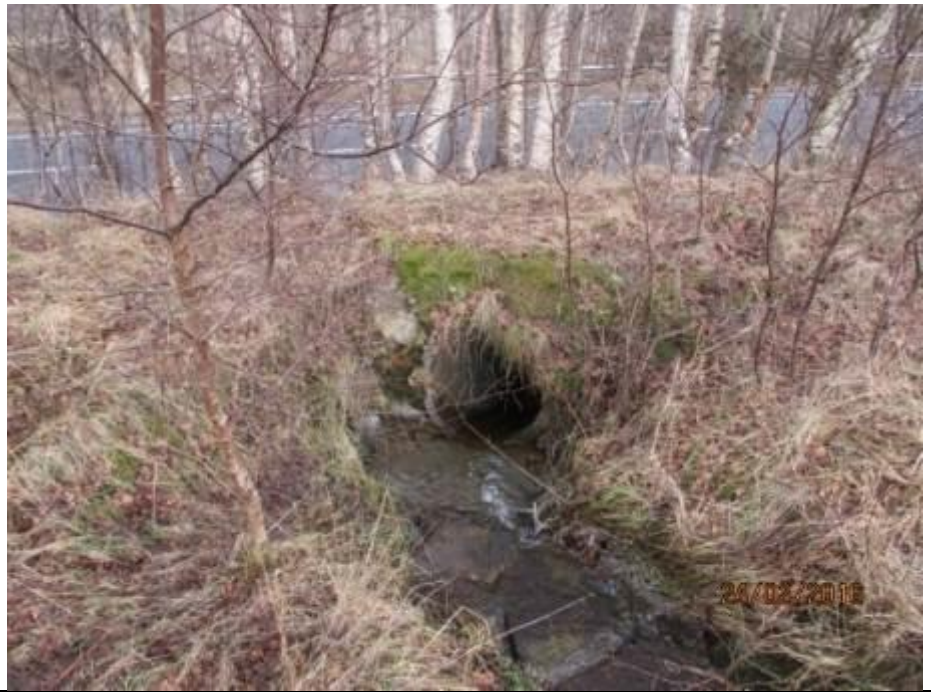
|---|---|
|  |  |
| **Photograph 39**<br><br>WF111 Existing downstream channel viewed from A9 culvert outlet | **Photograph 40**<br><br>WF111 Existing A9 culvert inlet and upstream channel |

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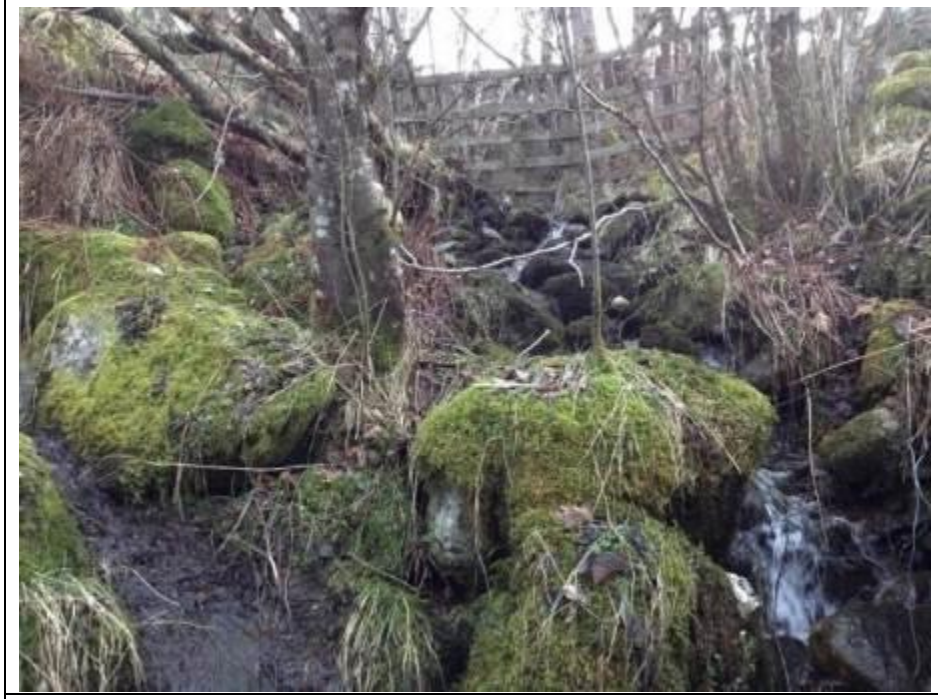
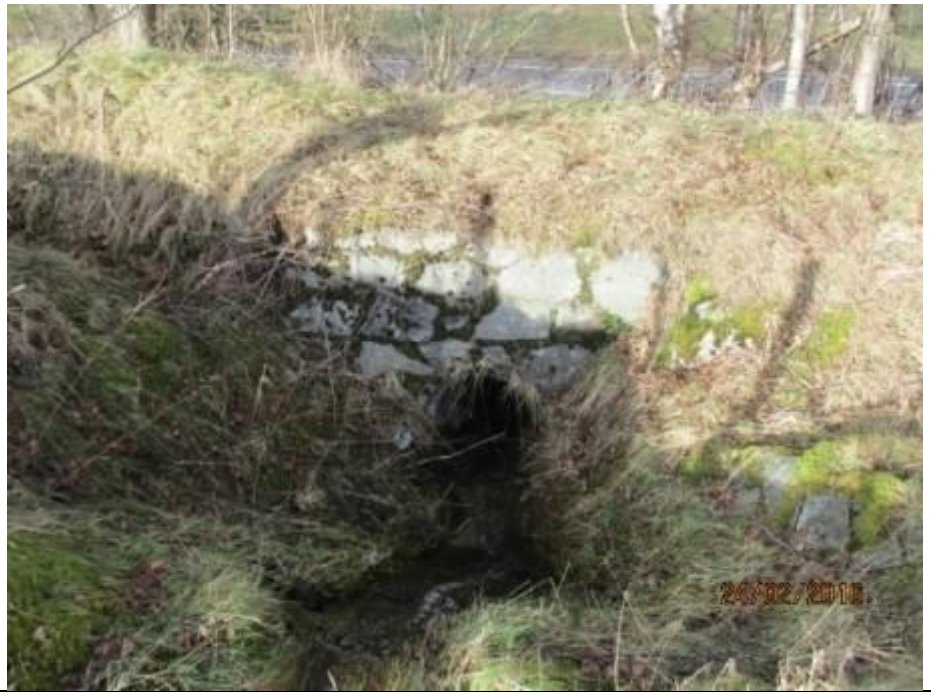
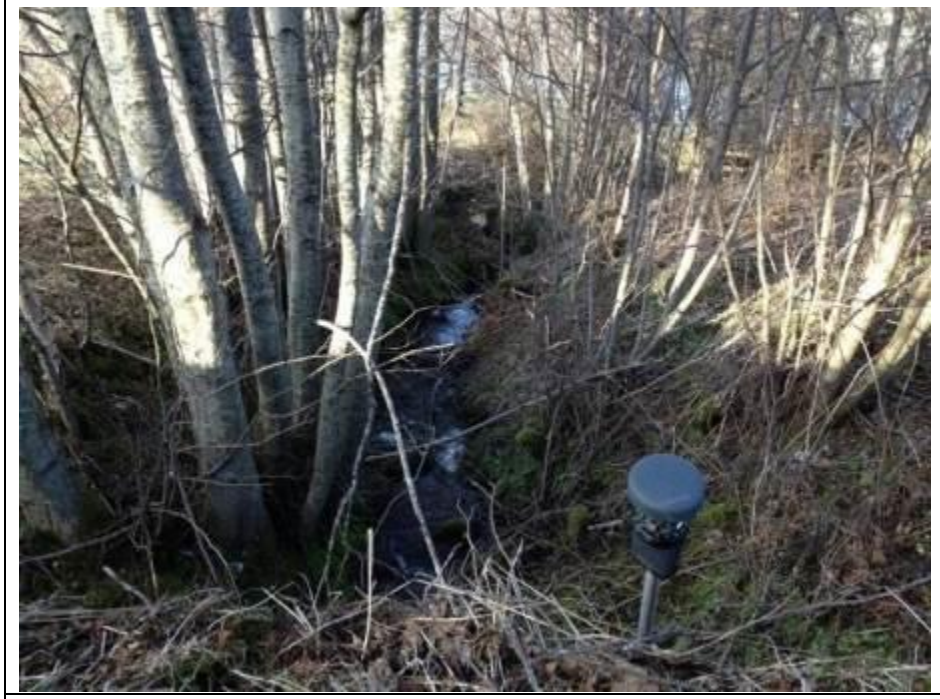
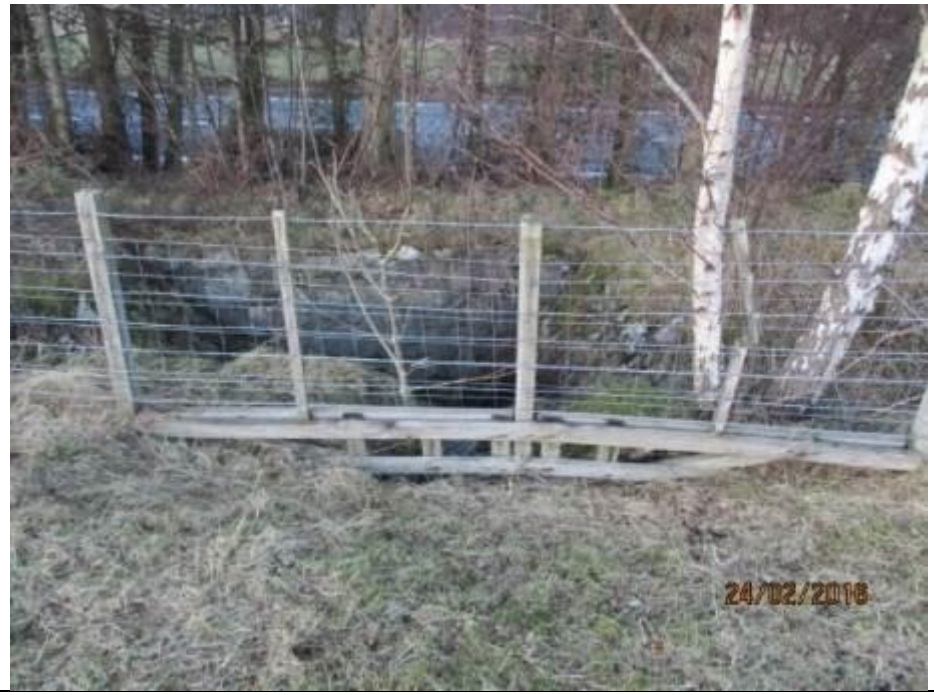
|  |  |
| **Photograph 41**<br><br>WF112 Existing A9 culvert outlet and downstream channel | **Photograph 42**<br><br>WF112 Existing A9 culvert inlet |



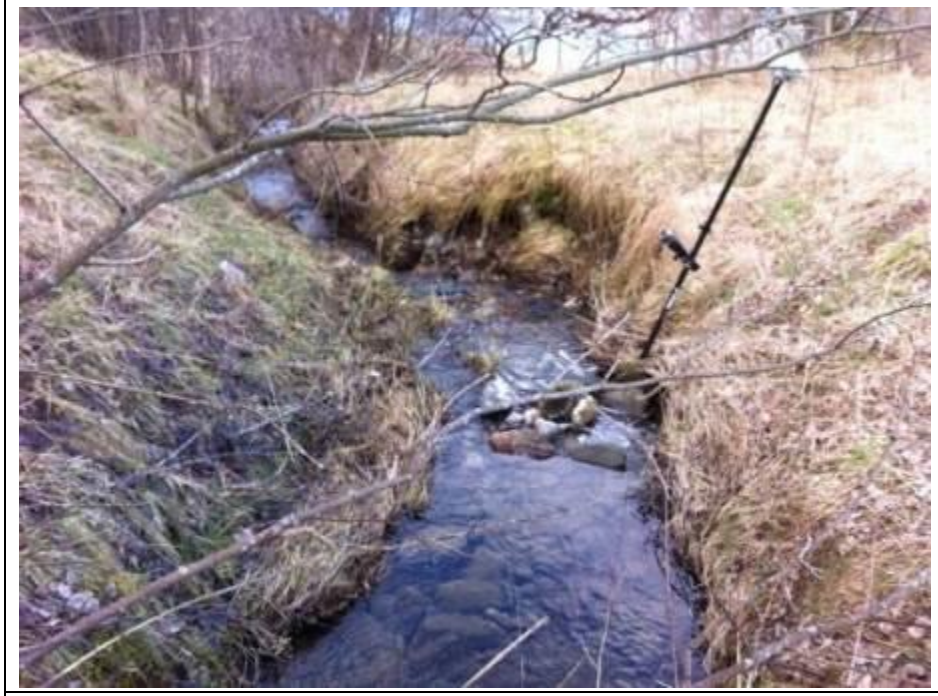
**Photograph 43**

WF113 Existing downstream channel viewed from A9 culvert outlet



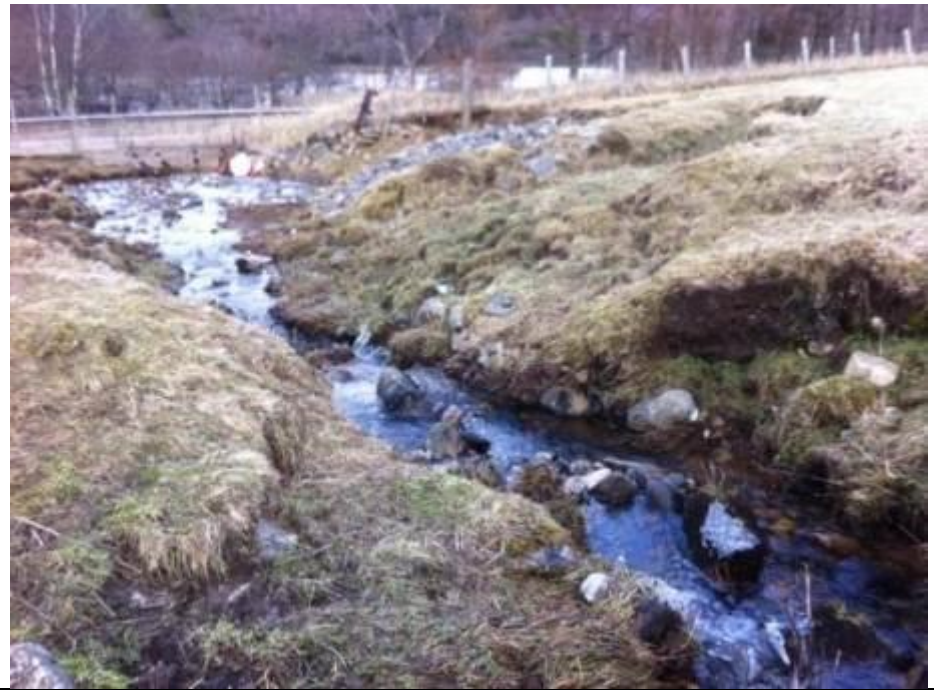

**Photograph 44**

WF113 Existing A9 culvert inlet



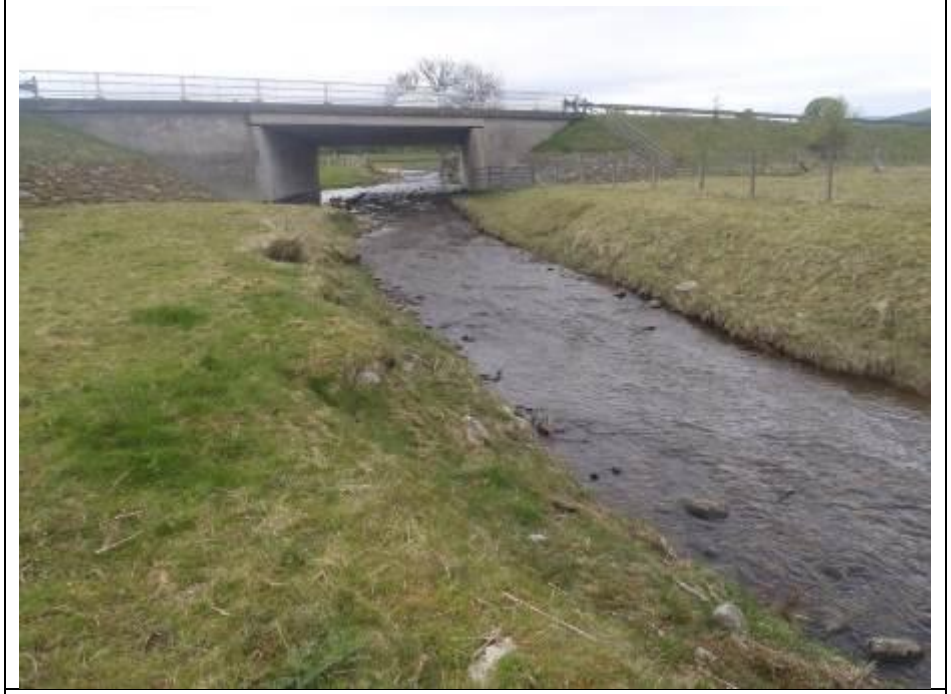
**Photograph 45**

WF114 Existing downstream channel viewed from A9 culvert outlet



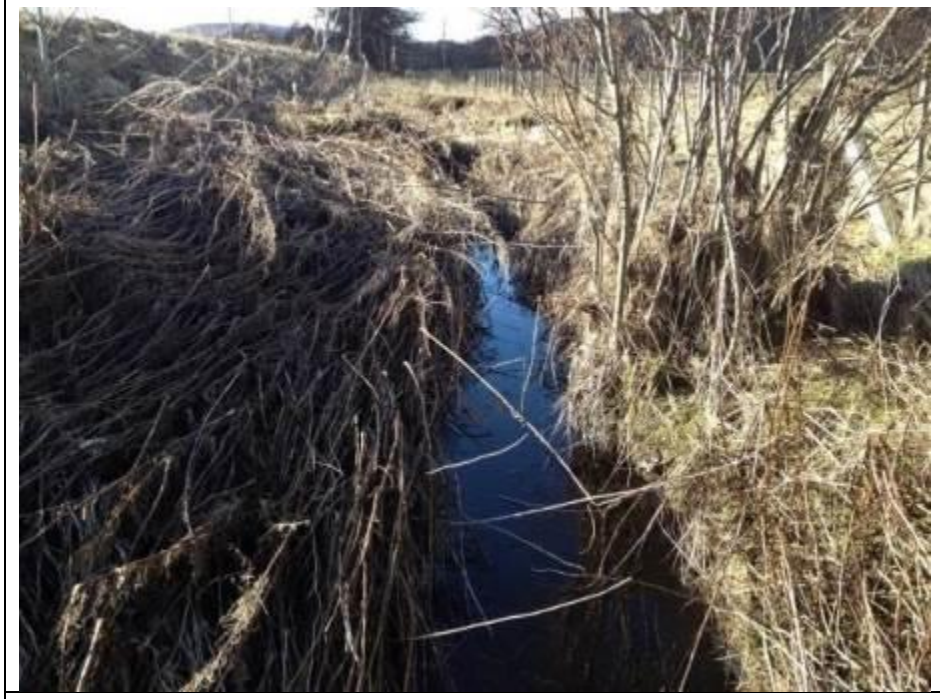
**Photograph 46**

WF114 Existing upstream channel viewed towards A9 culvert



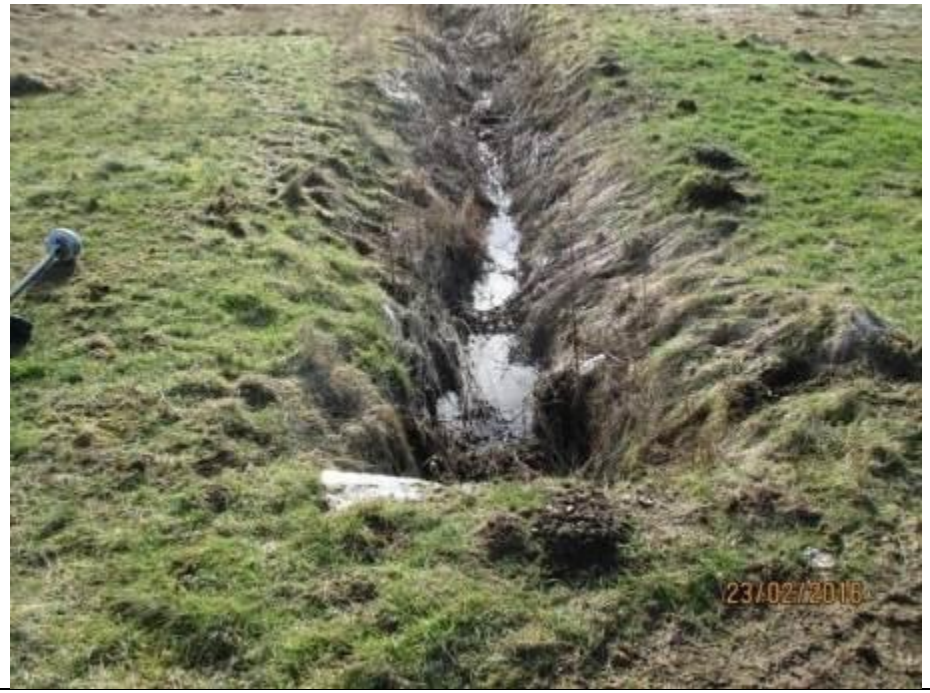
**Photograph 47**

WF115 Existing A9 bridge



**Photograph 48**

WF116 Existing downstream channel viewed towards A9 culvert outlet

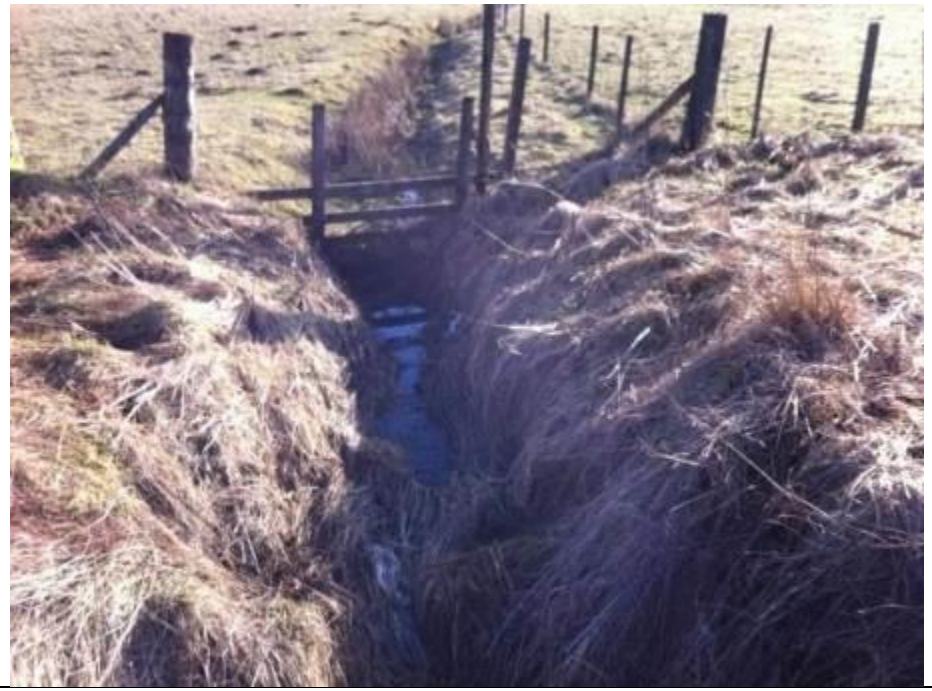



**Photograph 49**

WF116 Existing upstream channel viewed from A9 culvert inlet

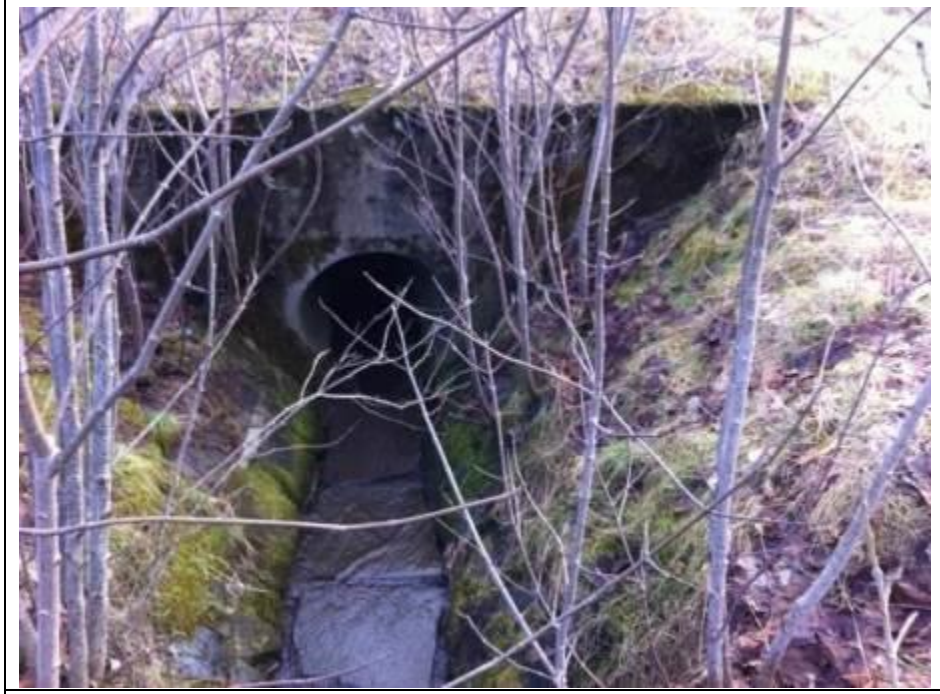
**Photograph 50**

WF117 Existing A9 culvert outlet



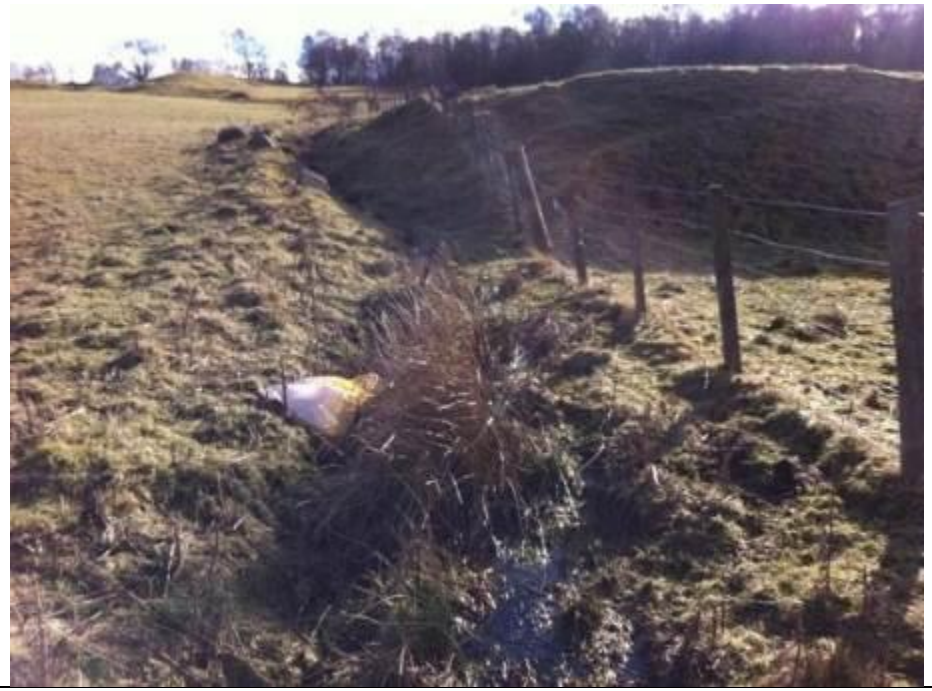
**Photograph 51**

WF117 Existing upstream channel viewed from A9 culvert inlet



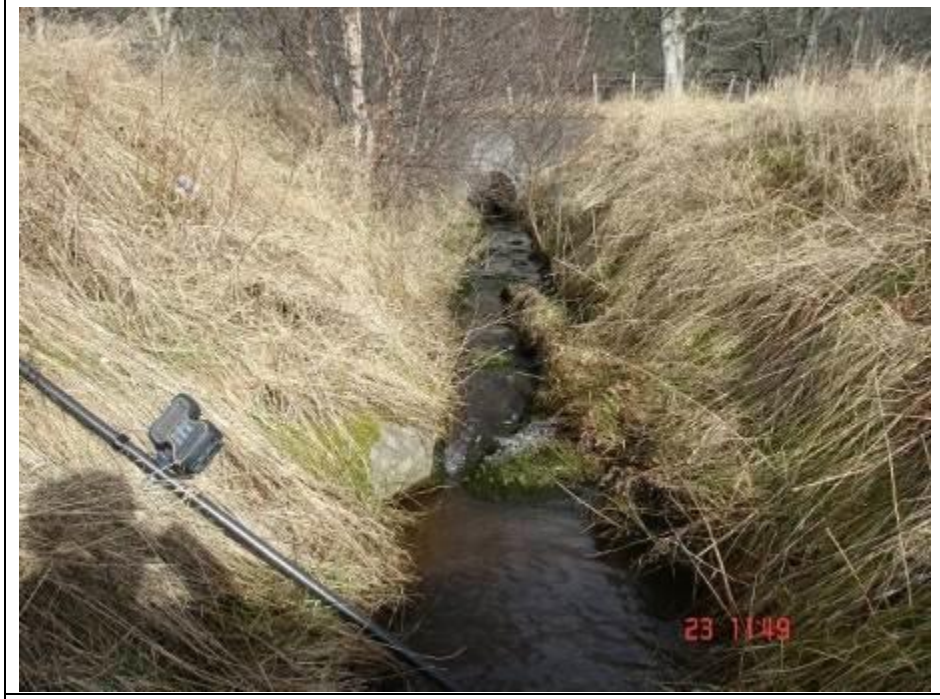
**Photograph 52**

WF118 Existing A9 culvert outlet



**Photograph 53**

WF118 Existing upstream channel viewed from A9 culvert inlet

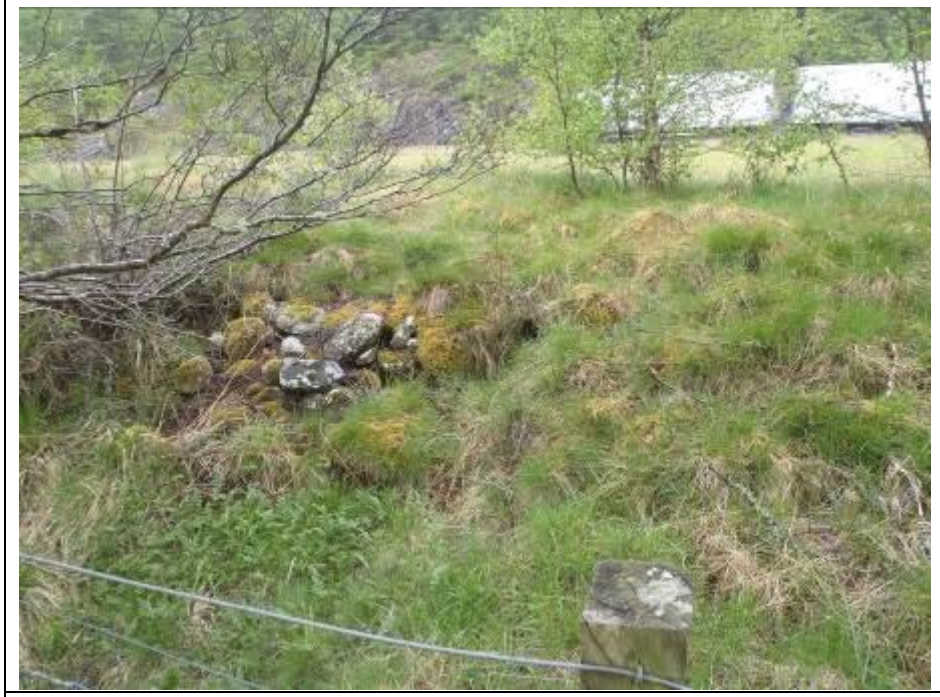


**Photograph 54**

WF119 Existing downstream channel viewed from A9 culvert outlet showing existing downstream access track culvert

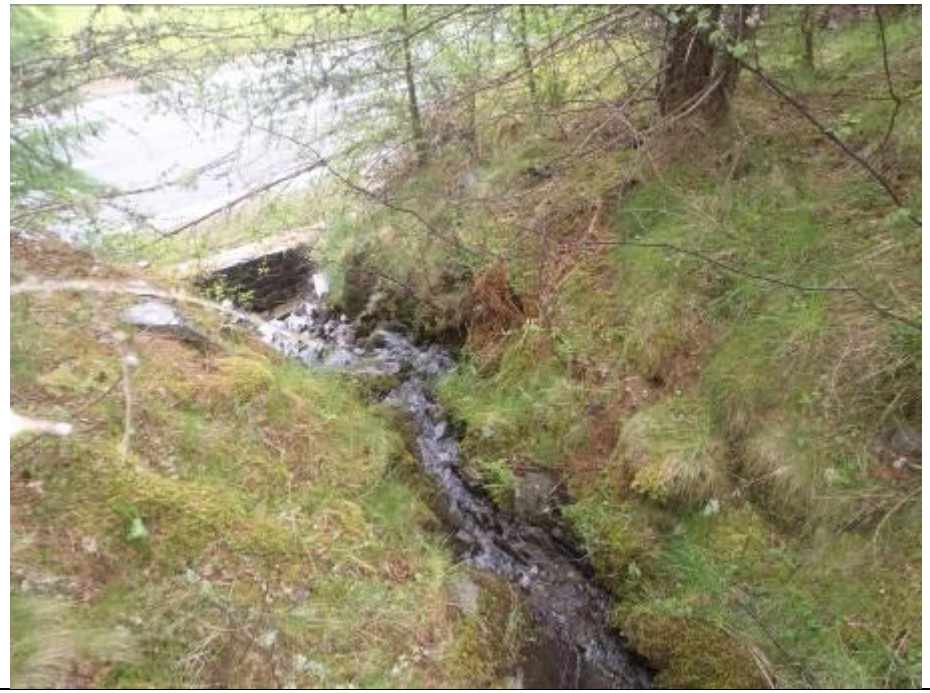
**Photograph 55**

WF119 Existing upstream channel viewed from A9 culvert inlet



**Photograph 56**

WF120 Existing A9 culvert outlet



**Photograph 57**

WF120 Existing A9 culvert inlet and upstream cascade

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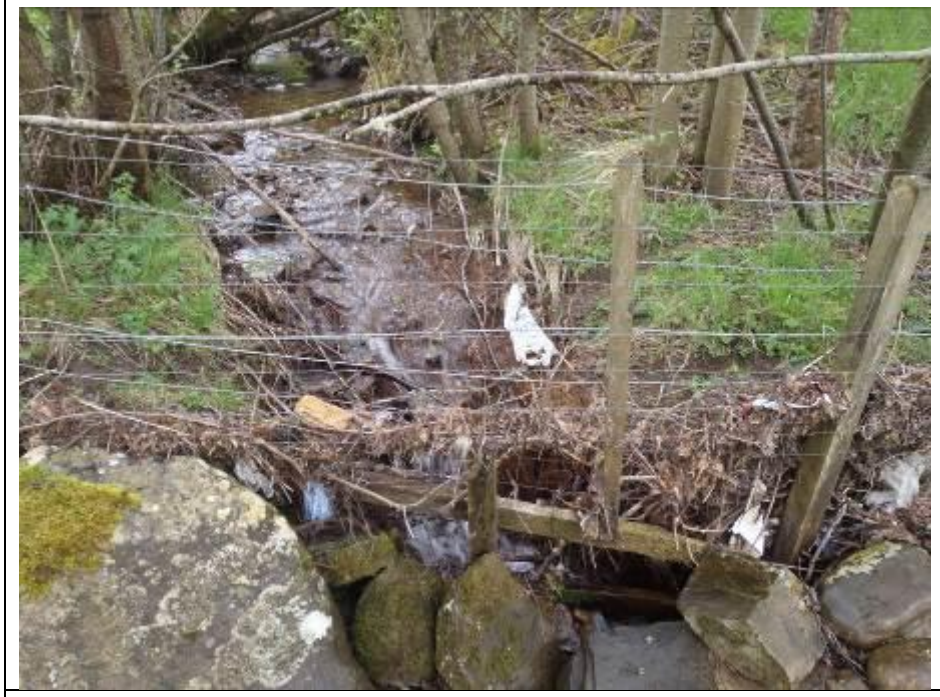
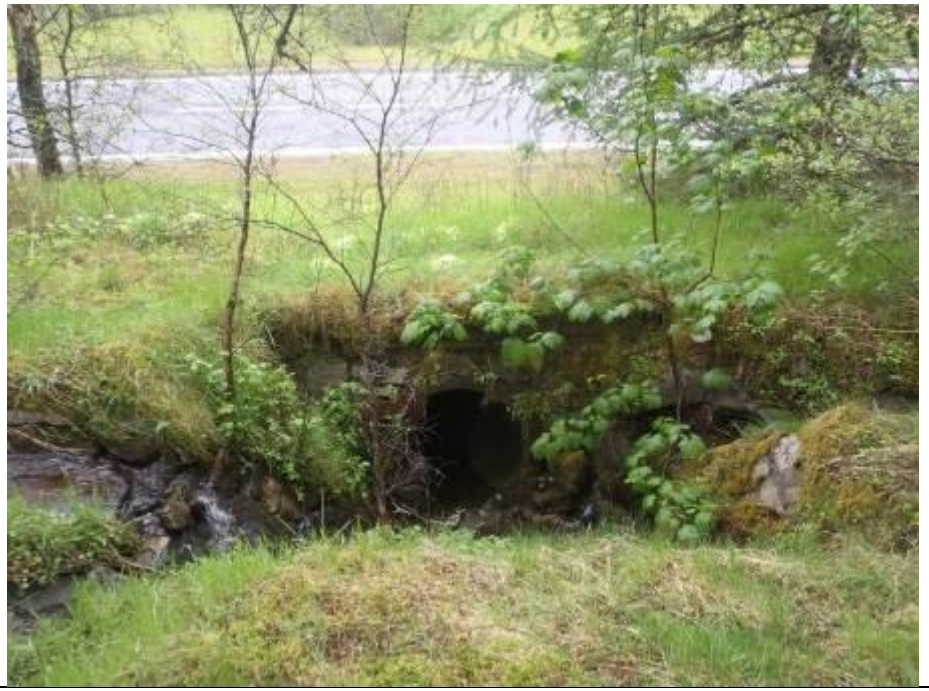
|  |  |
| **Photograph 58**<br><br>WF121 Existing downstream channel | **Photograph 59**<br><br>WF121 Existing A9 culvert inlet and upstream channel |

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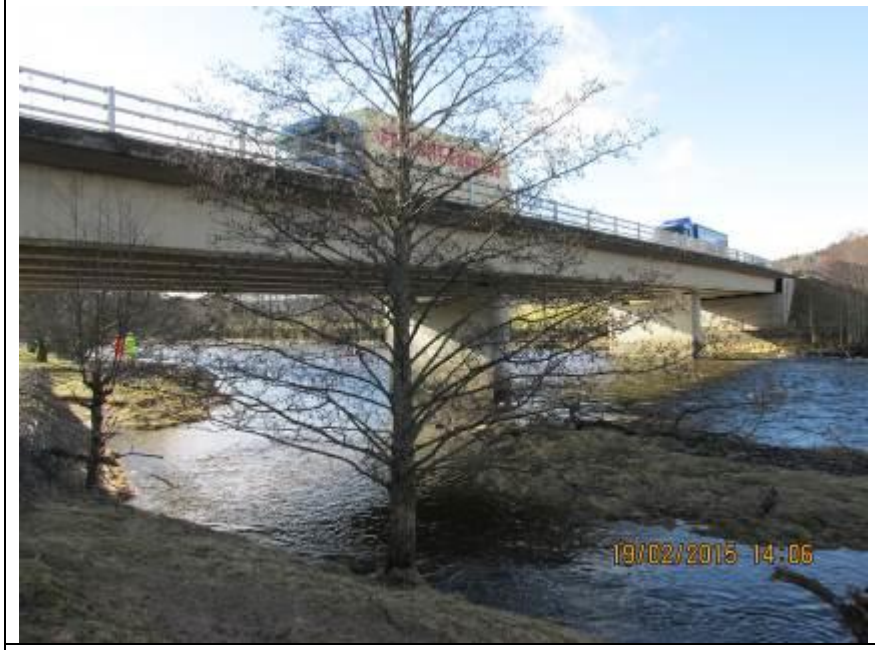
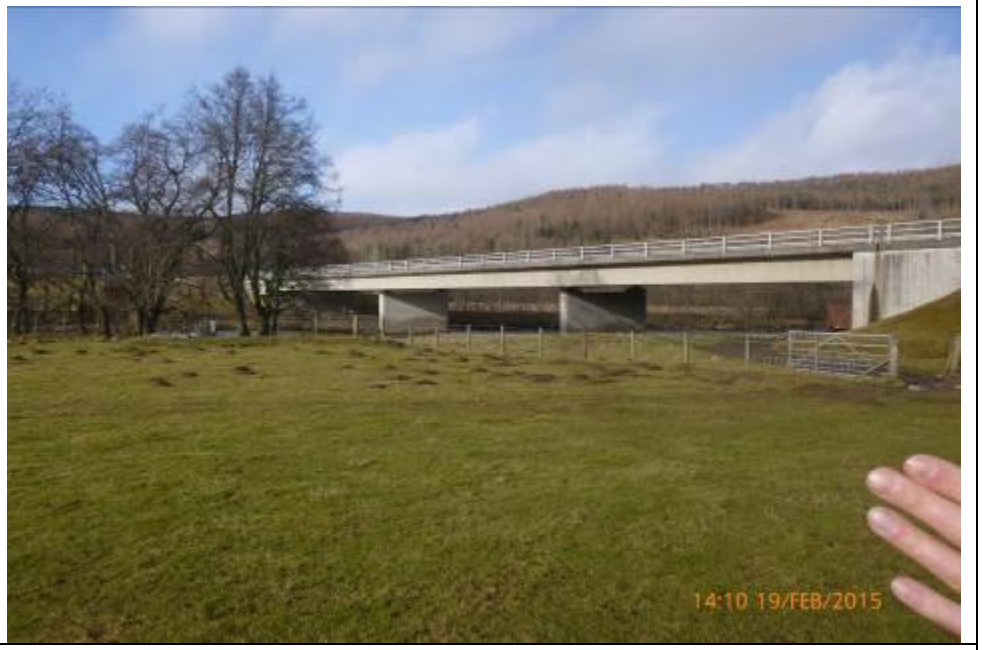
| (No image currently available) | (No image currently available) |
| **Photograph 60**<br><br>WF122 Existing A9 culvert outlet and downstream channel | **Photograph 61**<br><br>WF122 Existing A9 culvert inlet and upstream channel |



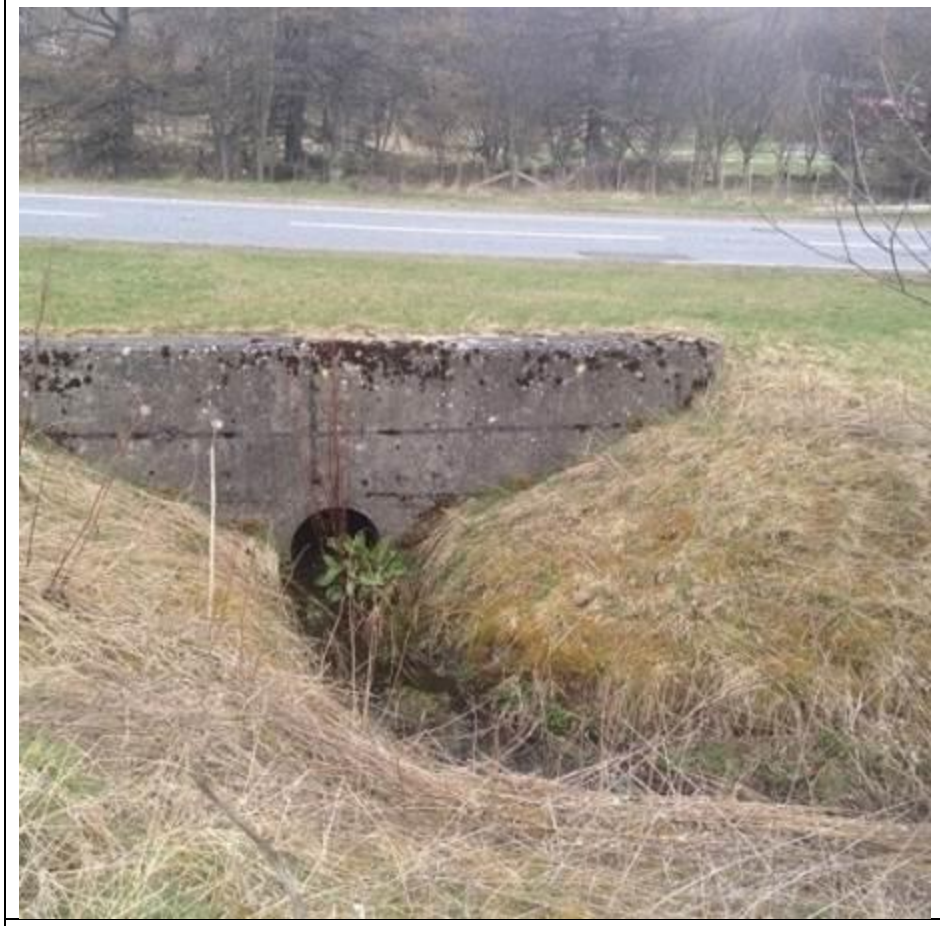

**Photograph 62**

WF100 Existing A9 Pitagowan bridge over River Garry – upstream view



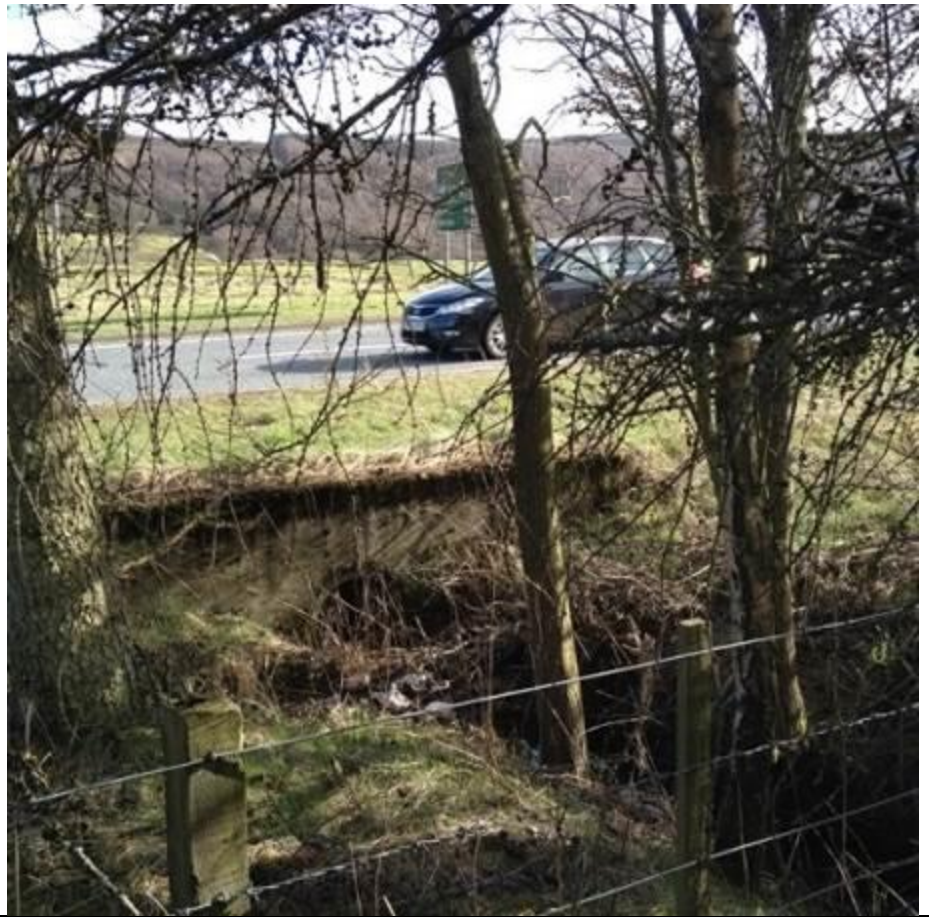

**Photograph 63**

WF100 Existing A9 Pitagowan bridge over River Garry



**Photograph 64**

WF125 Existing A9 culvert outlet and downstream channel



**Photograph 65**

WF125 Existing A9 culvert inlet and upstream channel

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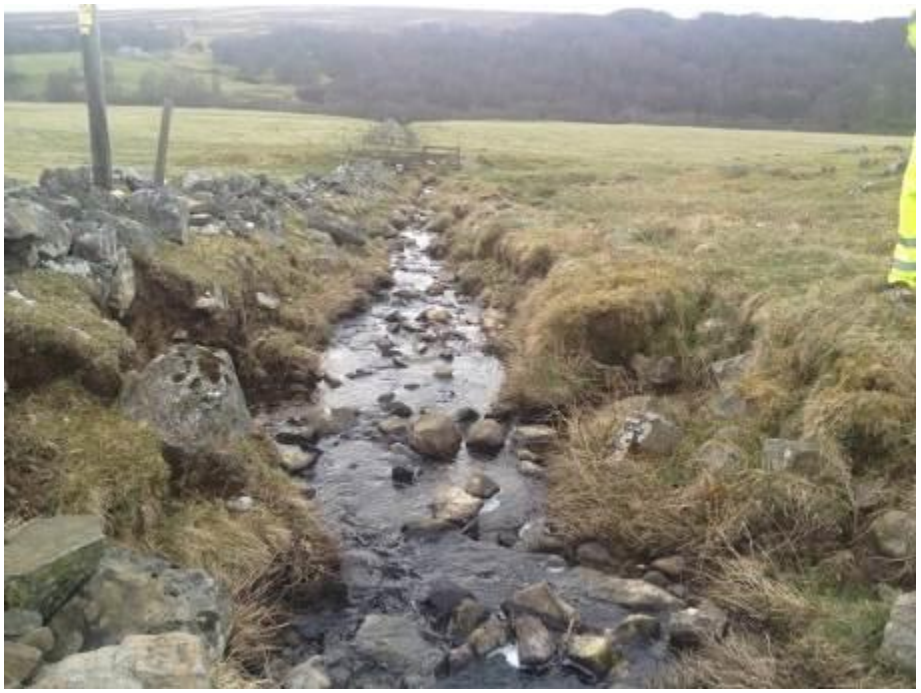
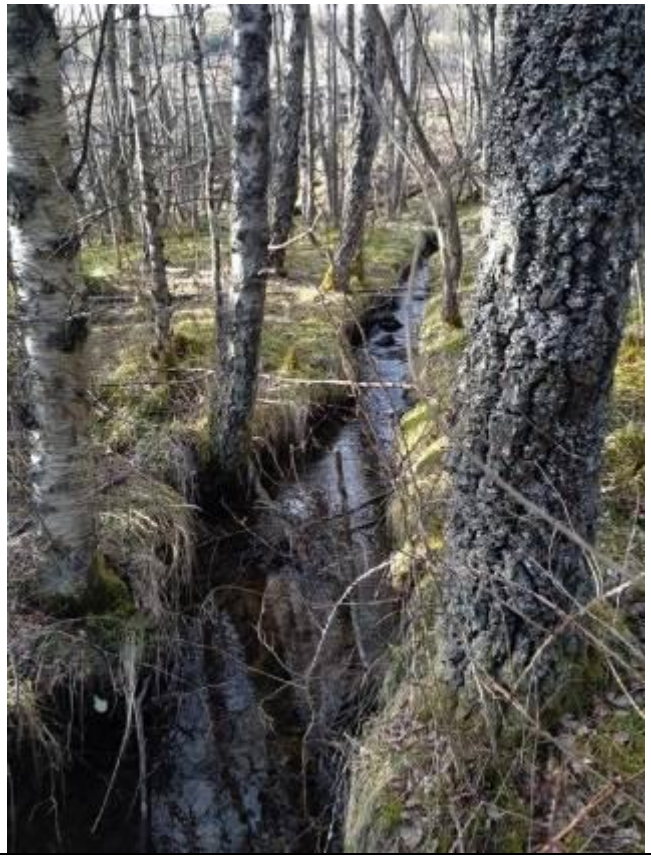
|  |  |
| **Photograph 66**<br><br>WF127 Existing downstream channel viewed from A9 culvert outlet | **Photograph 67**<br><br>WF127 Existing upstream channel |

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|  | (No image currently available) |
| **Photograph 68**<br><br>WF128 Existing A9 culvert outlet and downstream channel | **Photograph 69**<br><br>WF128 Existing A9 culvert inlet and upstream channel |

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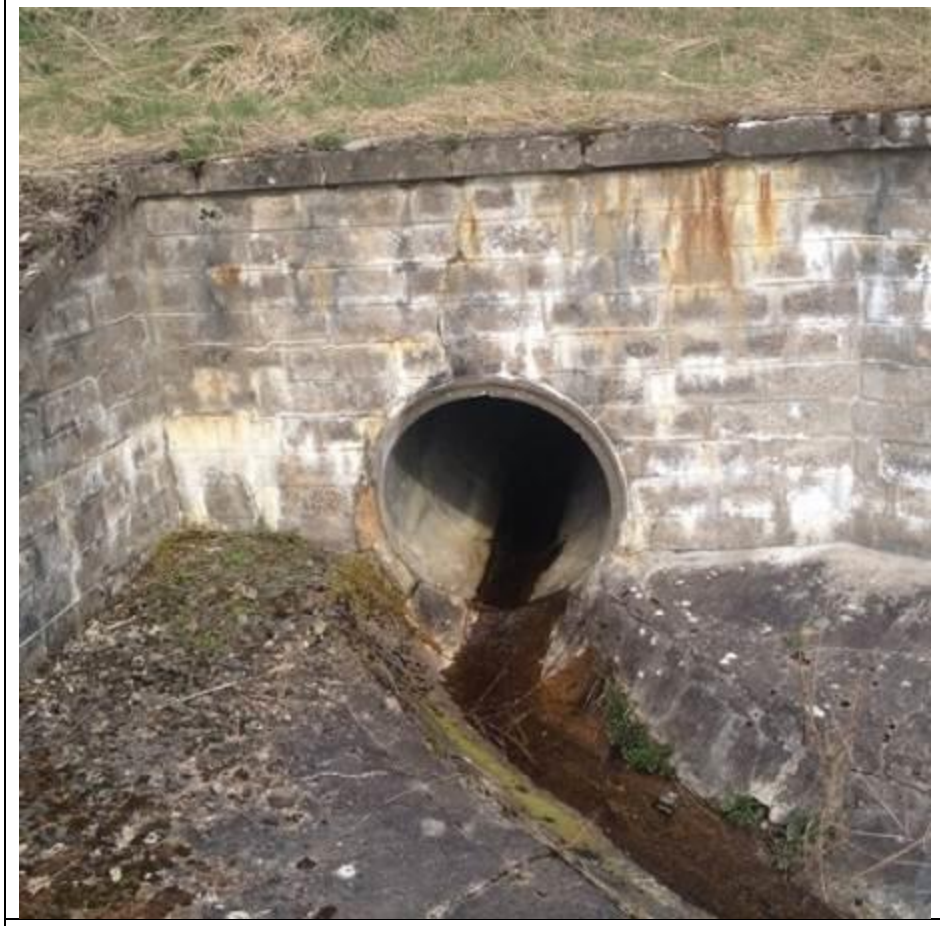
|  | (No image currently available) |
| **Photograph 70**<br><br>WF129 Existing A9 and rail culvert outlet and chamber | **Photograph 71**<br><br>WF129 Existing A9 culvert inlet and upstream channel |

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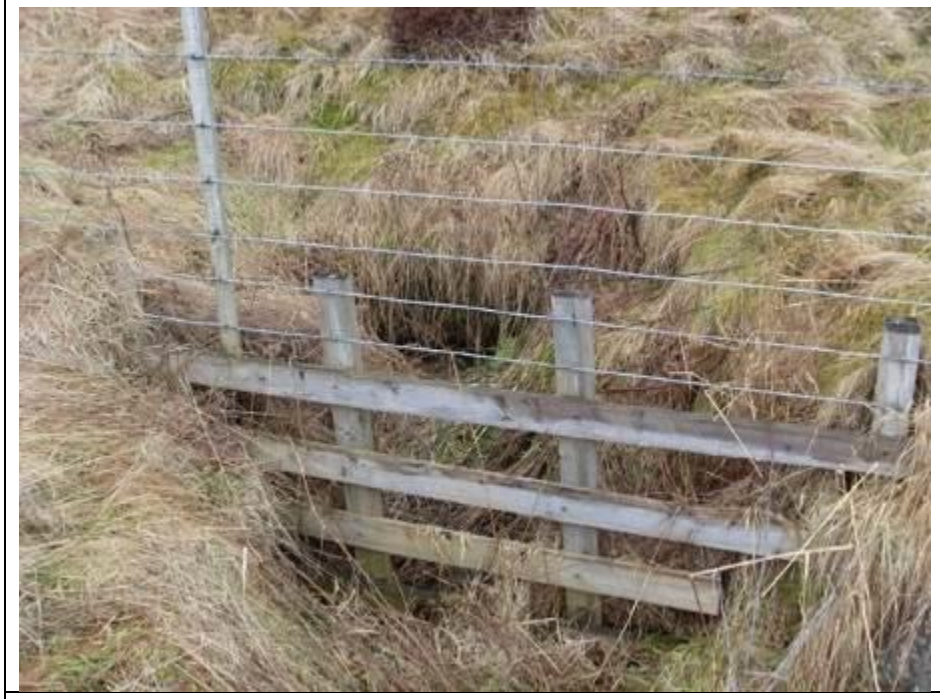
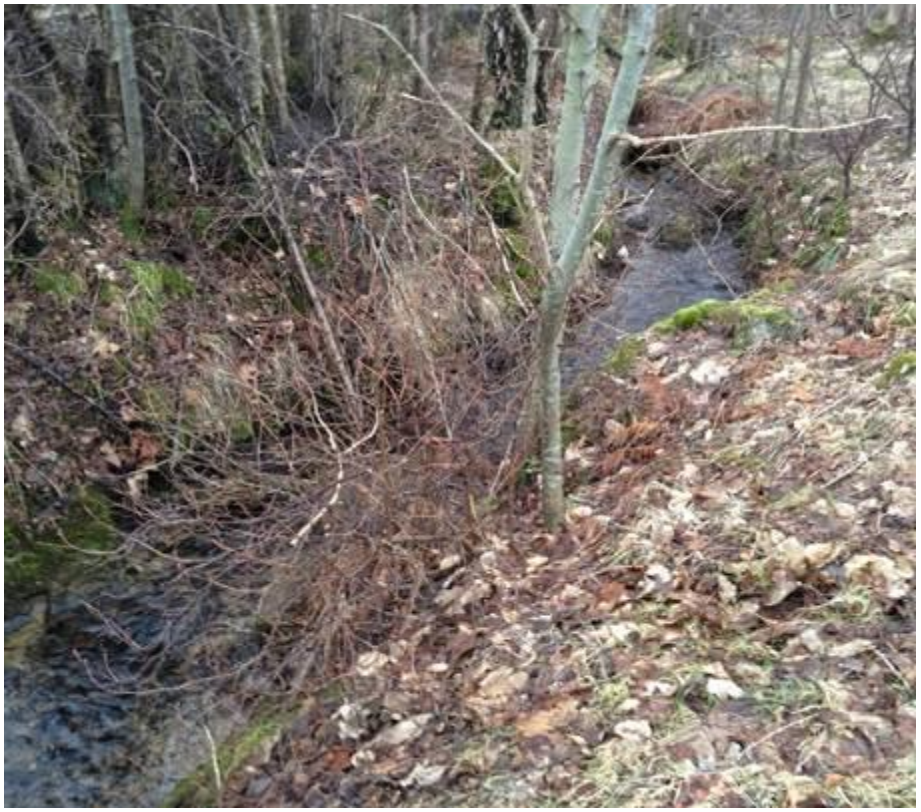
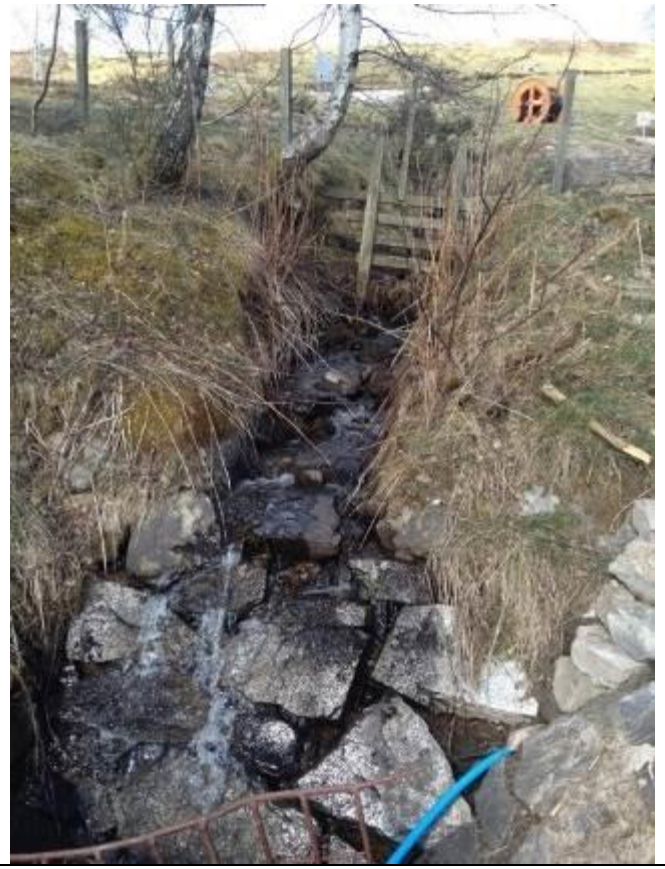
|  | (No image currently available) |
| **Photograph 72**<br><br>WF131 Existing A9 semi-buried culvert outlet | **Photograph 73**<br><br>WF131 Existing A9 culvert inlet and upstream channel |



**Photograph 74**

WF132 Existing A9 culvert outlet and downstream channel



**Photograph 75**

WF132 Existing upstream channel viewed from A9 culvert inlet

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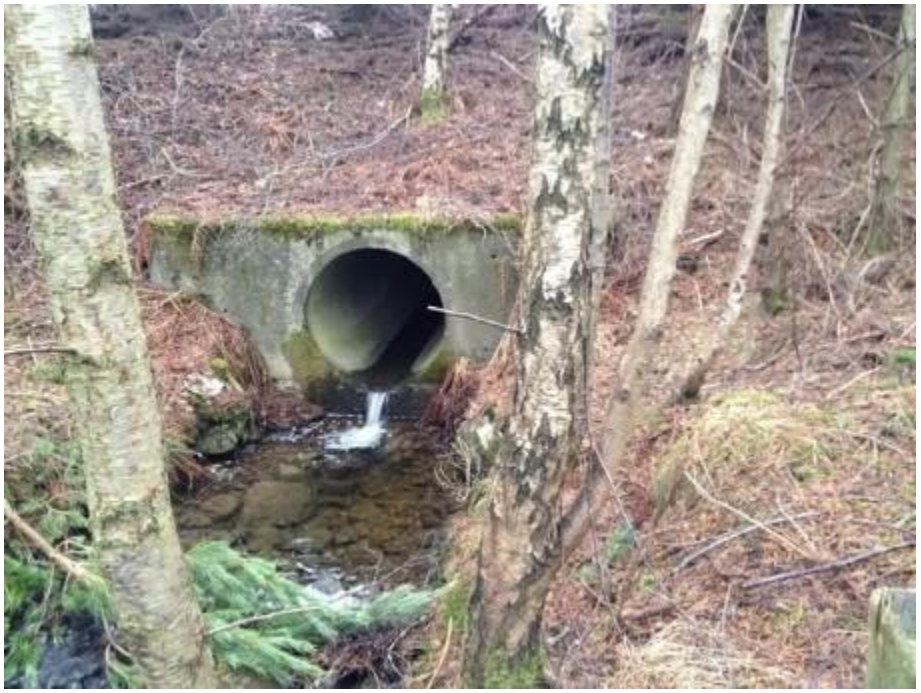
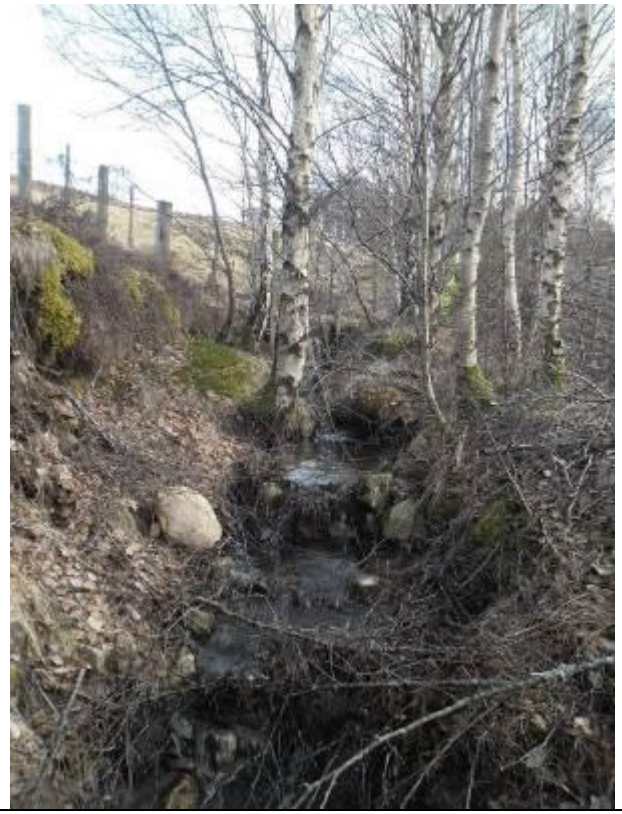
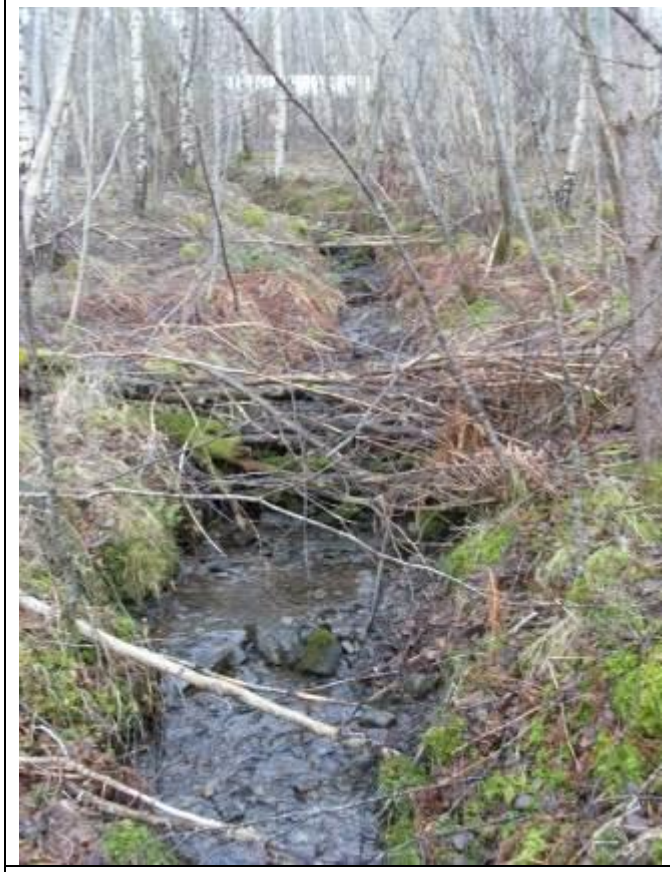
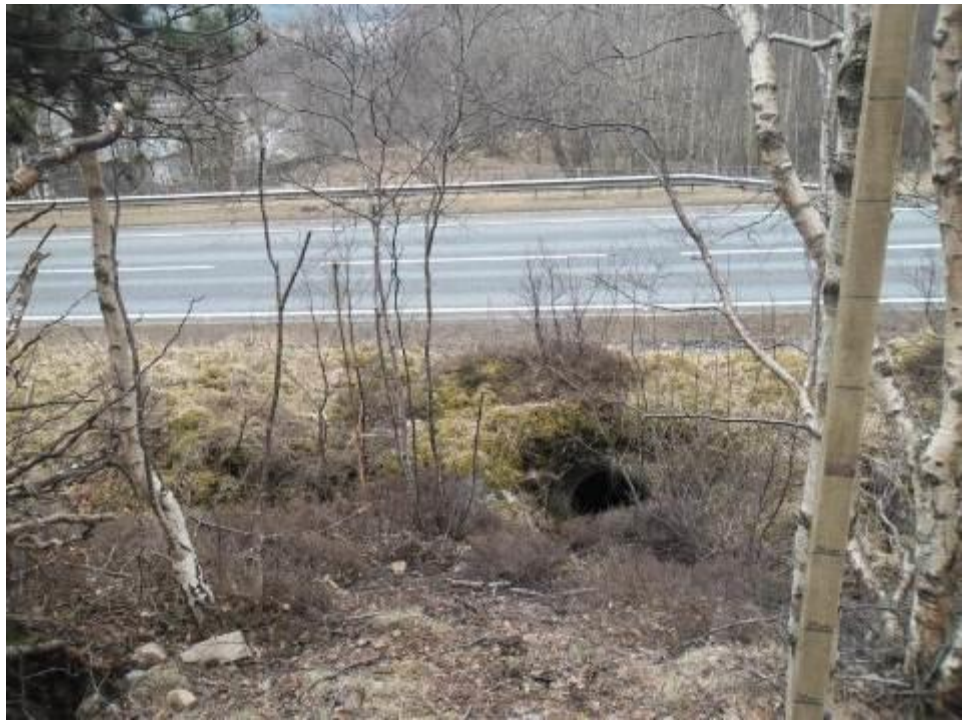
|  |  |
| **Photograph 76**<br><br>WF134 Existing A9 culvert outlet and downstream channel | **Photograph 77**<br><br>WF134 Existing A9 culvert inlet and upstream channel |



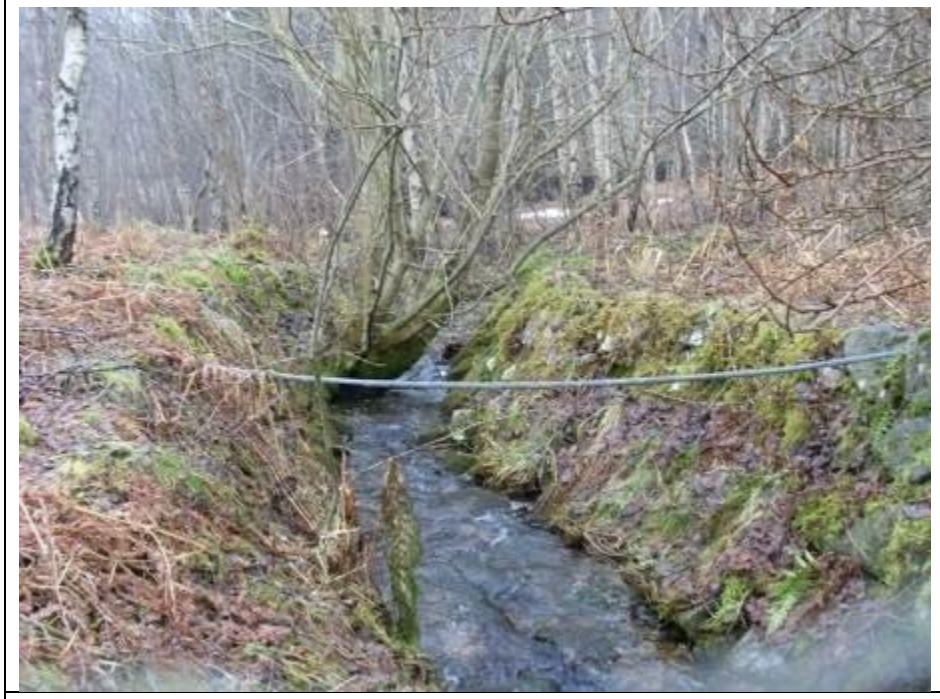
**Photograph 78**

WF136 Existing downstream channel



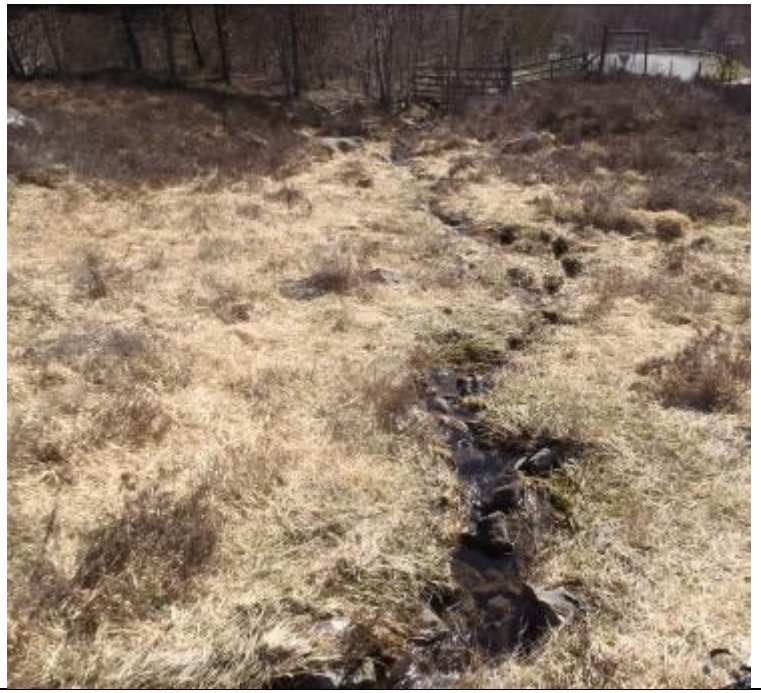
**Photograph 79**

WF136 Existing A9 culvert inlet and upstream channel



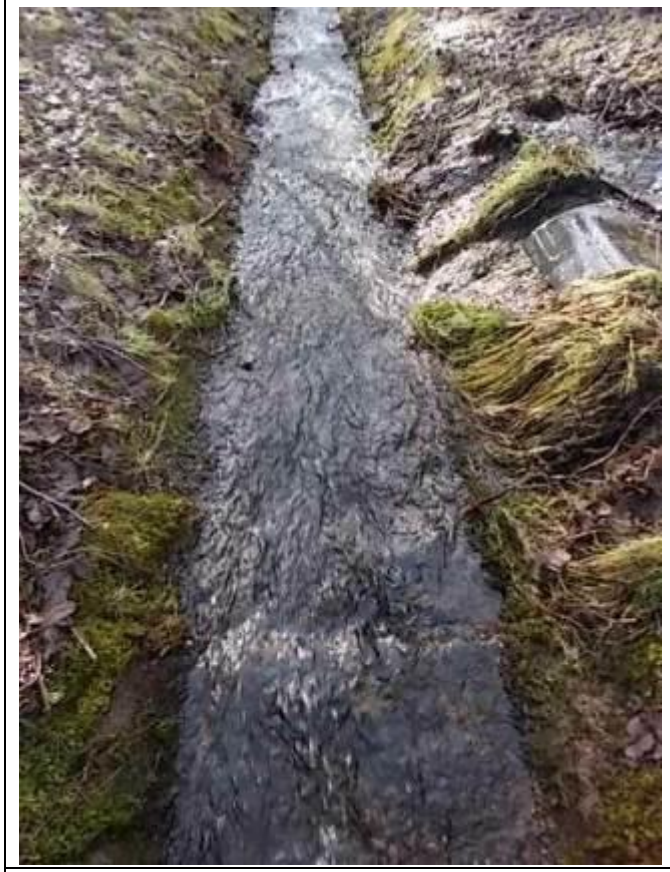
**Photograph 80**

WF137 Existing A9 culvert outlet and downstream channel



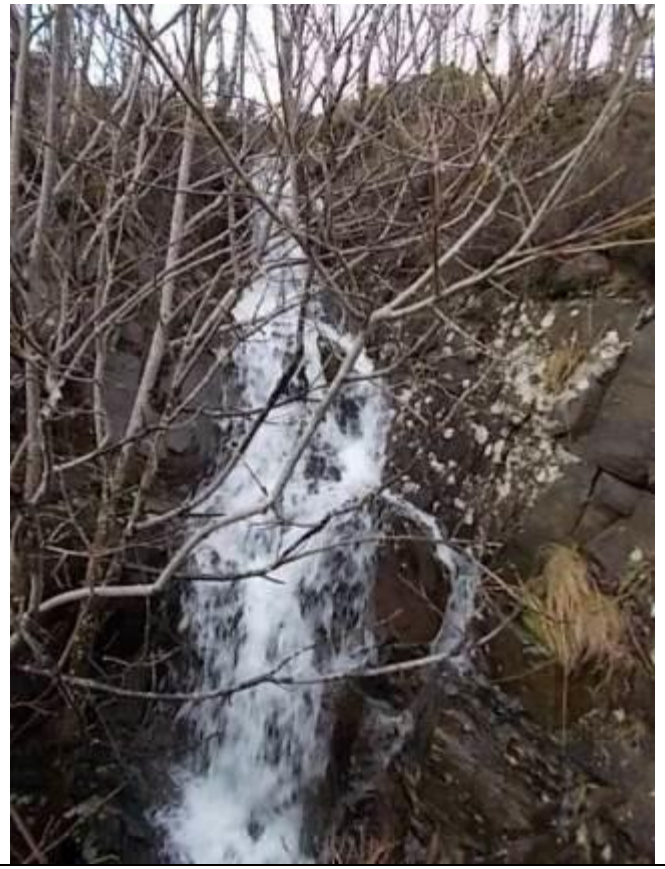
**Photograph 81**

WF137 Existing A9 culvert inlet and upstream channel



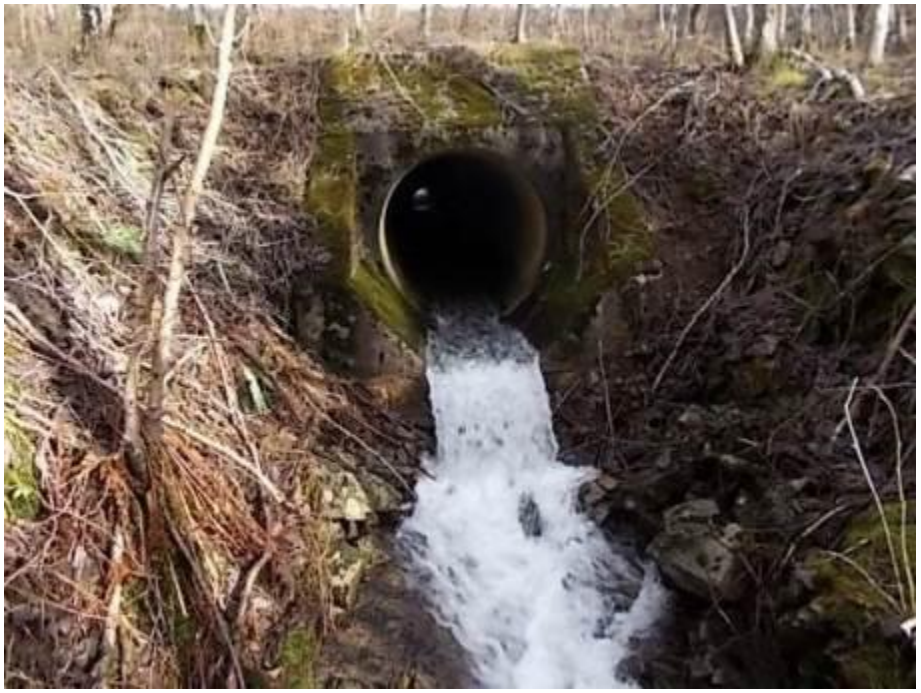
**Photograph 82**

WF139 Existing downstream channel viewed from A9 culvert outlet



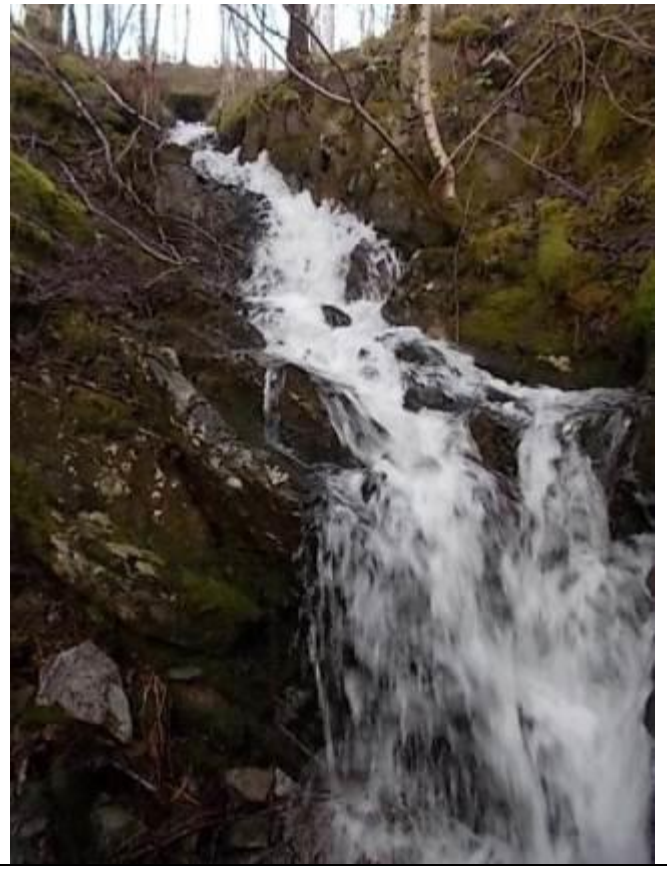
**Photograph 83**

WF139 Existing cascade upstream of A9 culvert inlet



**Photograph 84**

WF140 Existing A9 culvert outlet and downstream channel



**Photograph 85**

WF140 Existing cascade upstream of A9 culvert inlet

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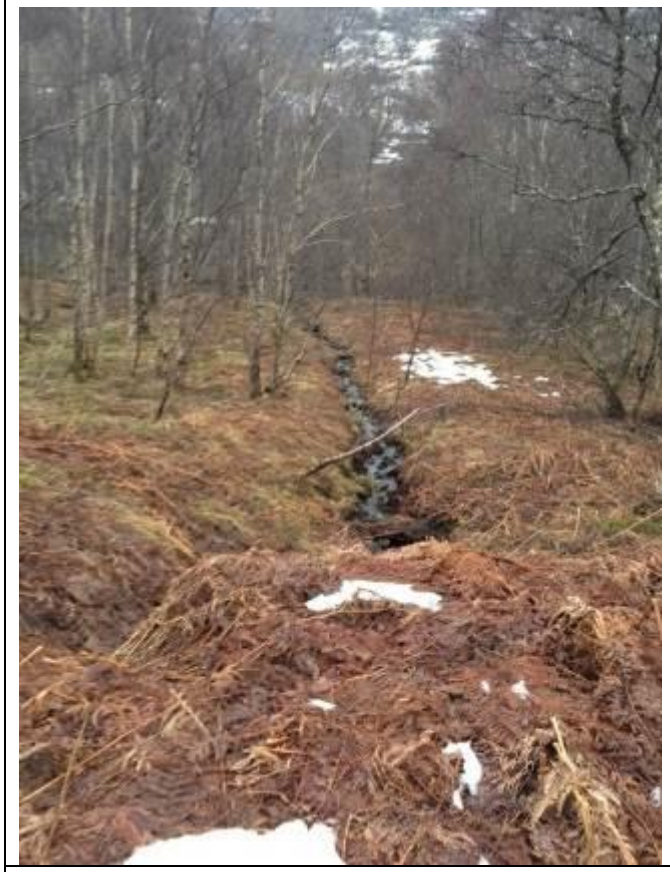
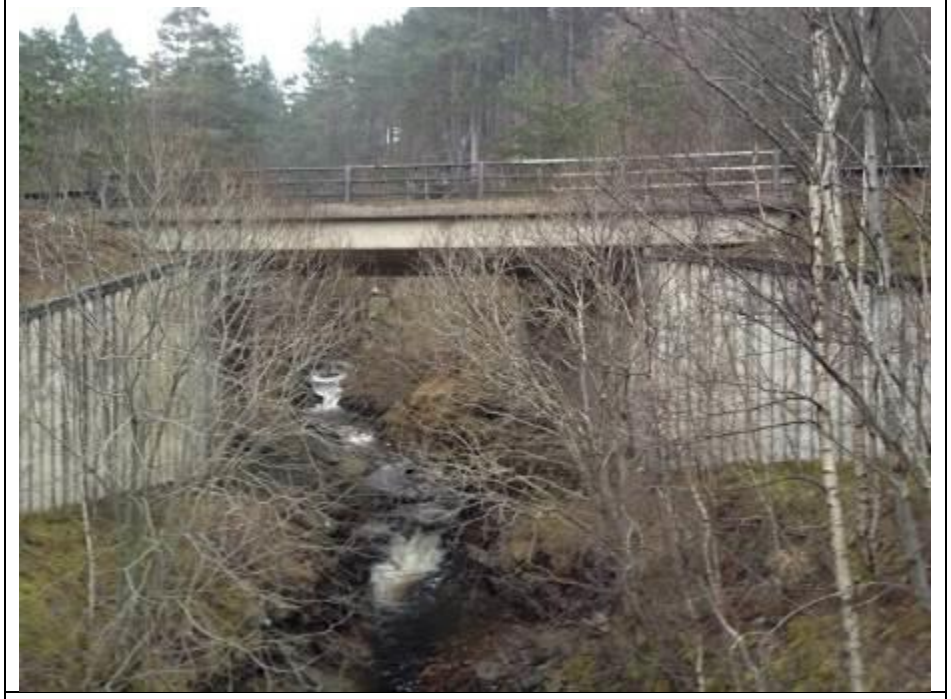
|  | (No image currently available) |
| **Photograph 86**<br><br>WF141 Existing downstream channel viewed from A9 culvert outlet | **Photograph 87**<br><br>WF141 Existing A9 culvert inlet and upstream channel |



**Photograph 88**

WF142 Existing bridge structure looking upstream

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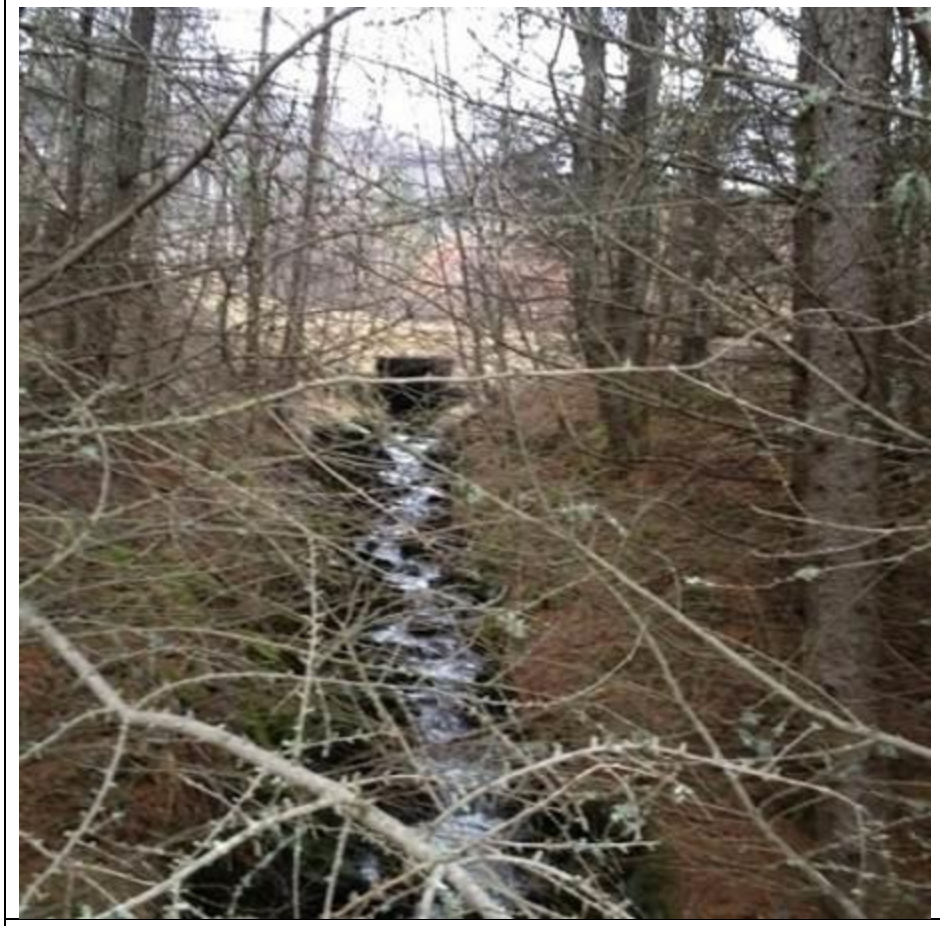
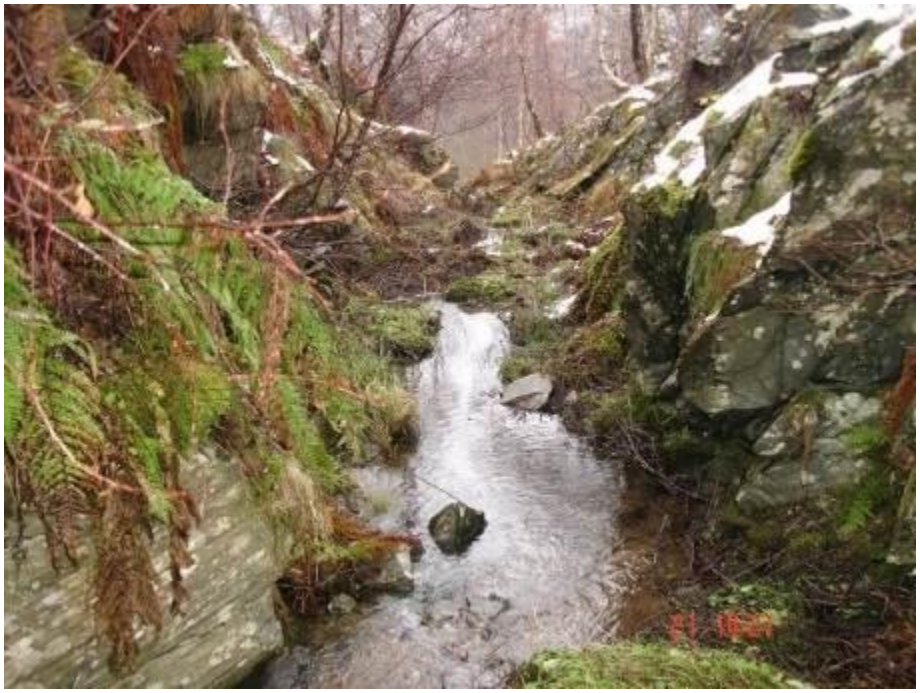
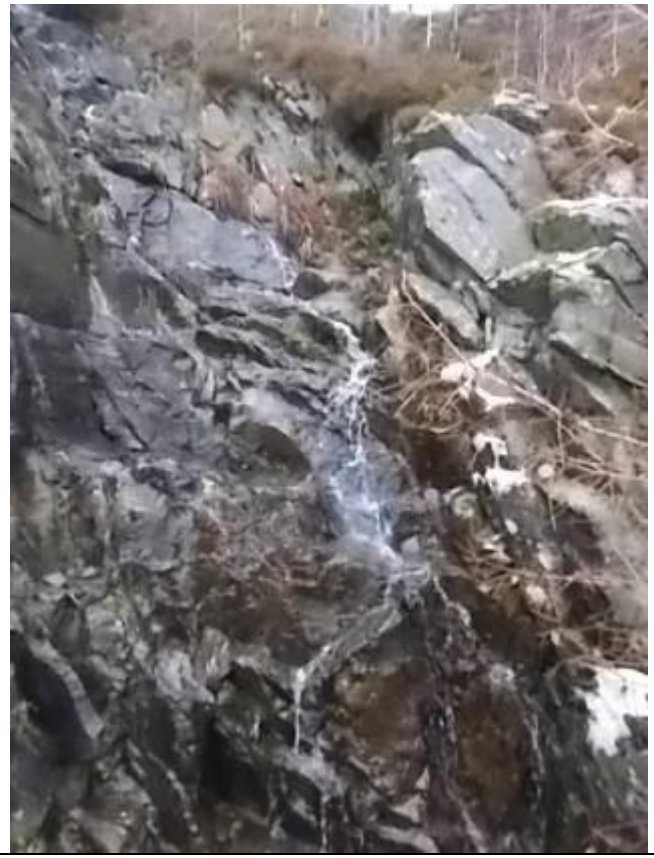
|  | (No image currently available) |
| **Photograph 89**<br><br>WF143 Existing A9 culvert outlet and downstream channel | **Photograph 90**<br><br>WF143 Existing A9 culvert inlet and upstream channel |



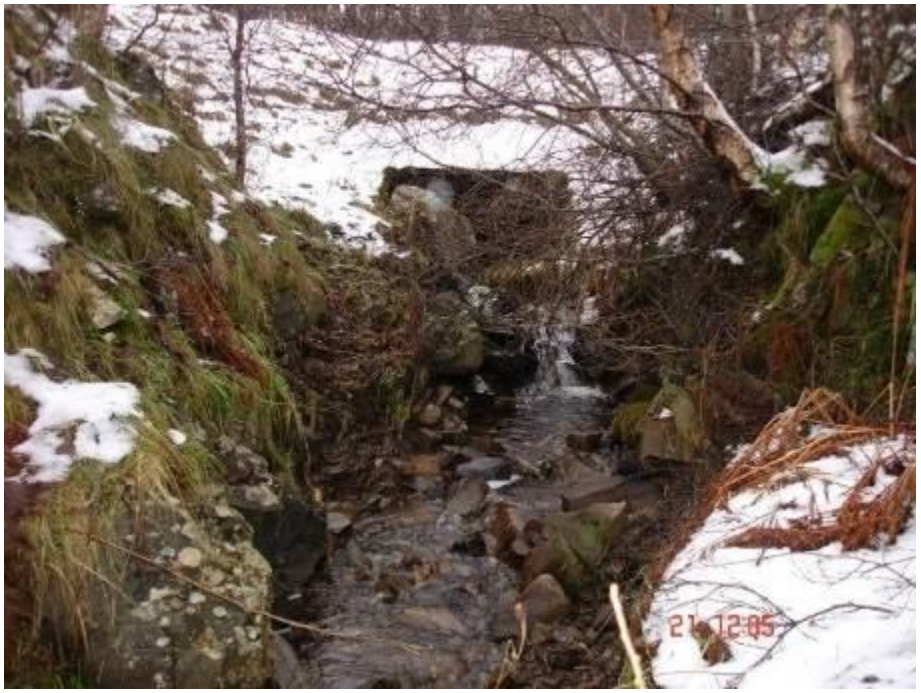
**Photograph 91**

WF144 Existing downstream channel viewed from A9 culvert outlet



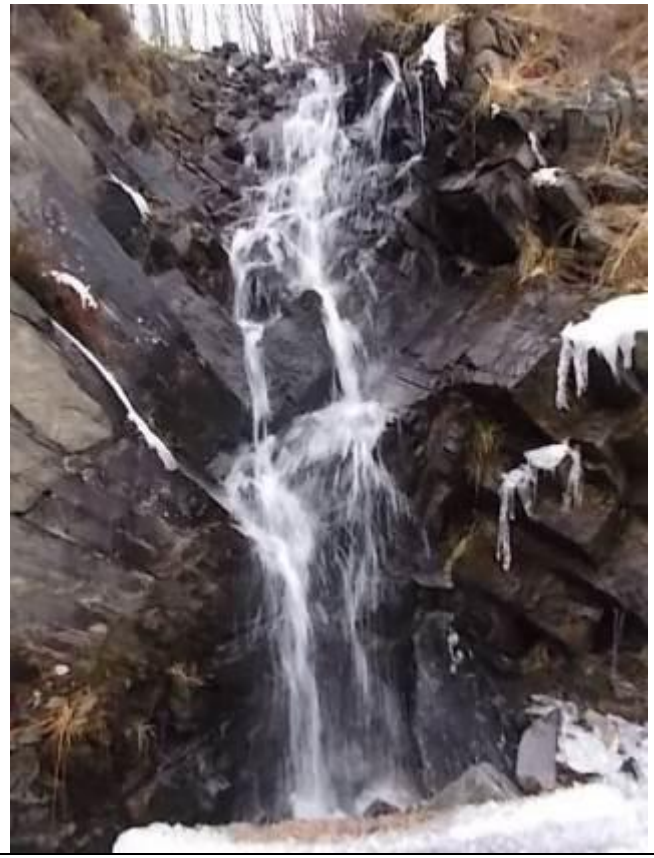
**Photograph 92**

WF144 Existing cascade at A9 culvert inlet



**Photograph 93**

WF145 Existing A9 culvert outlet and downstream channel



**Photograph 94**

WF145 Existing cascade at A9 culvert inlet

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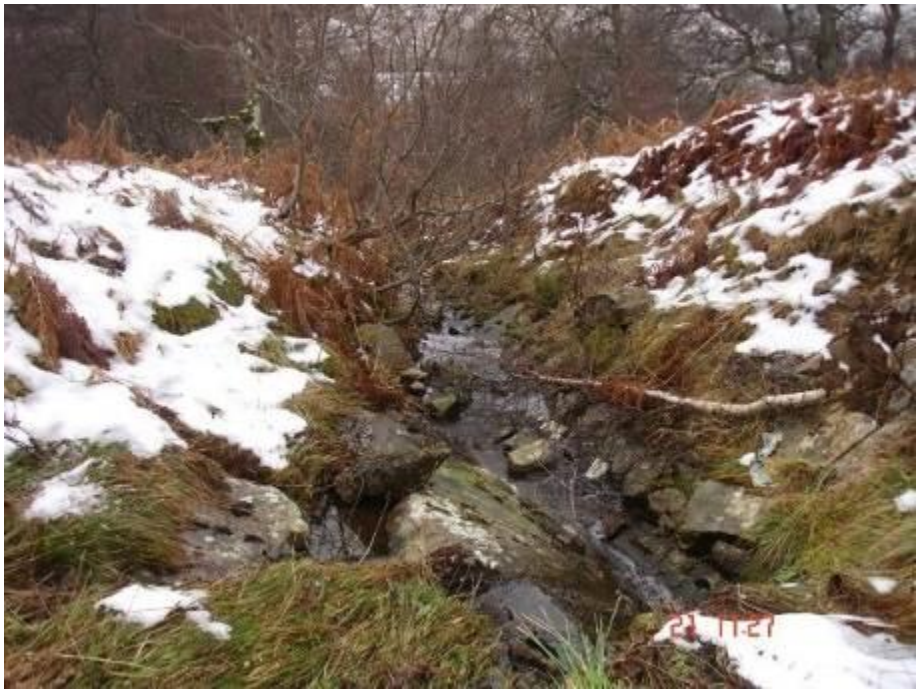
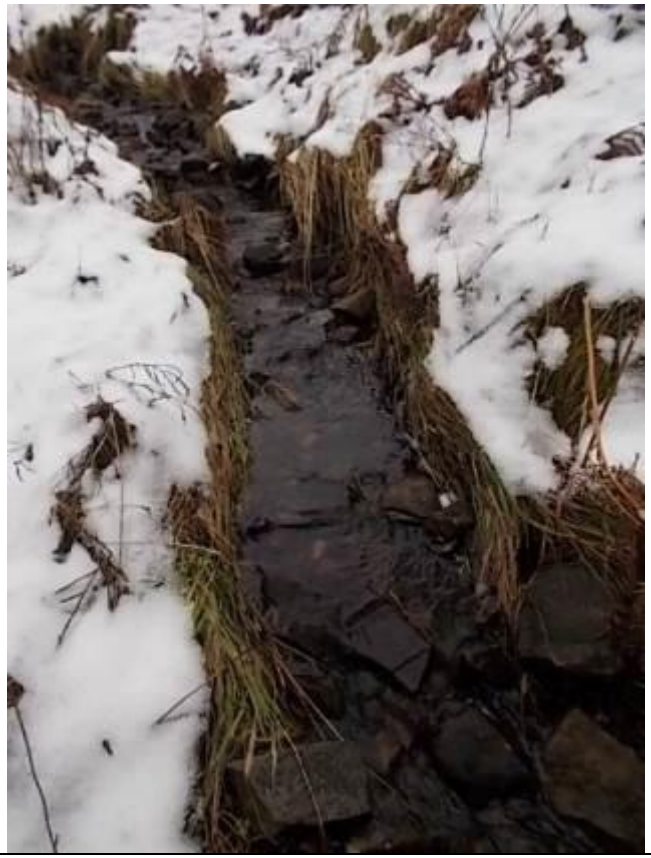
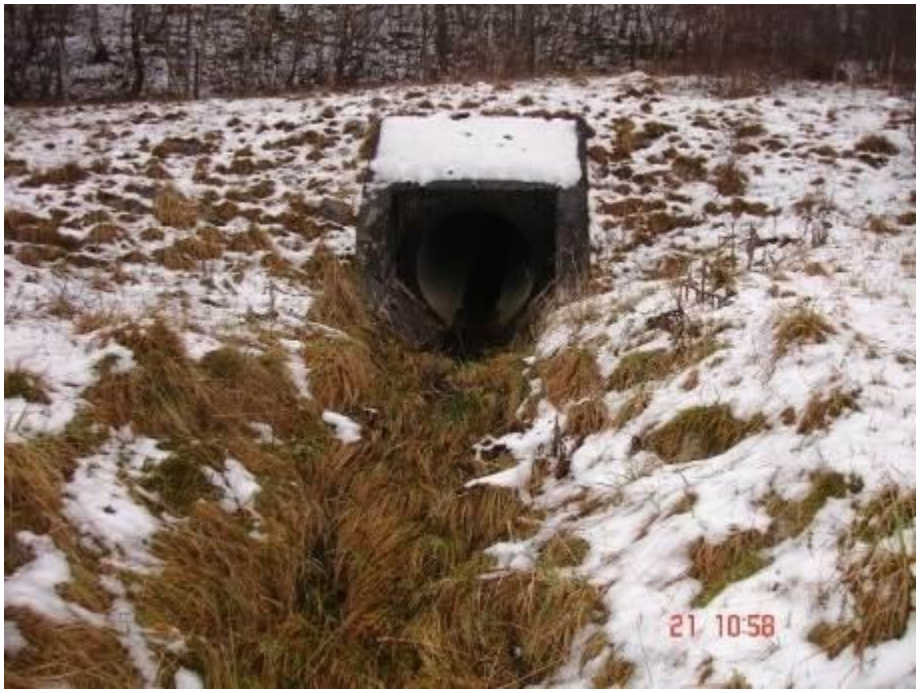
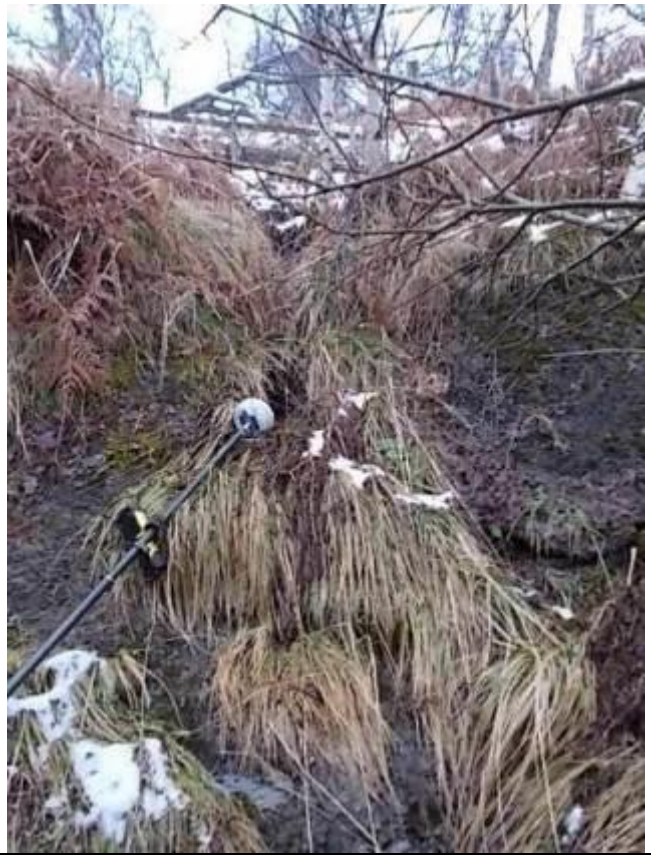
|  |  |
| **Photograph 95**<br><br>WF147 Existing downstream channel viewed from A9 culvert outlet | **Photograph 96**<br><br>WF147 Existing upstream channel |




**Photograph 97**

WF148 Existing A9 culvert outlet and downstream channel



**Photograph 98**

WF148 Existing upstream channel viewed from A9 culvert inlet

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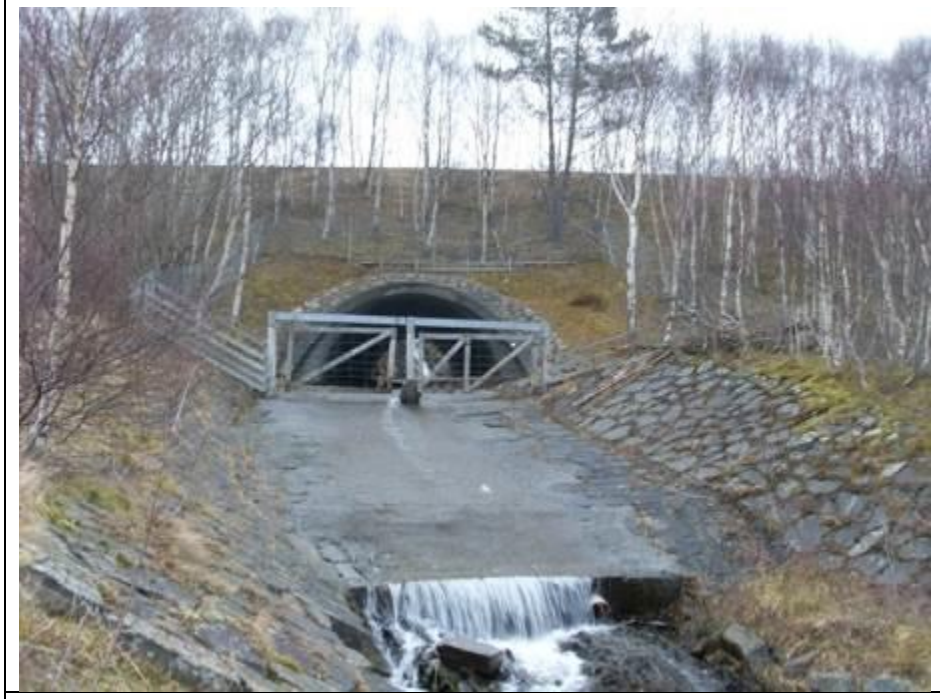
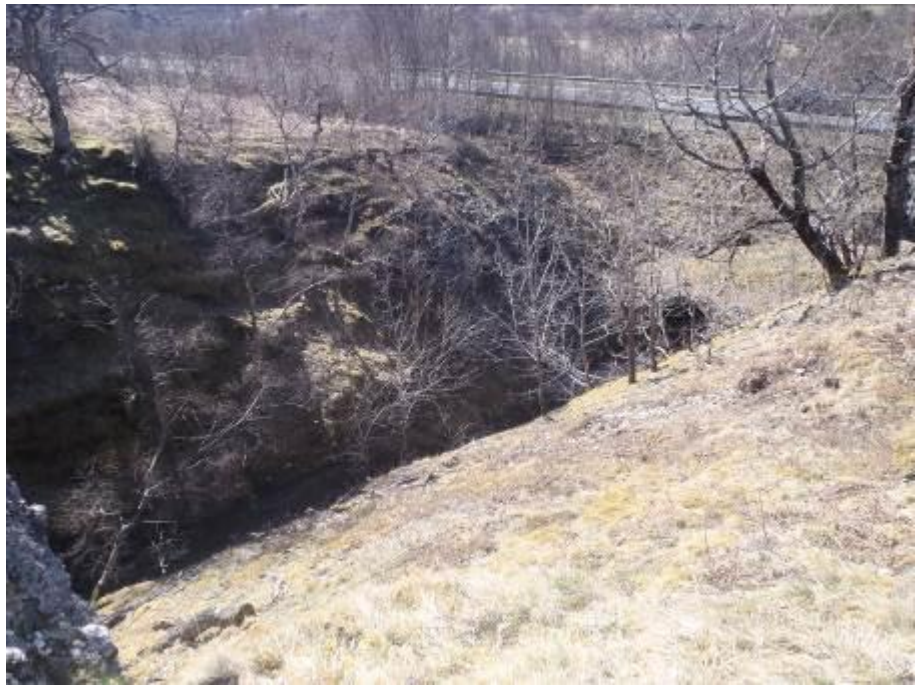
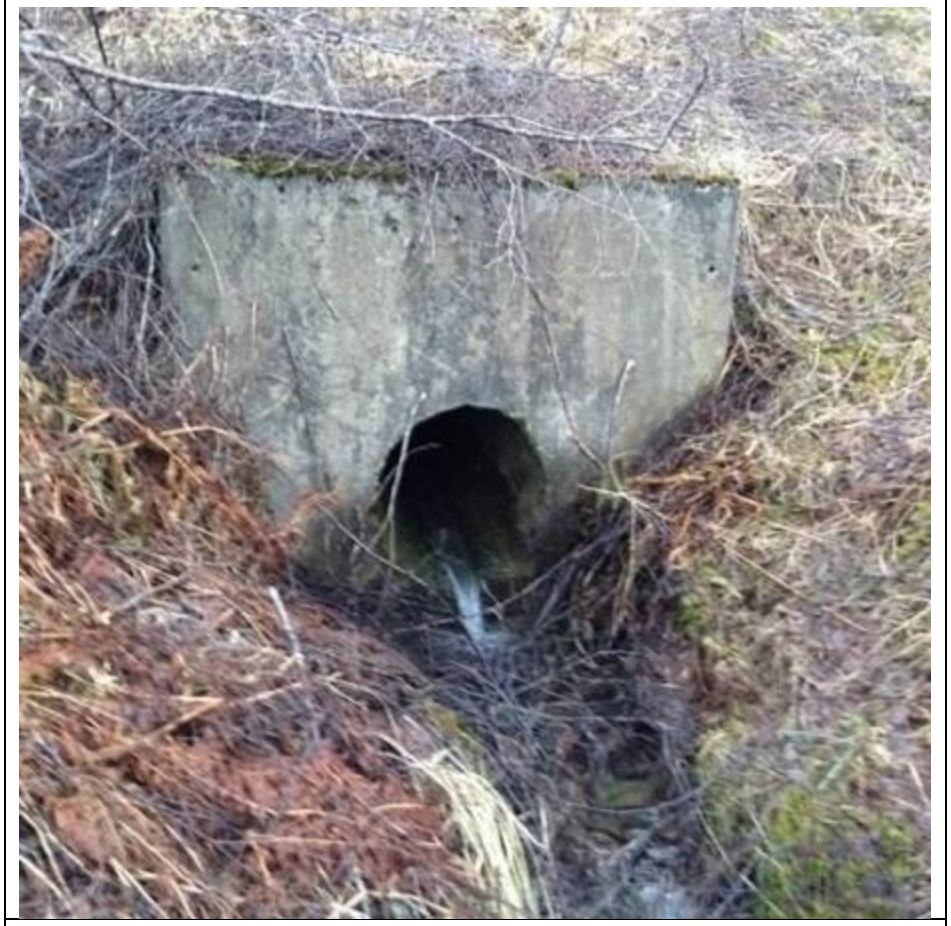
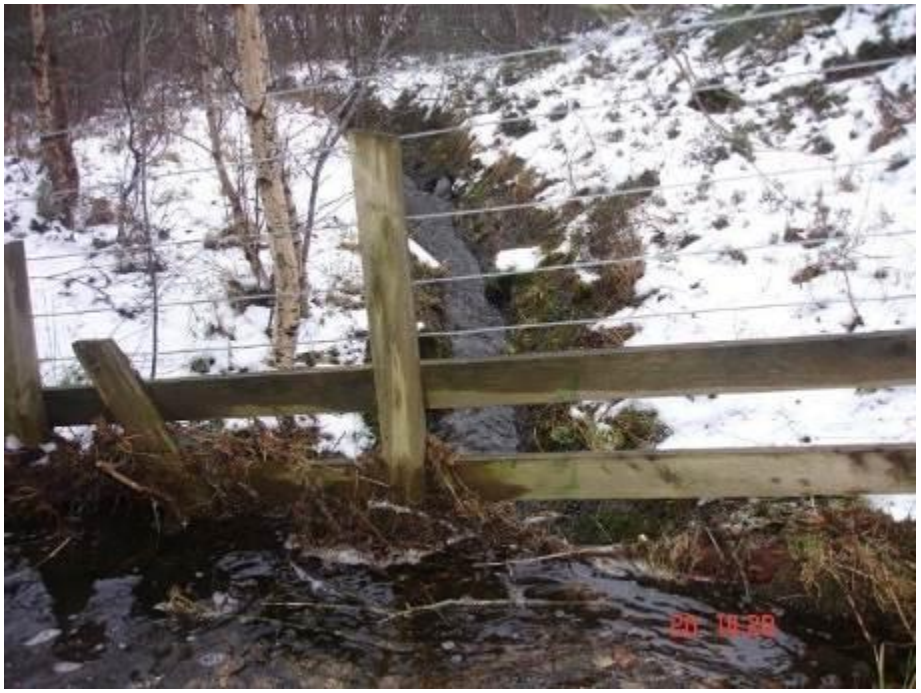
|  |  |
| **Photograph 99**<br><br>WF149 Existing A9 structure outlet and downstream channel | **Photograph 100**<br><br>WF149 Existing A9 culvert inlet and upstream channel |



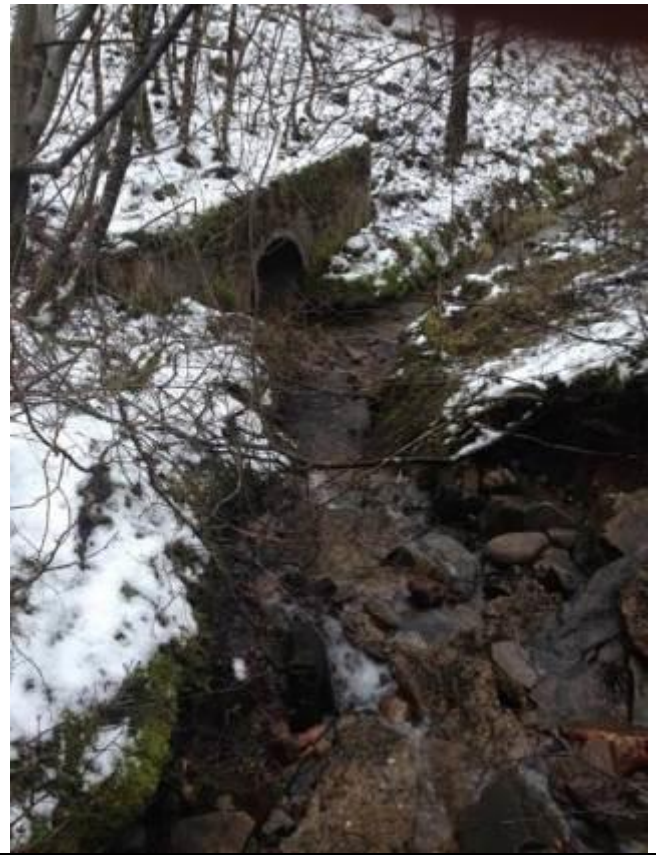
**Photograph 101**

WF150 Existing A9 pipe outlet



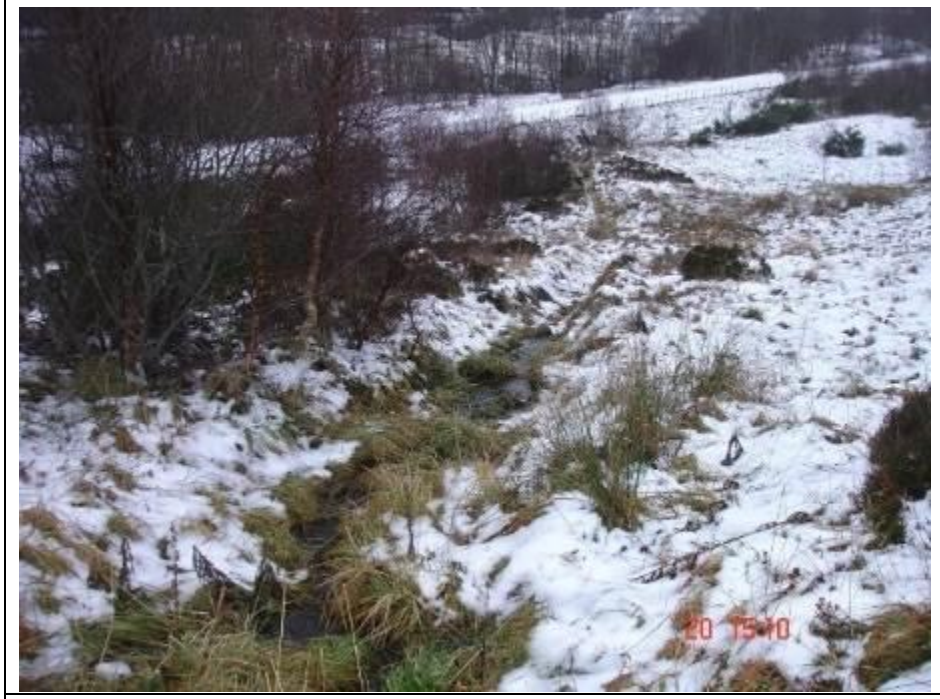
**Photograph 102**

WF151 Existing downstream channel viewed from A9 culvert outlet



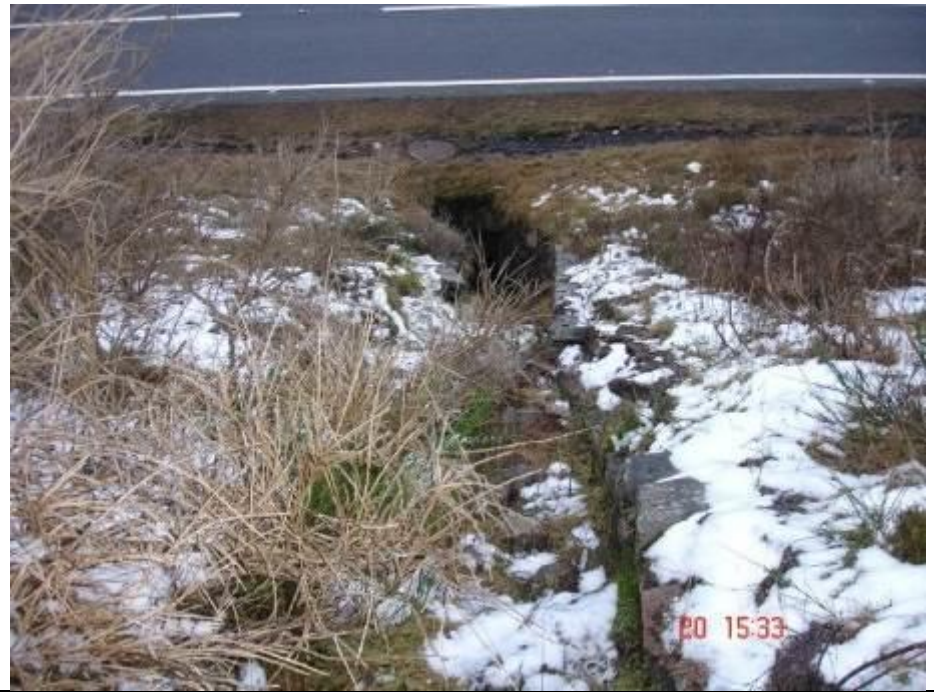
**Photograph 103**

WF151 Existing A9 culvert inlet and upstream channel



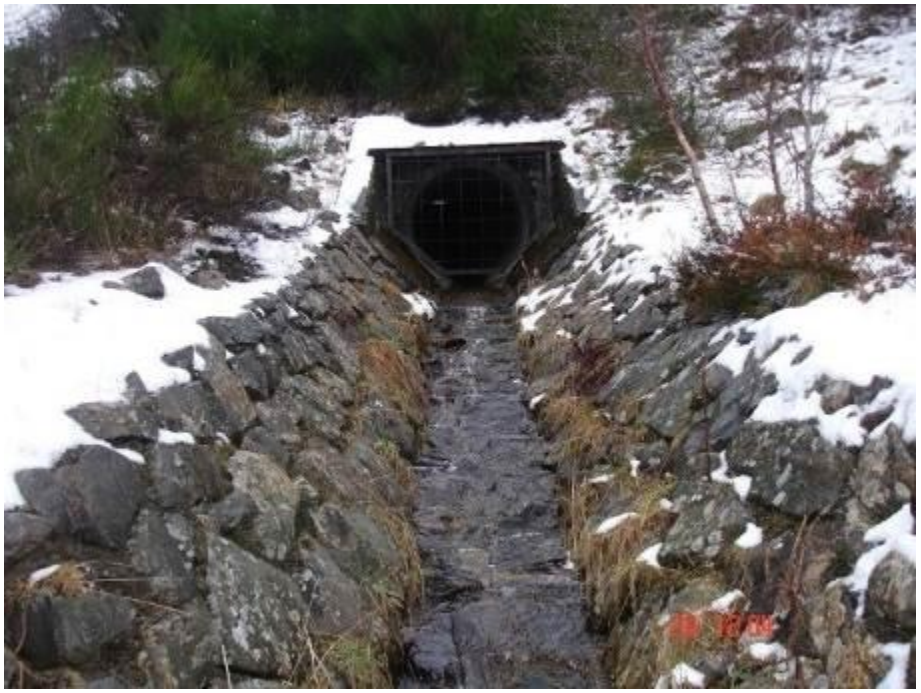
**Photograph 104**

WF152 Existing downstream channel viewed from A9 culvert outlet



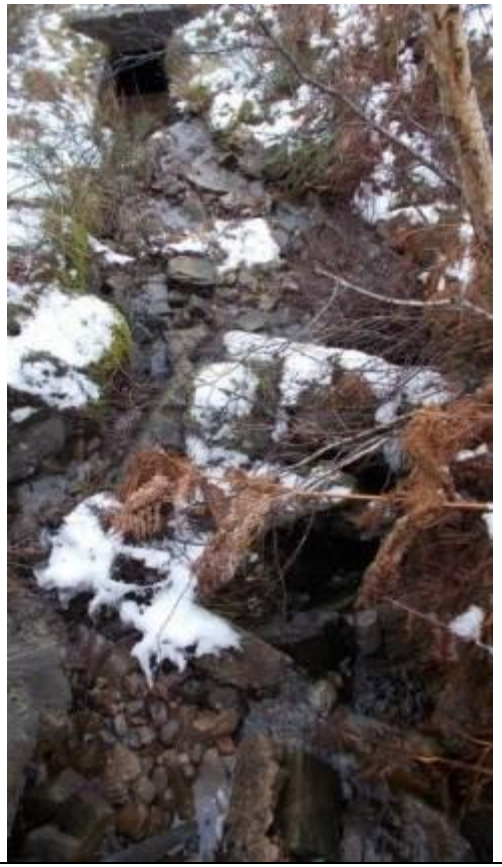
**Photograph 105**

WF152 Existing A9 culvert inlet and upstream channel



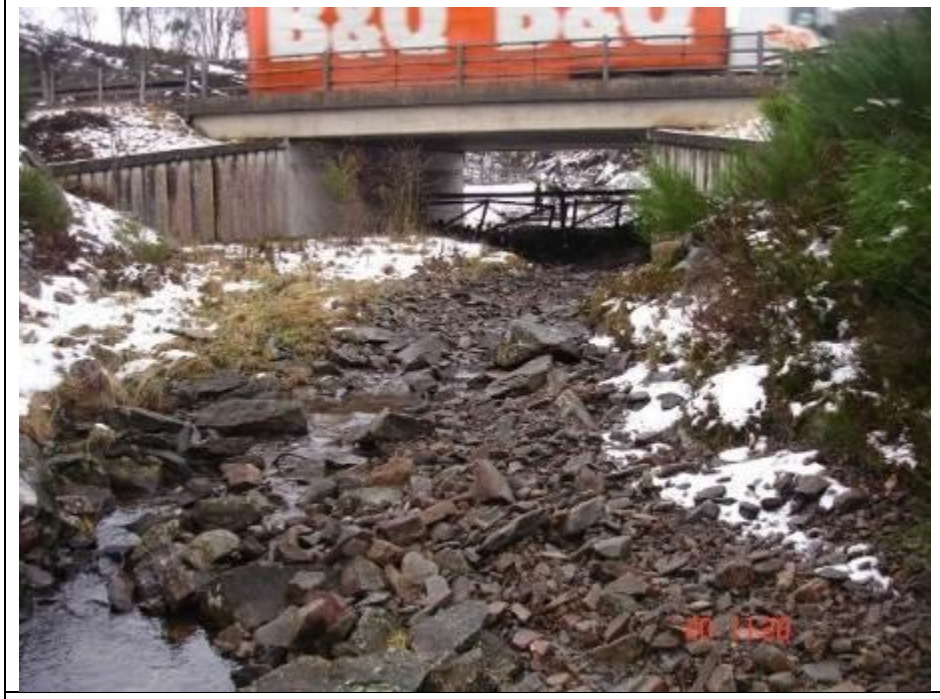
**Photograph 106**

WF153 Existing A9 culvert outlet and downstream channel



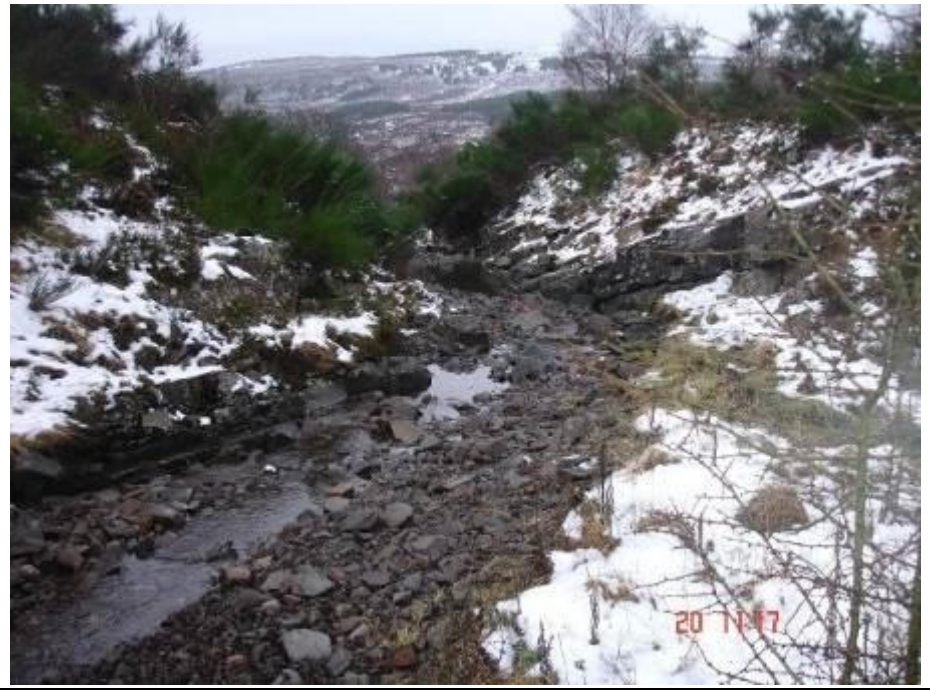
**Photograph 107**

WF153 Existing A9 culvert inlet and upstream channel



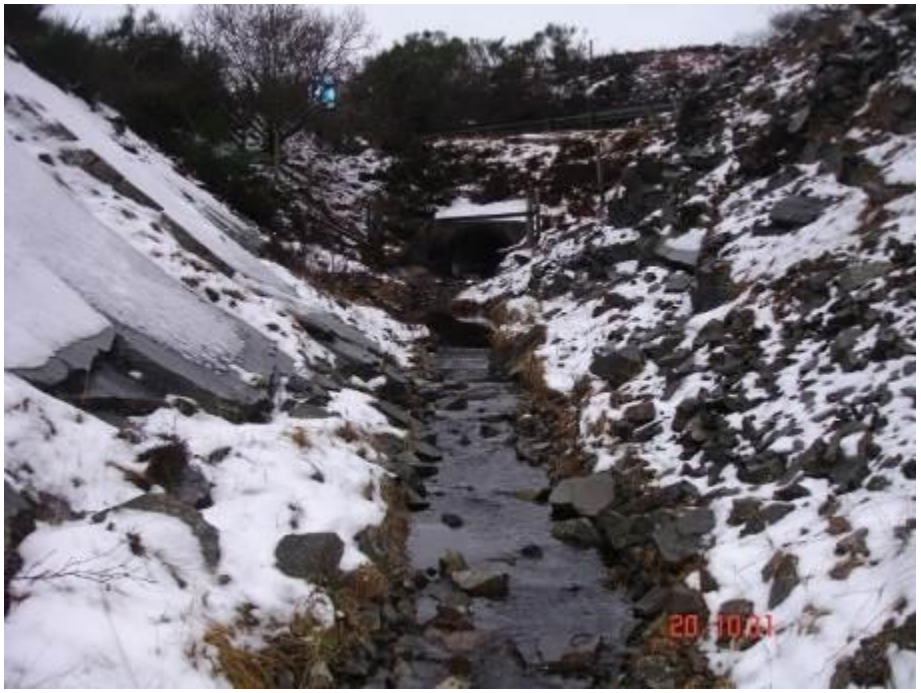
**Photograph 108**

WF88 Existing A9 culvert outlet and downstream channel



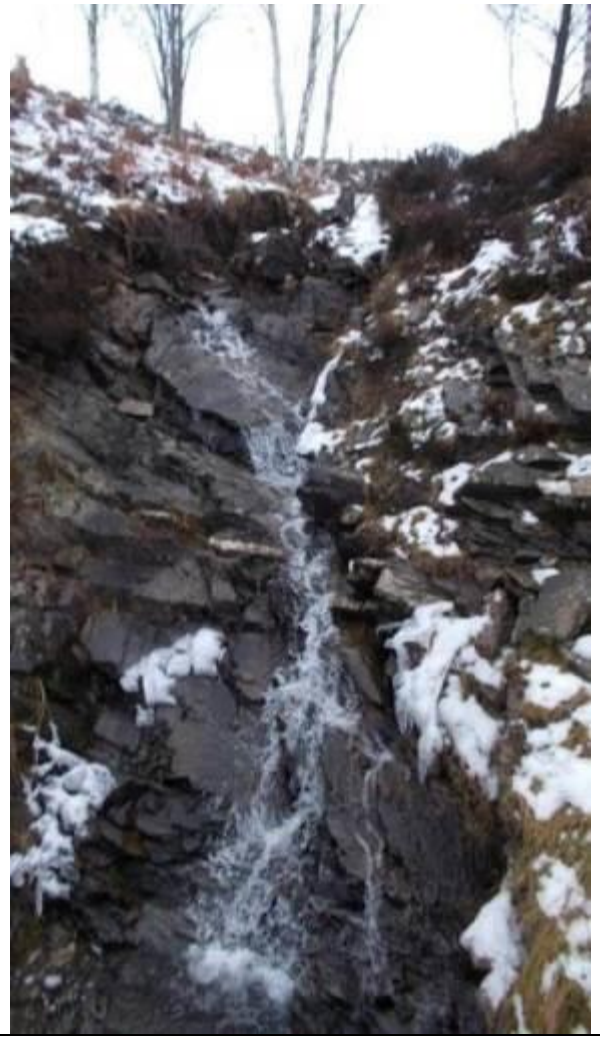
**Photograph 109**

WF88 Existing A9 culvert inlet and upstream channel



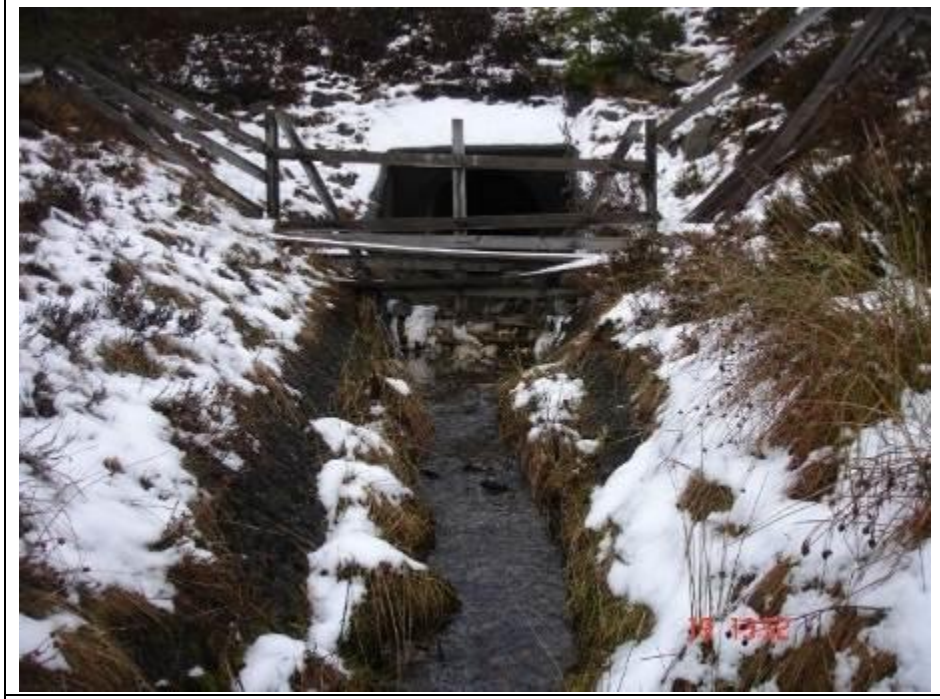
**Photograph 110**

WF154 Existing A9 culvert outlet and downstream channel



**Photograph 111**

WF154 Existing upstream cascade at A9 culvert inlet

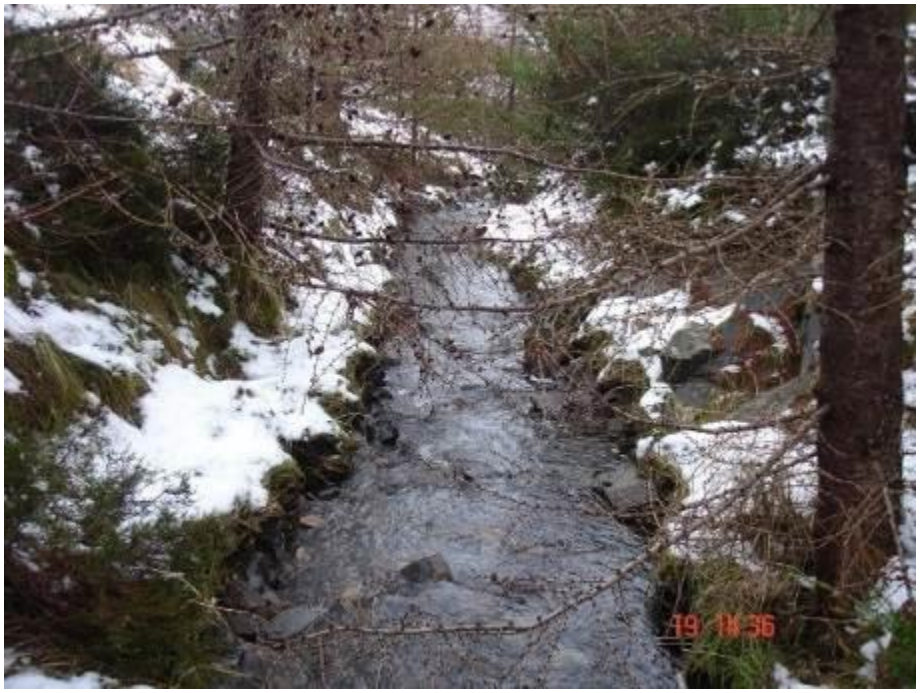


**Photograph 112**

WF155 Existing A9 culvert outlet and downstream channel

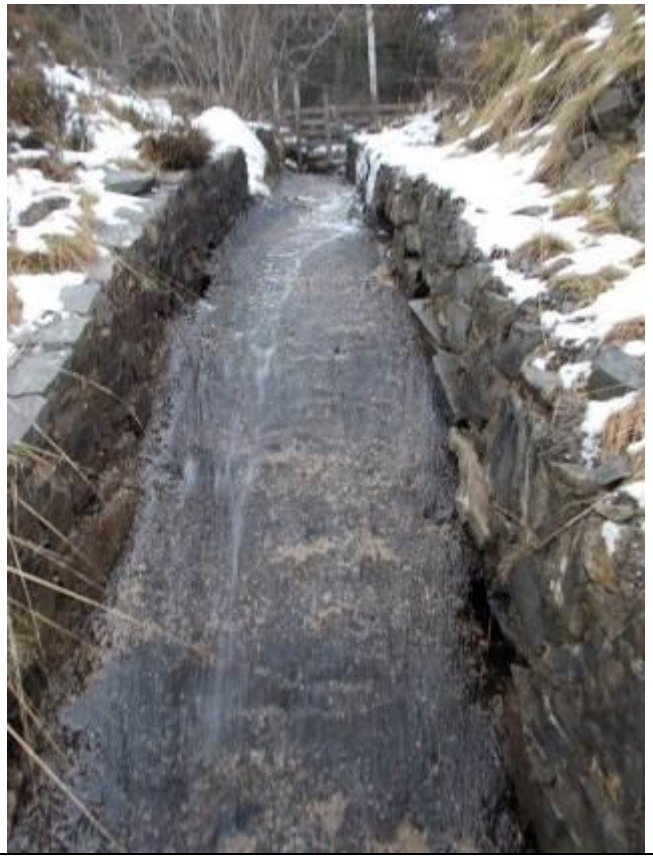
**Photograph 113**

WF155 Existing A9 culvert inlet



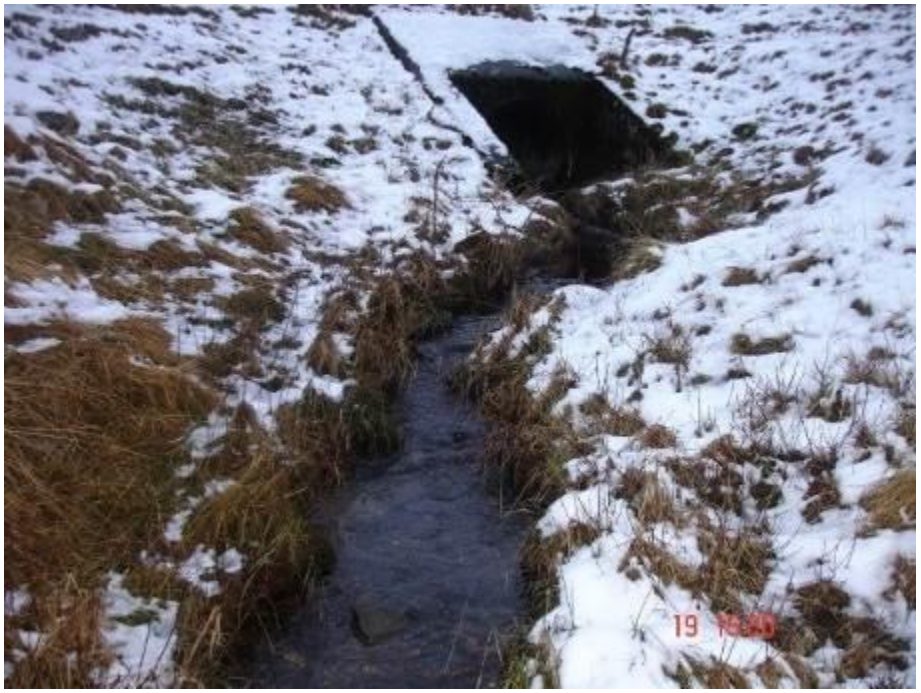
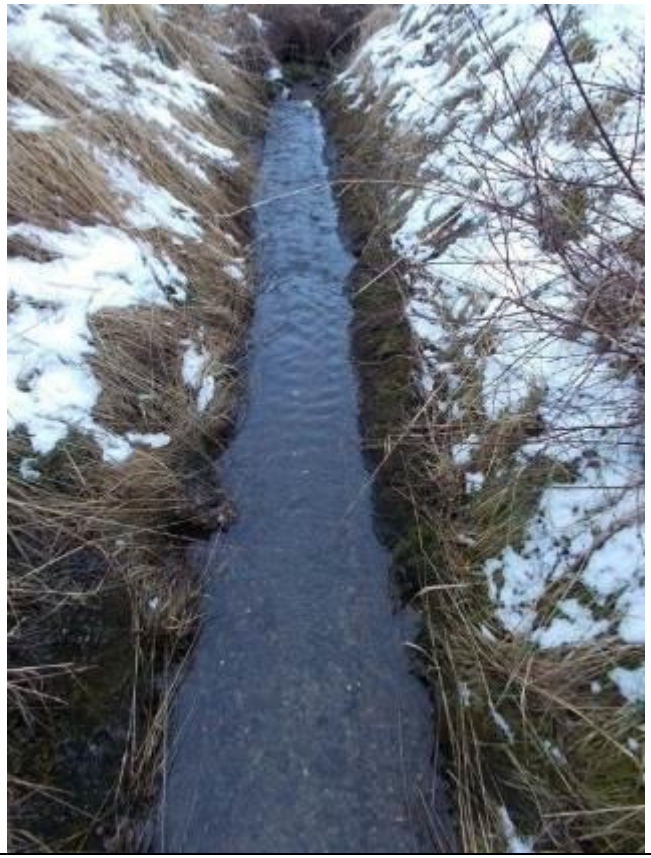
**Photograph 114**

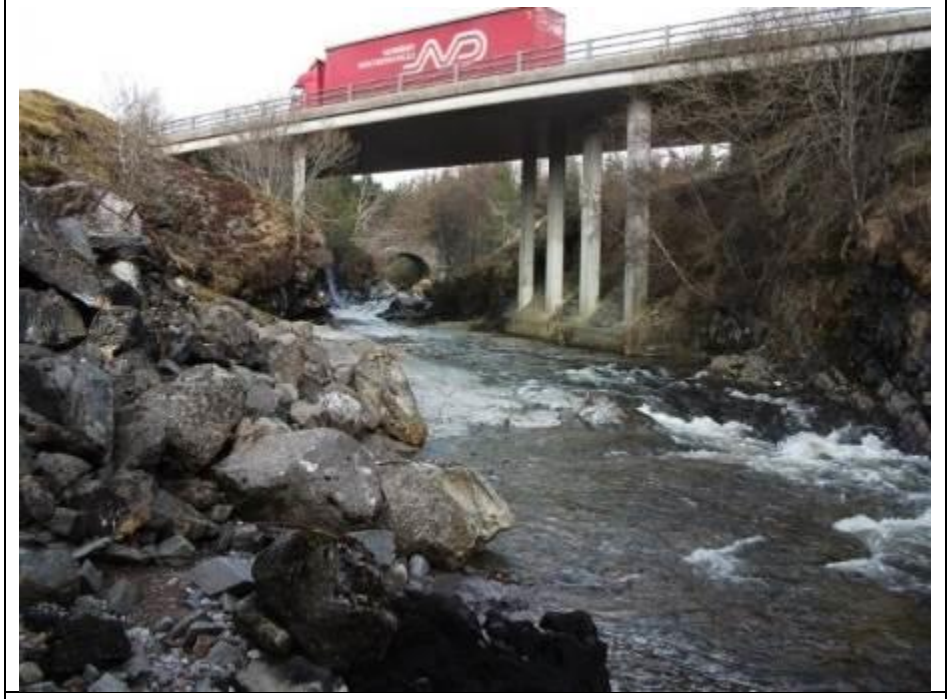
WF156 Existing downstream channel viewed from A9 culvert outlet



**Photograph 115**

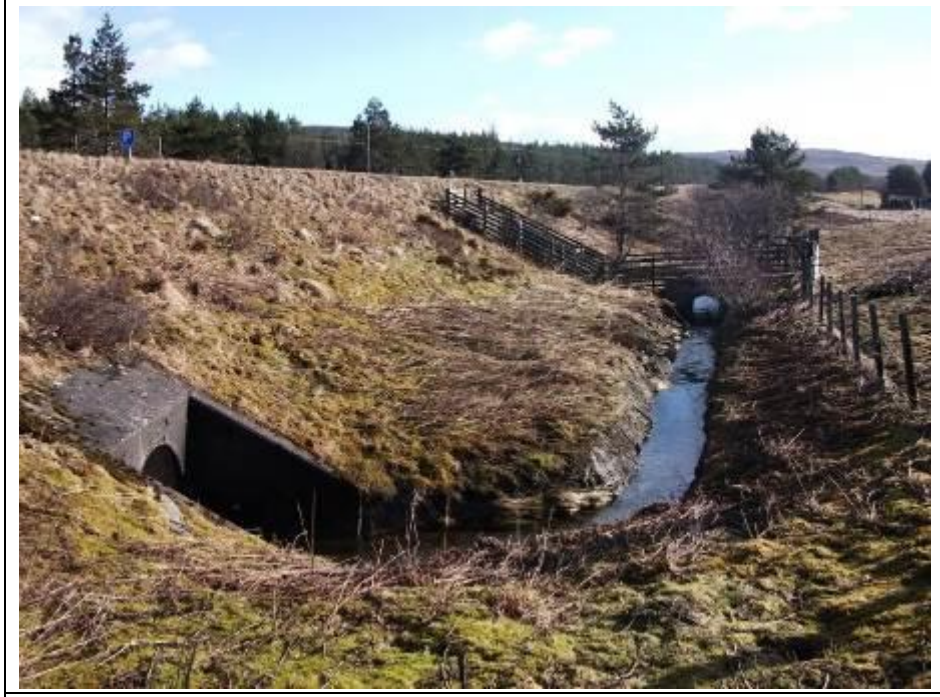
WF156 Existing upstream channel viewed from A9 culvert inlet

| | |
|---|---|
|  |  |
| **Photograph 116**<br><br>WF157 Existing A9 culvert outlet and downstream channel | **Photograph 117**<br><br>WF157 Existing A9 culvert inlet and upstream channel |



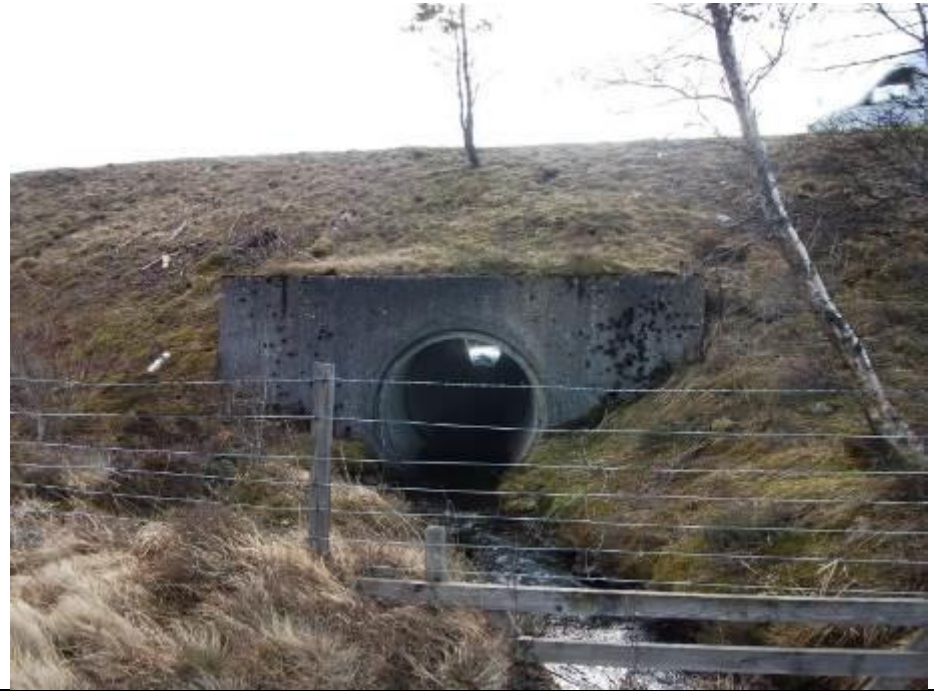
**Photograph 118**

WF158 Existing A9 structure looking upstream



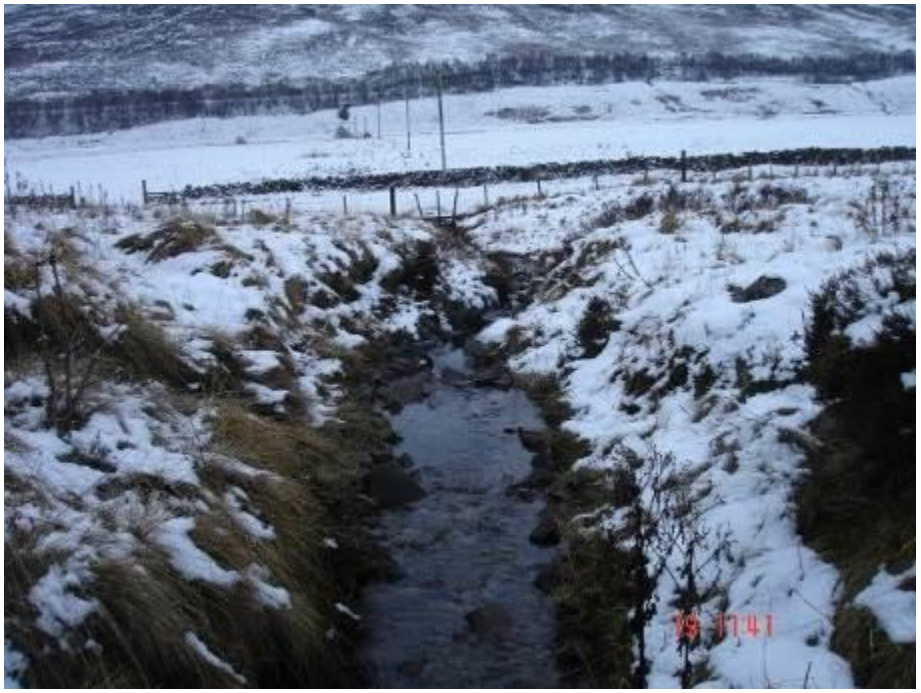
**Photograph 119**

WF159 Existing A9 culvert outlet and downstream channel



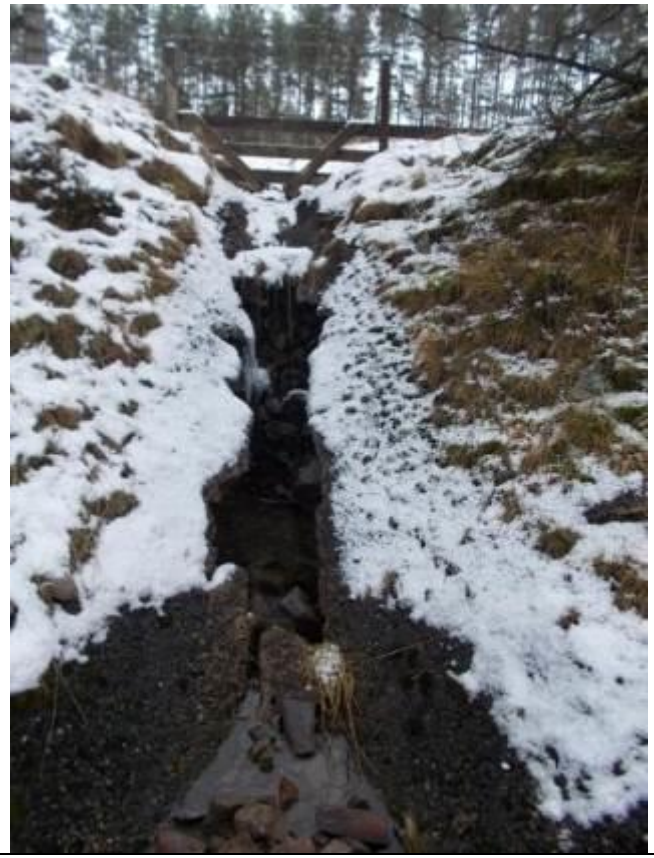
**Photograph 120**

WF159 Existing A9 culvert inlet and upstream channel



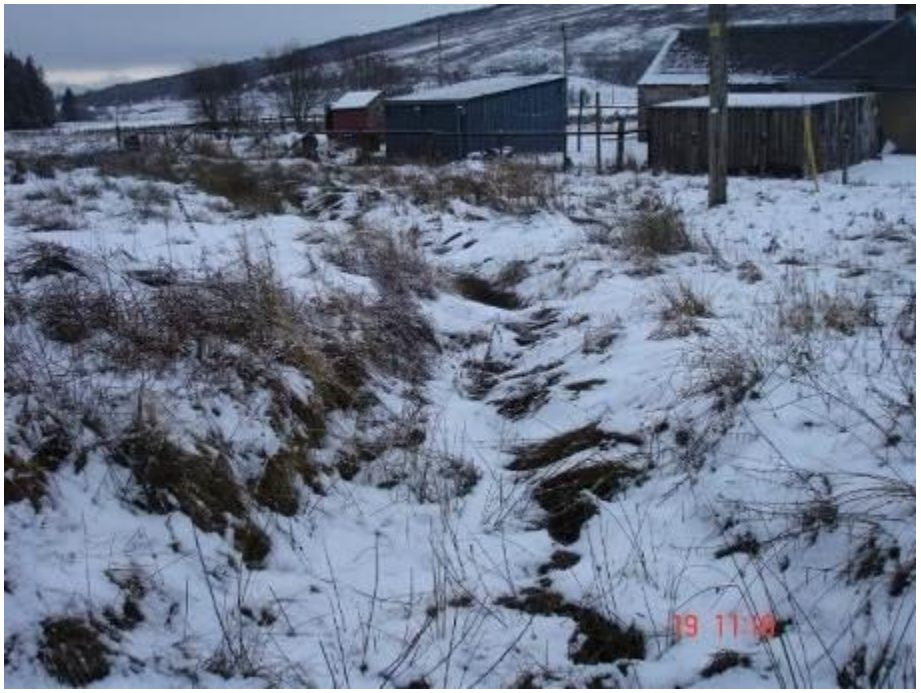
**Photograph 121**

WF160 Existing downstream channel viewed from A9 culvert outlet



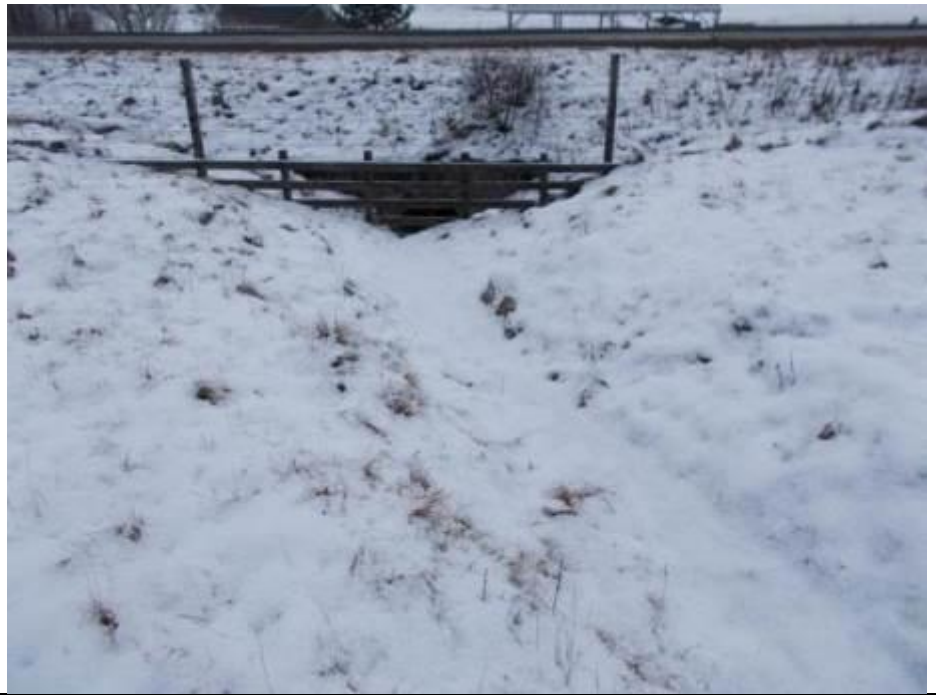
**Photograph 122**

WF160 Existing upstream cascade at A9 culvert inlet



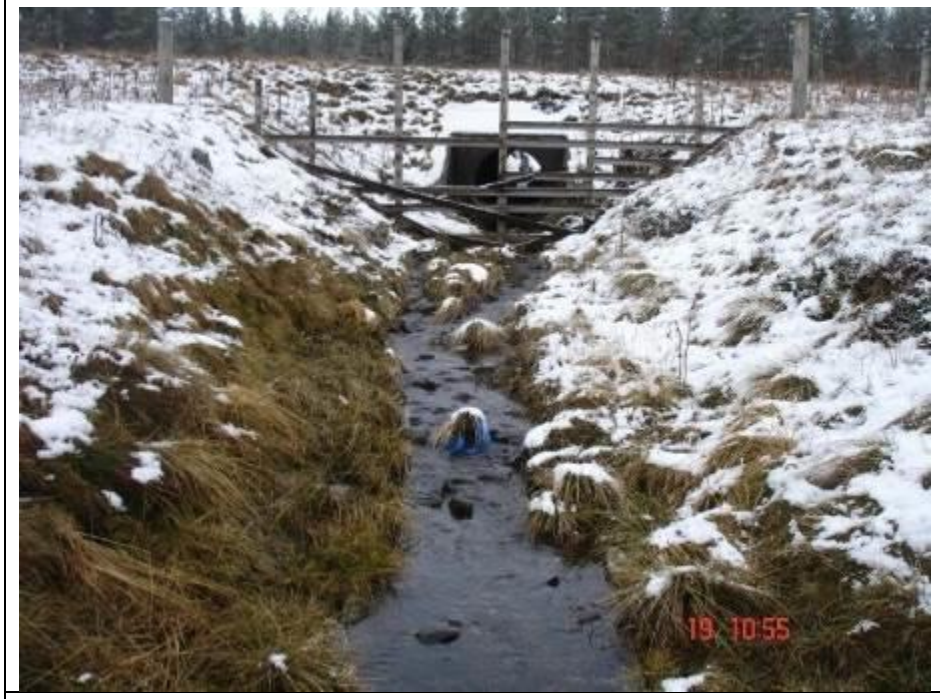
**Photograph 123**

WF161 Existing downstream channel viewed from A9 culvert outlet



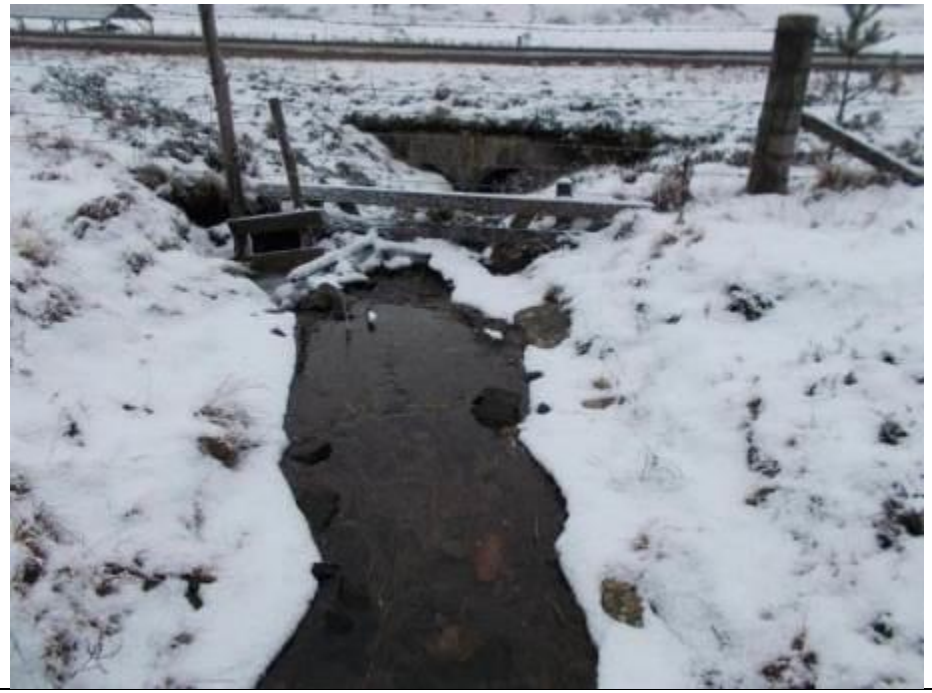
**Photograph 124**

WF161 Existing A9 culvert inlet and upstream channel



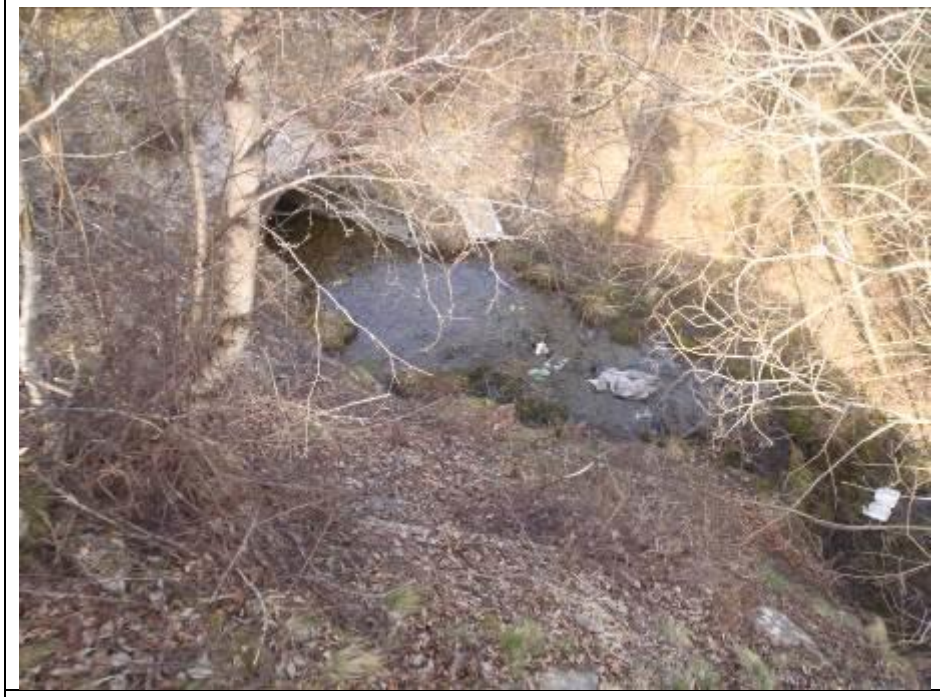

**Photograph 125**

WF162 Existing A9 culvert outlet and downstream channel



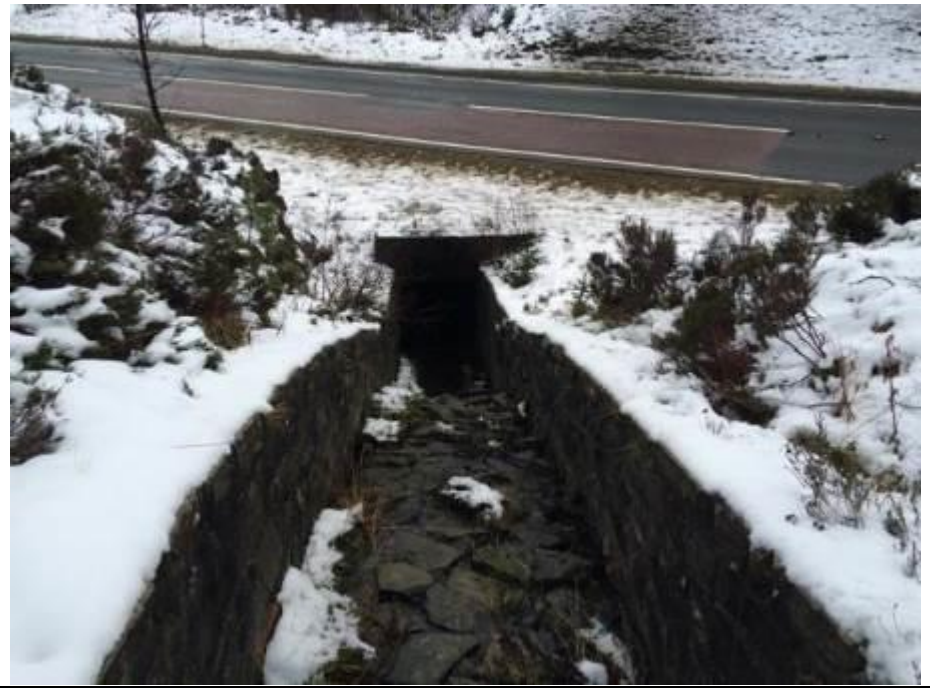
**Photograph 126**

WF162 Existing A9 culvert inlet and upstream channel



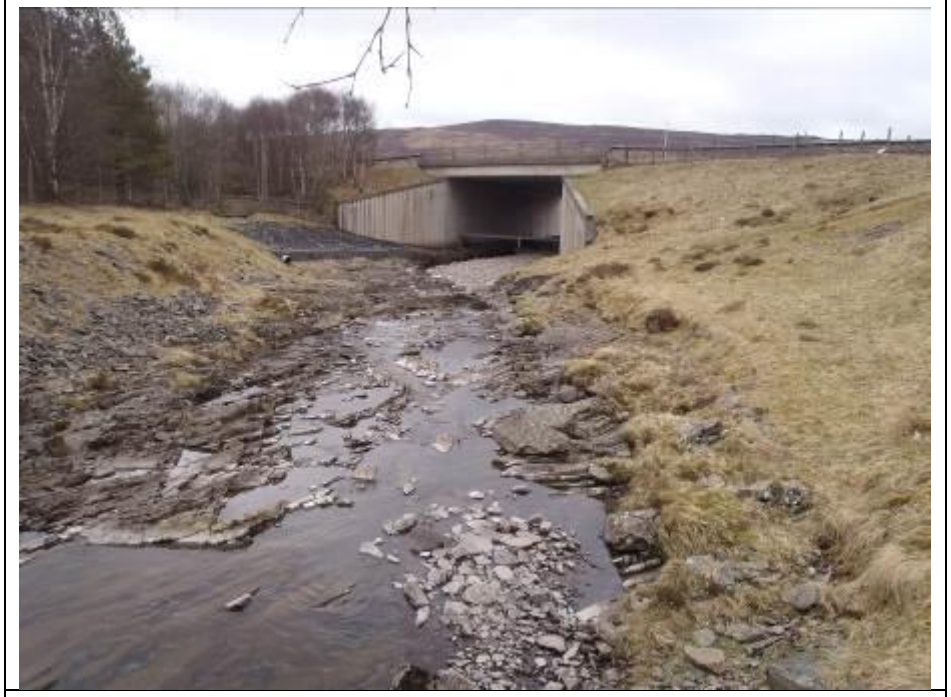
**Photograph 127**

WF163 Existing A9 culvert outlet and downstream channel



**Photograph 128**

WF163 Existing A9 culvert inlet and upstream cascade



**Photograph 129**

WF164 Existing A9 structure

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