# Appendix 11.4

## Hydromorphology Assessment
## Part 1

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# 1 Introduction

1.1.1 This appendix presents the detail of the hydromorphology assessment of the Proposed Scheme for Project 9 – Crubenmore to Kincraig of the A9 Dualling Programme. It supports the DMRB 'Road Drainage and Water Environment' impact assessment findings presented in **Chapter 11** of the Environmental Statement (ES). The Proposed Scheme is described in **Chapter 5** of the ES.

1.1.2 Hydromorphology is the study of landforms associated with river channels and floodplains and the processes that form them. Fluvial processes create a wide range of morphological forms within a catchment providing a variety of habitats within and around rivers. As a result, hydromorphology is integral to river management.

1.1.3 This assessment examines the impacts of the Proposed Scheme on the hydromorphology of the channels and floodplain within the River Spey catchments. Problems, such as excessive bank erosion or bed deposition, are a symptom of a change in discharge and/ or sediment supply elsewhere in the fluvial system so consideration of the hydromorphological implications of channel works need to be made within the context and understanding of the wider catchment.

1.1.4 This appendix describes the assessment methodology used to undertake the hydromorphology section of the Environmental Impact Assessment (EIA) for the Proposed Scheme (**Section 2**). It documents the baseline conditions that represent the condition of the water features within the study area without the construction and operation of the Proposed Scheme (**Section 3**).

1.1.5 Potential impacts that may occur as a consequence of the Proposed Scheme are then documented and considered in terms of both construction and operational-phase impacts for each of these waterbodies (**Section 4**).

1.1.6 Mitigation to avoid, reduce or offset potential adverse impacts is outlined, based on published guidance and best practice (**Section 5**). Thereafter, residual impacts are identified based on the implementation of proposed mitigation (**Section 6**) and cumulative impacts are discussed (**Section 7**).

# 2 Approach and Methods

## 2.1 Establishing Baseline Conditions

2.1.1 A total of 34 watercourses have been identified as crossing the A9 and having the potential to be impacted by the Proposed Scheme works, between Crubenmore to Kincraig (**Figure 1**). These have been identified from remotely sensed data and Ordnance Survey (OS) mapping, and subsequently verified via site walkover surveys. Each of these has been given a unique ID number that is used throughout this appendix and its annexes. For the purposes of the hydromorphological assessment each of these watercourses has then been classified as either 'Major', 'Minor' and 'Other':

- 'Major' watercourse crossings are those shown on 1:50,000 scale OS mapping
- 'Minor' watercourse crossings are those shown on 1:10,000 scale OS mapping
- 'Other' watercourses included are those not shown on OS mapping but identified during walkover surveys.

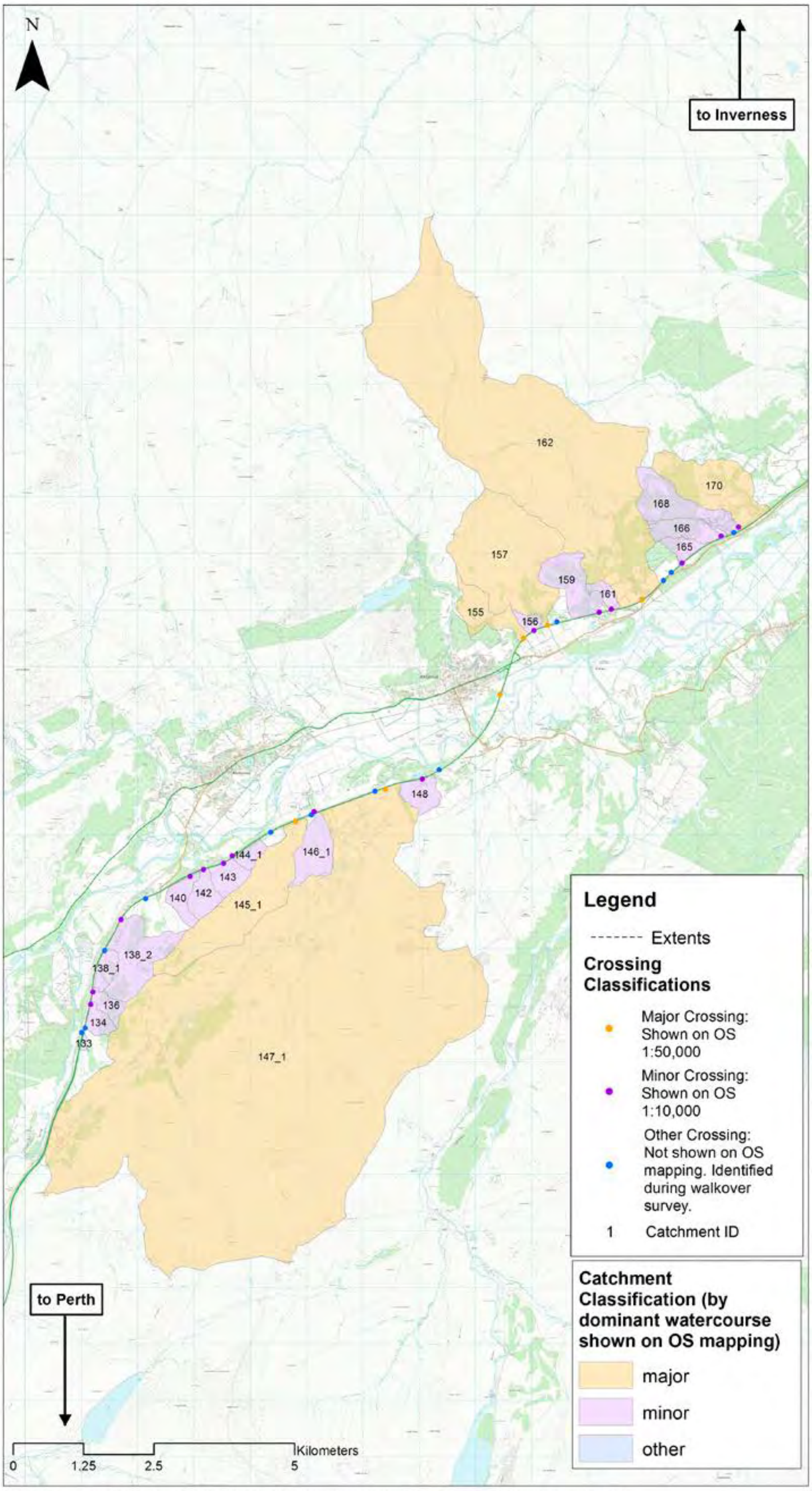




*Figure 1: Watercourse classifications and associated catchment boundaries*

2.1.2 For each crossing, a hydrological catchment has been delineated using Geographic Information Systems (GIS) and the available data. These assessments are based on elevation contours and watercourse features shown on the 1:25,000 scale OS mapping. For the purpose of this assessment some of the watercourses classified as 'Other' share a catchment with other similar sized watercourses due to the difficulties of identifying precise catchment boundaries between very small watercourses with the available data. These catchments have been updated for the Hydrology section of the Environmental Statement so there may be some limited variation in results for these very small watercourses.

2.1.3 The first phase of the hydromorphological baseline condition assessment (undertaken in 2016) involved a rapid expert judgement-based review of all watercourse crossings with an aim to scope out stable road drainage channels with no hydromorphological concern or interest (**Annex 11.4.1**). This involved a review of available site photography for each crossing, as well as the delineated catchments, aerial photograph and OS mapping. Each channel was rated as being at 'Low', 'Medium' or 'High' risk of erosion and deposition upstream of the crossing, at the crossing and downstream of the crossing.

2.1.4 All crossings classified as 'Major' or 'Minor' were automatically included in the scope for the subsequent detailed assessment. Those crossings classified as 'Other', which were judged in the first phase of assessment as being at low risk of erosion and deposition near the crossing, were excluded from the more detailed assessment. In general, the channels excluded from the scope of the detailed assessment are short, man-made drains with small catchments, little sediment availability and no evidence of recent hydromorphological activity. Many are drains created during the construction of the existing A9. This has resulted in 10 watercourses scoped out, leaving 24 included in the second phase of assessment.

2.1.5 The second phase of the baseline condition assessment involved a more detailed evaluation of each of the remaining catchments to better understand the processes acting within those catchments and how the crossings may impact on the geomorphological behaviour of the channel and the catchments. During this phase the potential hazards (erosion/ blockage) posed by the watercourses to any A9 related structures, earthworks or other built features within the catchments were also identified.

2.1.6 In addition to photographs of the watercourses collected during initial walkovers, GIS software, Google Earth Pro and other online resources have been used to analyse multiple sources of data. These include but were not limited to:

- Aerial photography collected for the project in 2015 (500m buffer of A9)
- OS mapping (1:10,000, 1:25,000, 1:50,000)
- Satellite imagery (Google and Bing)
- High resolution (5m) digital elevation data (unfiltered with a 500m buffer of A9)
- Lower resolution (50m) elevation data for whole catchments
- British Geological Survey Data (BGS) (1:50K)
- Scottish Natural Heritage (SNH) Environmental Designation Data
- Historical mapping (1800's)
- SEPA Water Framework Directive (WFD) information

2.1.7 For each catchment included in the scope of the detailed assessment, the above data have been used by geomorphologists to assess:

- Geology (superficial and bedrock)
- Mean slope angle within the catchment
- Sediment sources
- Existing channel morphology
- Sediment supply potential of the channels
- Erosion and deposition risk in the vicinity of the road
- Potential impacts on and impacts of third party infrastructure (railway, non-motorised user routes, residences, water supply infrastructure)

2.1.8 A walkover survey of the Major crossings and some Minor and Other crossings was undertaken by a geomorphologist. During this walkover a number of georeferenced photographs were taken and current form, processes and channel behaviour were noted for the area upstream, downstream and at the crossings (these have been included in the baseline).

2.1.9 For the Spey catchment a more detailed assessment has been undertaken based on the above information, more detailed historical analysis, available literature and modelling data.

## 2.2 Sensitivity of Channels

2.2.1 The hydromorphological assessment of the DMRB Stage 3 EIA has been undertaken for 24 watercourses. It follows the updated SEPA guidance (Supporting Guidance (WAT-SG-67). Assessing the Significance of Impacts - Social, Economic, Environmental. May 2015) combined with expert judgement to define the sensitivity of the channels, and magnitude and significance of the impacts.

2.2.2 Sensitivity has been assigned to each watercourse based on the existing hydromorphological quality of the watercourses and the extent and impacts of anthropogenic modifications on the morphology and processes within this watercourse. This includes the current sediment regime, channel morphology and processes and is documented in **Table 1**. The sensitivity of each watercourse is shown by catchment on **Figure 2**, with the highest sensitivity shown where there are multiple channels in a catchment.

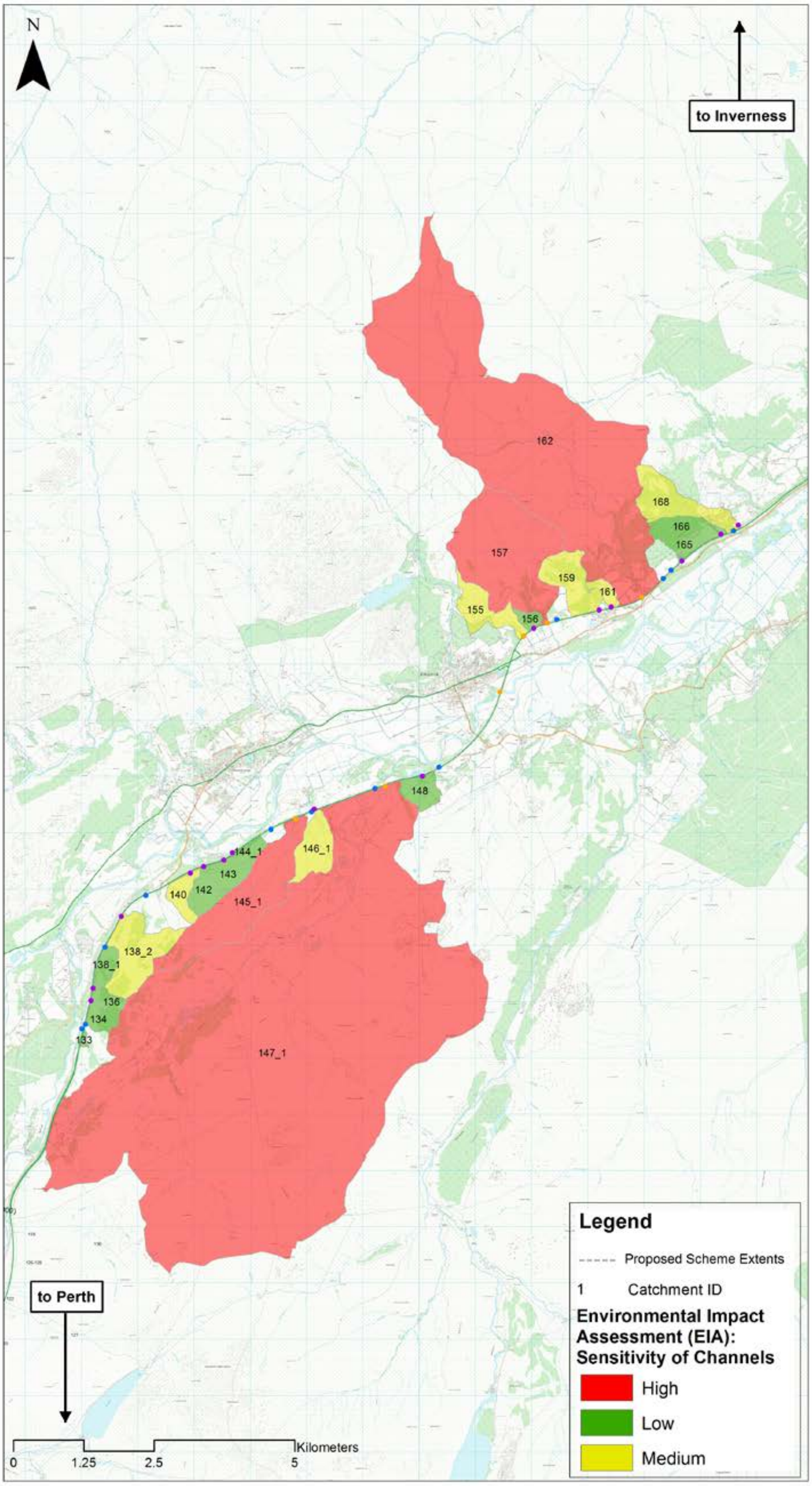




*Figure 2: Sensitivity of channels coloured by catchment*

*Table 1: Sensitivity classifications for watercourses*

| Sensitivity | Criteria/ Indicator of Value |
|---|---|
| Very High | **Sediment Regime**<br>Water feature sediment regime provides a diverse mosaic of habitat types suitable for species sensitive to changes in sediment concentration and turbidity, such as migratory salmon, freshwater pearl mussels. Water feature appears in complete equilibrium with natural erosion and deposition occurring. The water feature has sediment processes reflecting the nature of the catchment and fluvial system.<br>**Channel Morphology**<br>Water feature includes varied morphological features (e.g. pools, riffles, bars, natural bank profiles) with no sign of channel modification.<br>**Natural Fluvial Processes**<br>Water feature displays natural fluvial processes and natural flow regime, which would be highly vulnerable to change as a result of modification |
| High | **Sediment Regime**<br>Water feature sediment regime provides habitats suitable for species sensitive to changes in sediment concentration and turbidity, such as migratory salmon, freshwater pearl mussels. Water feature appears largely in natural equilibrium with some localised accelerated erosion and/or deposition caused by land use and/or modifications. Primarily the sediment regime reflects the nature of the natural catchment and fluvial system.<br>**Channel Morphology**<br>Water feature exhibiting a natural range of morphological features (e.g. pools, riffles, bars, varied natural river bank profiles), with limited signs of artificial modifications or morphological pressures.<br>**Natural Fluvial Processes**<br>Predominantly natural water feature with a diverse range of fluvial processes that is highly vulnerable to change as a result of modification. |
| Medium | **Sediment Regime**<br>Water feature sediment regime provides some habitat suitable for species sensitive to change in suspended sediment concentrations or turbidity. A water feature with natural processes occurring but modified, which causes notable alteration to the natural sediment transport pathways, sediment sources and areas of deposition.<br>**Channel Morphology**<br>Water feature exhibiting some morphological features (e.g. pools, riffles and depositional bars). The channel cross-section is partially modified in places, with obvious signs of modification to the channel morphology. Natural recovery of channel form may be present (e.g. eroding cliffs, depositional bars).<br>**Natural Fluvial Processes**<br>Water feature with some natural fluvial processes, including varied flow types. Modifications and anthropogenic influences having an obvious impact on natural flow regime, flow pathways and fluvial processes. |
| Low | **Sediment Regime**<br>Water feature sediment regime which provides very limited physical habitat for species sensitive to changes in suspended solids concentration or turbidity. Highly modified sediment regime with limited/no capacity for natural recovery.<br>**Channel Morphology**<br>Water feature that has been extensively modified (e.g. by culverting, addition of bank protection or impoundments) and exhibits limited-to-no morphological diversity. The water feature is likely to have uniform flow, uniform banks and absence of bars. Insufficient energy for morphological change.<br>**Natural Fluvial Processes**<br>Water feature which shows no or limited evidence of active fluvial processes with unnatural flow regime or/and uniform flow types and minimal secondary currents. |

## 2.3 Erosion risk assessment

2.3.1 The developing Scheme Design has been reviewed against the aerial photography and historical mapping in order to identify areas of engineering (proposed and existing) potentially at risk from fluvial erosion over the life of the scheme; highlighting areas that may require ongoing monitoring or erosion protection. This is detailed in **Annex 11.4.2.**

## 2.4 Establishing Changes in Conditions

2.4.1 The developing Scheme Design (**Annex 11.4.3**) was reviewed and used to undertake the initial (pre mitigation) assessment, outlining the potential impacts of the scheme on each of the waterbodies. It has been used to calculate the length and bed slope of culverts, channel realignments and bridges and the number and location of outfalls (both SuDS basin outfalls and earthworks drainage). In line with 'best practice' guidance and published standards, the following initial design approach was adopted by the engineering team:

- All culverts and bridges designed for a 1:200 year flow with allowances for climate change and freeboard, upsizing where required
- A natural bed will be provided in all culverts and erosion and scour protection provided only where necessary

2.4.2 The potential impacts of these works have then been considered for the watercourses in each of the catchments identified (and scoped in) based on the understanding of the form and processes within the watercourse catchments gained in the baseline and a review of the design information. Expert judgement has been used to consider likely changes and an assessment of the impacts of changes has been made for each of the impacted watercourses.

2.4.3 For culverts a comparison of the type (pipe or box), length, discharge, slope, and bed material has been made between the existing culvert and the proposed culvert. The potential impacts of these changes on the morphology, sediment regime and fluvial process of the waterbodies have then been recorded.

2.4.4 For bridges a comparison of the length, bed material and distance set back from the channel has been made between the existing and the proposed. The potential impacts of these changes on the morphology, sediment regime and fluvial process on the waterbodies have then been recorded.

2.4.5 For channel realignments a comparison of morphology has been undertaken with the existing channels, as well as a review of the design planform, slope, cross section, length, and velocity and stream power, in order to identify potential impacts on the morphology, sediment regime and fluvial process of the waterbodies.

2.4.6 For outfalls, only the proposed locations have been considered and it has been assumed that these have a negligible discharge to the channels, as well as a minimal grey engineering headwall and bed protection.

2.4.7 For erosion protection, the extent and type have been taken into account as well as the proximity to the watercourse (set-back or in-channel). The potential impacts of these changes on the morphology, sediment regime and fluvial process of the waterbodies have then been recorded.

## 2.5 Magnitude and Significance of Impacts

2.5.1 The initial assessment of the magnitude of impacts was undertaken based on SEPA guidance (2015) by combining the potential change in WFD, spatial extent of the impacts on watercourse status and timescale of the potential impact.

2.5.2 Firstly, the potential change in WFD status has been assessed for works on each watercourse using the Single Activity Limits test (SEPA- WAT-SG-21). The thresholds (**Table 2**) are regarded as the maximum extent of an individual pressure (type of engineering work) which, on its own, could cause a significant and long term impact on the water environment and cause a downgrade in WFD status.

2.5.3 In order to undertake this test, a target river type (the natural river type the watercourse would be before any management (**Figure 3**)) has been assigned to each impacted reach as part of the baseline study for this report. Where two different types are impacted on the same watercourse the worst case (more sensitive type) has been selected for this test.

2.5.4 This has been applied to each element of works on each of the watercourses and those works that have failed the test are noted in the assessment tables. It should be noted that none of the elements fails the Single Activity Limits test.

2.5.5 All assessments have assumed the works cause a drop in WFD status of 1 level (for most watercourses this is from Good to Moderate) as per the guidance. However, in the majority of cases (except where the Single Activity Limit thresholds are reached), there is not expected to be a change in WFD status caused by the works after best practice and mitigation are applied, so the assessment is assuming a worst case.

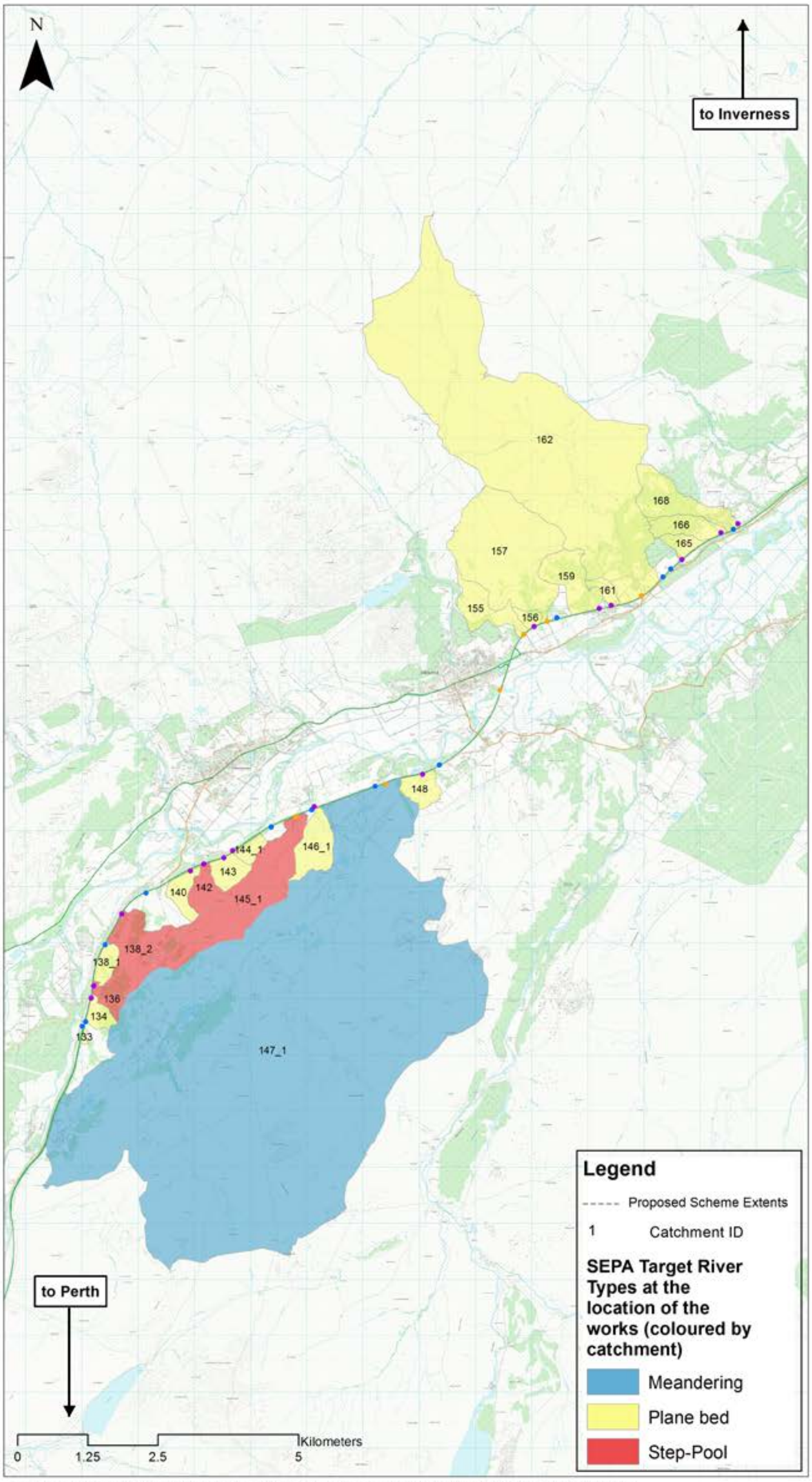




*Figure 3: SEPA target river types (in the vicinity of the road) coloured by catchment*

*Table 2: Single Activity Limit testing - threshold of significant impacts for different river types*

| Activity | Bedrock or Cascade | Step pool or Plane bed | Braided, Wandering or Plane riffle | Active Meandering | Passive Meandering |
|---|---|---|---|---|---|
| | **Type A** | **Type B** | **Type C** | **Type D** | **Type F** |
| Riparian vegetation removal | 7500 | 2500 | 1410 | 1410 | 2500 |
| Sediment Removal | 900 | 540 | 360 | 320 | 590 |
| Dredging | 540 | 340 | 250 | 210 | 390 |
| Embankments & Floodwalls (excludes bank reinforcement) | 1070 | 670 | 270 | 390 | 780 |
| Set Back Embankments and Floodwalls | 22500 | 11250 | 3460 | 5630 | 11250 |
| Grey (Hard) Bank Protection | 2810 | 1180 | 600 | 710 | 1180 |
| Green (Soft) Bank Protection | 7500 | 2370 | 1450 | 1450 | 2370 |
| Bank Reprofiling | 7500 | 2370 | 1450 | 1450 | 2370 |
| High Impact Realignment (e.g. straightening) | 680 | 390 | 140 | 190 | 450 |
| Low Impact Realignment (e.g. re-meandering) | 1730 | 1020 | 730 | 590 | 1180 |
| Flood Bypass Channel | 900 | 660 | 240 | 330 | 800 |
| Open Culverts | 460 | 230 | 100 | 130 | 260 |
| Culvert with natural bed (e.g. arch culvert) | 540 | 340 | 140 | 190 | 390 |
| Culvert with artificial bed (e.g. pipe or box culverts) | 420 | 280 | 120 | 160 | 330 |
| Croys, Groynes, Flow Deflectors (length of structure =) | 1730 | 590 | 300 | 360 | 590 |
| Bed Reinforcement | 680 | 390 | 140 | 210 | 450 |
| Impoundments (length of impounded water =) | 540 | 340 | 140 | 190 | 390 |
| Bridges (number of piers x river width) | 1410 | 800 | 260 | 400 | 900 |

(NB- numbers are lengths of works in metres at or over which the threshold is crossed)

2.5.6 A scale of impact has been assigned based on **Table 3** with the WFD status, based on the highest between Water Flows and Levels, and Physical Condition, where there is a difference. Where a channel does not have a WFD status it has been assigned that of the river to which it is a tributary.

2.5.7 The length of the channel affected takes into account the length of direct impacts e.g. the loss of bank (both sides) due to the culvert, and the potential downstream distance of indirect impacts e.g. changes in sediment transport. This indirect impact distance is based on expert judgment and is assumed to be the length of the channel, until it reaches its confluence with a larger watercourse. Where the supply of sediment and water from the larger, receiving watercourse is assumed to be greater than the changes caused by the works, these changes are no longer considered significant.

2.5.8 Where the scale of impacts is between classes (e.g. negligible-very small), expert judgment has been used involving the scale of work, as well as the results of the Single Activity Limit test result, to select the appropriate scale. This scale then feeds into **Table 4**: and is combined with duration of impact (either construction time or the length of time the infrastructure will be present), to give a magnitude of the impact.

*Table 3: Definitions of Scale of impacts*

| Change in WFD status | Length of river channel/bank affected (km) | | | | | |
|---|---|---|---|---|---|---|
| | < 0.5 | 0.5 to < 1.5 | 1.5 to < 5 | 5 to < 10 | 10 to < 20 | ≥ 20 |
| High → Good | Negligible | Very Small | Very Small - Small | Small - Medium | Medium | Medium - Large |
| Good ↔ Moderate<br>Moderate ↔ Poor<br>High → Moderate<br>Poor ↔ Bad | Negligible - Very Small | Very Small - Small | Small | Medium | Medium - Large | Large |
| High → Poor<br>Good ↔ Poor<br>Moderate ↔ Bad | Very Small | Small | Medium | Medium - Large | Large - Very Large | Large - Very Large |
| Good ↔ Bad<br>High → Bad | Small | Small - Medium | Medium - Large | Large | Large – Very Large | Very Large |

*Table 4: Calculations of magnitude of an identified impact*

| Duration of impact | Scale of impact (extent & severity) | | | | | |
|---|---|---|---|---|---|---|
| | Negligible | Very Small | Small | Medium | Large | Very Large |
| Very short (up to 1 year) | Negligible | Negligible | Minor | Minor | Moderate | Moderate |
| Short (up to 6 years) | Negligible | Minor | Minor | Moderate | Moderate | Major |
| Long (more than 6 years) | Negligible | Minor | Moderate | Moderate | Major | Major |

2.5.9 **Table 3** and **Table 4**: have been used to assess the magnitude of impacts on the hydromorphology of the channel as outlined in this section. For this assessment, all the works undertaken are assumed to change the WFD status (downwards/negatively) by one category (see above) so length of channel affected is the key control on scale of impact. All works considered at this stage are long term so the length of impact is the key consideration with respect to magnitude.

2.5.10 The DMRB method of defining magnitude (outlined in **Table 5** differs from the SEPA method; however, the two are easily aligned with the magnitude for each being directly compatible, based on a change in WFD status, duration of impacts (in this case all Long Term) and more importantly the length of channel impacted. This alignment is outlined in **Table 5** based on long term impacts.

*Table 5: Definitions of magnitude of an identified impact*

| SEPA Magnitude (as assessed) | DMRB Magnitude Criteria |
|---|---|
| **Major Adverse**<br>Impact that has the potential to impact on a waterbody scale- Over 10km of channel affected and/or would cause a drop in WFD status by 2 levels (e.g. Good to Poor) | **Sediment Regime**<br>Significant impacts on the water feature bed, banks and vegetated riparian corridor resulting in changes to sediment characteristics, transport processes, sediment load and turbidity. This includes extensive input of sediment from the wider catchment due to modifications. Impacts would be at the waterbody scale.<br>**Channel Morphology**<br>Significant/extensive alteration to channel planform and/or cross section, including modification to bank profiles or the replacement of a natural bed. This could include: significant channel realignment (negative); extensive loss of lateral connectivity due to new/extended embankments; and/or, significant modifications to channel morphology due to installation of culverts or outfalls. Impacts would be at the waterbody scale.<br>**Natural Fluvial Processes**<br>Significant shift away from baseline conditions with potential to alter processes at the catchment scale.<br>**Condition Status**<br>Substantial adverse impacts at the water body scale, which causes loss or damage to habitats. Impacts have the potential to cause deterioration in hydromorphology quality elements*. Prevents the water body from achieving Good status. |
| **Moderate Adverse**<br>1.5-10km of channel impacted, or 0.5-1.5km of channel impacted where the Threshold of significant impacts test is failed and a drop in WFD status is likely due to the works. | **Sediment Regime**<br>Some changes and impacts on the water feature bed, banks and vegetated riparian corridor resulting in some changes to sediment characteristics, transport processes, sediment load and turbidity. Impacts would be at the multiple reach scale.<br>**Channel Morphology**<br>Some alteration to channel planform and/or cross section, including modification to bank profiles or the replacement of a natural bed. Activities could include: channel realignment, new/extended embankments, modified bed and/bank profiles, replacement of bed and/or banks with artificial material and/or installation of culverts. Impacts would be at the multiple reach scale.<br>**Natural Fluvial Processes**<br>A shift away from baseline conditions with potential to alter processes at the reach or multiple reach scale.<br>**Condition Status**<br>Moderate adverse impacts at the reach or multiple reach scale, which causes some loss or damage to habitats. Impacts have the potential to cause failure or deterioration in one or more of the hydromorphological quality elements. May prevent the water body from achieving Good status. |
| **Minor Adverse**<br>0.5-1.5km of channel impacted, or <0.5km of channel impacted where the Threshold of significant impacts test is failed and a drop in WFD status is likely due to the works. | **Sediment Regime**<br>Limited impacts on the water feature bed, banks and vegetated riparian corridor resulting in limited (but notable) changes to sediment characteristics, transport processes, sediment load and turbidity at the reach scale.<br>**Channel Morphology**<br>A small change or modification in the channel planform and/or cross section. Includes upgrade to and/or extension of existing watercourse crossing and/or structure with associated minor channel realignment with localised impacts.<br>**Natural Fluvial Processes**<br>Minimal shift away from baseline conditions with typically localised impacts up to the reach scale.<br>**Condition Status**<br>Minor adverse impacts at the reach scale, which may cause partial loss or damage to habitats. Impacts have the potential to cause failure or deterioration in one of the hydromorphological quality elements. |
| **Negligible**<br><0.5km of channel affected<br>One drop in WFD status used in assessment but no change likely. | Minimal or no measurable change from baseline conditions in terms of sediment transport, channel morphology and natural fluvial processes. Any impacts are likely to be highly localised and not have an effect at the reach scale. |

| SEPA Magnitude (as assessed) | DMRB Magnitude Criteria |
|---|---|
| **Minor Beneficial**<br>0.5-1.5km of channel impacted, with little to no change in WFD status. | **Sediment Regime**<br>Partial improvement to sediment processes at the reach scale, including reduction in siltation and localised recovery of sediment transport processes.<br>**Channel Morphology**<br>Partial improvements include enhancements to in-channel habitat, riparian zone and morphological diversity of the bed and/or banks.<br>**Natural Fluvial Processes**<br>Slight improvement on baseline conditions with potential to improve flow processes at the reach scale.<br>**Condition Status**<br>Slight beneficial impacts at the reach scale, which may cause partial habitat enhancement. Impacts have the potential to improve one of the hydromorphological quality elements. |
| **Moderate Beneficial**<br>Multiple reaches impacted-1.5-10km of channel impacted with potential for improved WFD status by one level, or a shorter impact with the potential to improve WFD by 2 levels. | **Sediment Regime**<br>Reduction in siltation and recovery of sediment transport processes at the reach or multiple reach scale.<br>**Channel Morphology**<br>Partial creation of both in-channel and vegetated riparian habitat. Improvement in morphological diversity of the bed and/or banks at the reach or multiple reach scale. Includes partial or complete removal of structures and/or artificial materials.<br>**Natural Fluvial Processes**<br>Notable improvements on baseline conditions and recovery of fluvial processes at the reach or multiple reach scale.<br>**Condition Status**<br>Notable beneficial impacts at the reach to multiple reach scale. Impacts have the potential to improve one or more of the hydromorphological quality elements and/or assist the water body in achieving Good status. |
| **Major Beneficial**<br>Impacts improve much of the waterbody (10km or over) by one WFD status or 5-10km by 2 WFD status. | **Sediment Regime**<br>Improvement to sediment processes at the catchment scale, including recovery of sediment supply and transport processes.<br>**Channel Morphology**<br>Extensive creation of both in-channel habitat and riparian zone. Morphological diversity of the bed and/or banks is restored, such as natural planform, varied natural cross-sectional profiles, recovery of fluvial features (e.g. cascades, pools, riffles, bars) expected for river type. Removal of modifications, structures, and artificial materials.<br>**Natural Fluvial Processes**<br>Substantial improvement on baseline conditions at catchment scale. Recovery of flow and sediment regime. |

*Hydromorphological quality elements are: quality and quantity of flow; river depth and width variation; structure and substrate of the bed dynamics; river continuity; structure of the riparian zone.

## 2.6 Significance of Impacts (without mitigation)

2.6.1 The magnitude and sensitivity that have been assigned are then multiplied as per **Table 6** to give the initial, pre mitigation impact significance (**Annex 11.4.3**). Where there is a difference between the differing elements considered the worst case significance is taken.

*Table 6: Definition of 'significance' of impact*

| Magnitude of impact/ Sensitivity of attribute | Negligible | Minor | Moderate | Major |
|---|---|---|---|---|
| **Very High** | Neutral | Moderate/ Large | Large/ Very large | Very Large |
| **High** | Neutral | Slight/ Moderate | Moderate/ Large | Large/ Very Large |
| **Medium** | Neutral | Slight | Moderate | Large |
| **Low** | Neutral | Neutral | Slight | Slight/ Moderate |

## 2.7 Significance of Impacts (with embedded mitigation)

2.7.1 Mitigation required to reduce or eliminate adverse impacts of the Proposed Scheme on the hydromorphology of the channels has been documented for each catchment and incorporated into design where possible, and reasons given where not. This mitigation has then been 'embedded' into the Scheme Design (**Drawings 5.1 to 5.9**, contained in **Volume 3**). The assessment process has then been repeated with this embedded mitigation in place, and a significance of impacts has been assigned.

## 2.8 Significance of Impacts (with additional 'Project specific' mitigation)

2.8.1 A schedule of Project Specific mitigation (i.e. where mitigation is not already included in the Scheme Design) has been created to mitigate any remaining impacts, and the assessment process run for a third time as discussed in **Section 5.3** of this appendix.

# 3 Baseline Conditions

3.1.1 This section of the report provides hydromorphological context for catchments being assessed, identifying zones of sediment production, transfer and deposition, and characterisation of the watercourses as a whole and the location of different processes. This understanding is then used to assess the impact of the Proposed Scheme on the hydromorphology of the channels within the catchments.

3.1.2 All watercourses and their catchments within the project have been given an ID and these have been used to distinguish between different channels and catchments and to identify each of the hydromorphological receptors considered in this assessment (**Figure 1**). All will be affected by changes in flow and sediment regime that could be caused by the proposed scheme; however, the impacts of these changes may take years to manifest themselves.

3.1.3 Hydromorphological baseline conditions have been established for each impacted waterbody catchment and these are presented as a series of tables, maps and photographs in **Annex 11.4.4** and as a report for the Spey Catchment in **Annex 11.4.4**. The methodologies used to undertake this baseline are described in **Section 2**. As part of this process each area of impacted watercourse has been assigned a river type based on SEPA, 2011, and these are summarised (based on catchment) in **Figure 3.**

3.1.4 The WFD aims to maintain or improve the physical and chemical quality of watercourse within the European Union by 2027 and, to support this objective, River Basin Management Plans (RBMP) have been produced by SEPA for all catchments. The watercourses within the Proposed Scheme extent are part of the River Spey catchment. As well as the Spey itself three other baseline watercourses have been individually assigned WFD ecological status by Scottish Environment Protection Agency (SEPA) based on a variety of attributes including Water Flows and Levels and Physical Condition (i.e. hydrology and morphology) (**Table 7**).

*Table 7: WFD classification*

| WFD designated watercourse | Ecological Status | Water flows and levels classification | Physical condition classification | Tributaries to watercourse (ID) |
|---|---|---|---|---|
| River Truim-lower catchment-23146 | Moderate | Good | Good | 133-136 |
| River Spey-Spey Dam to Loch Insh- 23142 | Good | Good | Good | 137-170 |
| Milton Burn- 23143 | Good | High | Good | 147 |
| Raitts Burn- 23136 | Moderate | High | Good | 162 |

3.1.5 Non-baseline watercourses within the study area have not been assigned individual Ecological Status. Where these occur, the status of the larger watercourse into which it flows has been assigned for the purpose of this report and **Chapter 11**, as the waterbody/ catchment likely to be potentially impacted (**Table 7**).

3.1.6 As well as aiming to stop deterioration of the watercourses, the RBMPs also promote improvement of habitats impacted by existing morphological pressures in order to achieve future Good ecological status. The physical condition of the watercourse is a key part to achieving this as it impacts the ecological and chemical components. The WFD status of the watercourses and potential change in this status is considered in **Chapter 11**.

3.1.7 These baseline conditions have been assessed for each watercourse to give a sensitivity of each catchment based on **Table 1** and this is summarised in **Figure 2.**

# 4 Potential Impacts

## 4.1 Construction Impacts

4.1.1 This section addresses the potential impacts of the activities that will be carried out during construction of the Proposed Scheme. By their nature, culverts, bridges, realignments, erosion protection and outfalls all pose a risk to the hydromorphology of the channel and floodplain, as significant proportions of the required works, such as excavation, construction and landscaping are located within or in close proximity to watercourses. Detailed construction methods are currently unknown, but the potential impacts are considered below.

4.1.2 Any works involving engineering within the channel (culverts, bank protection, realignment, bridges and headwalls) have potential to destabilise and permanently change the form of the banks. The significance of this impact will vary depending of the existing nature of the banks and will be much reduced where banks are currently manmade or altered. These works will have an adverse impact on the morphology of the channels where they occur, and this impact has the potential to have a medium duration, with adjustment potentially taking many years.

4.1.3 Vegetation clearance will tend to destabilise the more natural banks, changing the form, as the vegetation helps to bind the bank material together, as well as drawing water, and protecting the underlying material from erosion from runoff and flow. This will have an adverse impact on the morphology of the channel in the areas where it occurs with a medium-term duration.

### Damage to Bed Form

4.1.4 Construction works within the channel can damage existing bed forms (including areas of gravel bars, pools and steps), bed armouring and sediment composition, and for some years after, until sufficient flows have occurred to redistribute sediment across the channel and reform the bed morphology and sediment profile of the channel. Fine sediment is also released during construction potentially smothering gravels at the site and further downstream.

### Increased Sediment Supply

4.1.5 The working methods are likely to result in damage to and increased instability of the channel bed and banks. As both bed and banks potentially become destabilised by the works, material from them becomes more likely to be delivered to the channel and is therefore available to be entrained and transported downstream. This increase in supply is likely to be ongoing for some time post construction as the banks and bed then readjust.

### Change in Flow Conditions

4.1.6 Any temporary narrowing of the channel to create a dry working environment will alter the discharge, velocity and water levels of the channel. This will have a very short term impact on the morphology of the channel in the areas where this occurs as well as potentially impacting on the channel downstream.

### Change of Continuity of Sediment Transfer

4.1.7 Methods of construction that include stopping downstream sediment transport such as damming the channel or pumping of water downstream will temporarily reduce the downstream continuity of sediment transfer during the works, having an adverse, short term impact on sediment continuity.

### Change in Sediment Dynamics

4.1.8 The works are likely to temporarily increase local supply from the damaged bed and banks. This will lead to a change in sediment dynamics within the channel at the site and downstream and is likely to result in increased downstream transport and/or local deposition. This will extend past construction until there has been sufficient flow to redistribute sediment and adjust to the change in conditions. This will have an adverse impact on the morphology of the channel in the areas where it occurs as well as impacting on the channels downstream.

## 4.2 Operational Impacts

4.2.1 Operational impacts are those which will occur following the completion of the Proposed Scheme and are considered to be long term impacts. Often it is difficult to quantify the magnitude of long term impacts due to the timescales over which they may occur (tens to hundreds of years) and the resilience of the environment to adapt to future changes; professional judgement is used to undertake the assessment, based on the methodology in **Section 2**.

4.2.2 The initial impact assessment was undertaken on the developing Scheme Design (**Annex 11.4.3**). Works proposed on each watercourse were identified, and then assessed, based on the baseline information (**Annex 11.4.4**), with the workings and results for each waterbody/ catchment given in a series of tables in **Annex 11.4.5** and summarised in **Table 8**.

*Table 8: Summary of Hydromorphology assessment results*

| Watercourse ID | EIA sensitivity | Significance of impact (Proposed Scheme) | Residual impact (after hydromorphological mitigation is applied) |
|---|---|---|---|
| 133 | Low | Neutral | Neutral |
| 134 | Low | Neutral | Neutral |
| 136 | Low | Neutral | Neutral |
| 138_1 | Low | Neutral | Neutral |
| 138_2 | Medium | Slight Adverse | Slight Beneficial |
| 140 | Medium | Slight Adverse | Slight Beneficial |
| 142 | Low | Neutral | Neutral |
| 143 | Low | Neutral | Neutral |
| 144_1 | Low | Neutral | Neutral |
| 145_1 | Medium - due to modified channel d/s of crossings | Moderate Adverse | Moderate Beneficial |
| 146_1 | Medium | Slight Adverse | Moderate Beneficial |
| 147_1 | High | Slight Adverse | Neutral |
| 148 | Low | Neutral | Neutral |
| 152 | Very High | Large Beneficial | Large Beneficial |
| 155 | Medium | Slight Adverse | Slight Beneficial |
| 156 | Low | Neutral | Neutral |
| 157 | High | Slight Adverse | Slight Beneficial |
| 159 | Medium | Slight Adverse | Slight Beneficial |
| 161 | Medium | Slight Adverse | Slight Beneficial |
| 162 | High | Neutral | Neutral |
| 165 | Low | Neutral | Neutral |
| 166 | Low | Neutral | Neutral |
| 168 | Medium | Neutral | Neutral |
| 170 | Medium | Neutral | Neutral |

### Loss of Natural Bed Form and Sediment Inputs

4.2.3 The permanent loss of natural bed form will occur where pipe culverts are to replace a natural (adjustable) channel bed. However, it should be noted that for the main line, where pipe culverts are proposed in the design, they replace and extend an existing pipe culvert (albeit in an offset location), so loss of natural bed will be minimal. Permanent loss of natural bed will also occur, to a lesser extent where outfall headwalls and any bank protection works occur.

4.2.4 The existing bed substrate will also be removed in the shorter term through the installation of box culverts and channel diversions, but over time a natural bed should reform in these situations, and these culvert types are often replacing current pipe culverts, improving the current conditions by encouraging a more natural bed to form over the long term.

4.2.5 The loss of natural bed will reduce the morphological diversity of the channel bed and will alter the sediment supply from the bed. This will have an adverse impact on the natural processes and morphological diversity of the channel at the location of engineering and in downstream reaches where the bed is currently able to erode and add sediment to the channel.

### Replacement of Natural Bed Form and Sediment Inputs

4.2.6 In some instances, the natural bed form of the channel (or similar) will be replaced by the Proposed Scheme, for example, where a pipe culvert is to be replaced with a box culvert, where a culvert is removed and where alterations to bridges are proposed to allow more natural bed forms. This will have a beneficial impact on the watercourses by improving the natural processes, sediment continuity and morphology within the bed of the channel.

### Loss of Natural Bank Form and Sediment Inputs

4.2.7 A permanent loss of natural bank form will occur through the installation of erosion protection, head walls, channel realignment (to a limited extent) and culverts. This will only impact on the channel where banks are currently natural in form, as opposed to where they are currently engineered. The loss of natural bank form will result in reduced sediment supply from these banks that may impact on the processes and morphological diversity of the channel at the location of engineering and in downstream reaches. This will have an adverse impact on the morphology and sediment regime of the channel where banks are currently able to erode and add sediment to the channel.

### Fixing Channel Position

4.2.8 Culverts, bank protection, headwalls and bridges all involve fixing the current position of the channel (planform and vertical), limiting the channel's ability to respond to environmental change through channel adjustment. This may result in scour to the engineered structures and bed, changing the current processes and potentially sediment regime. It reduces the resilience of the channel to future changes in water and sediment inputs (climate and/or land-use change). The degree of significance of the impacts varies depending on the extent of the works on the channel and the location of existing infrastructure/ hard engineering, but it will impact the watercourse for the length of the works.

### Change in Flow Conditions

4.2.9 All of the works have the potential to alter the flow conditions (discharge and velocity, as well as flow patterns) within the channels. The changes from natural to engineered channels (addition/ extension of culverts, realignments, bridges) have a local adverse impact on the flows in the waterbodies. Similarly, at outfalls and other areas where water is moved across catchments, the natural discharge of the channels is altered, changing flow, sediment regime and potential processes (locations of erosion and deposition) away from the existing

4.2.10 Where current culverts and bridges are causing reduced downstream discharge under high flow events this pressure is proposed to be removed as part of the Proposed Scheme. So a more natural flow (and resultant sediment regime) will be achieved. This will have a beneficial impact on flows within watercourse where the structure sits (upstream and downstream), as well as in the receiving downstream with the potential to improve morphology and processes.

4.2.11 The proposed replacement River Spey Bridge (Hydro ID 152), will naturalise the flow conditions of the Spey locally under all flows, as the piers will be removed from the existing channel, and the embankment length will be reduced, to create more natural flow conditions upstream and downstream and to increase channel-floodplain coupling.

### Change in Continuity of Sediment Transfer

4.2.12 Significant steps, culverts and channel diversions have the potential to alter the continuity of sediment transfer, by causing excessive erosion or deposition. For example, the significant steps (catchment pits, weirs etc.) hold back the sediment, reducing its downstream transfer.

4.2.13 Undersized culverts hold back the flow, causing sediment to drop out upstream (creating and area of deposition) and then have excessive energy downstream of the culvert so cause scour. Equally increasing the downstream discharge of a channel could destabilise the channel causing excessive erosion and incision as it adjusts, and thus producing and transporting excess sediment.

4.2.14 The upsizing of culverts will improve the downstream continuity of sediment transfer as long as the downstream channels are suitably sized, as sediment will be moved through the culvert rather than being deposited upstream as water backs up behind the culvert, but this may lead to downstream channel adjustment.

4.2.15 The removal of catch pits and other significant steps as part of the design has the potential to increase the continuity of downstream sediment transfer, improving downstream morphology and processes and having a beneficial impact of the waterbodies.

4.2.16 The change of culverts from pipe to arch or box, as well as alterations to bridges to allow a more natural bed will also improve the continuity of sediment transfer, having a beneficial impact on the waterbody.

4.2.17 The proposed replacement River Spey Bridge (Hydro ID 152) will naturalise the upstream and downstream sediment continuity in the Spey locally under all flow conditions. Piers will be removed from the channel, improving low and normal conditions, and the restriction to high flows will be removed, allowing more natural channel-floodplain interaction.

### Change in Sediment Dynamics

4.2.18 The works will alter the sediment inputs to the channel, as well as changing the way that the sediment moves within the waterbody. These changes will result in a change to sediment dynamics and natural processes within the channel at the location of the works and in the reaches downstream.

4.2.19 Excessive erosion of the created by the works have the potential to generate excessive sediment (as more sediment is available from the embankment that would be from the channel banks), and change patterns of deposition within the channels. Conversely areas of bank protection stop the inputs of sediment to the channel from erosion, also changing sediment dynamics.

4.2.20 The proposed replacement River Spey Bridge will naturalise the movement of sediment in the Spey under all flow conditions, as the piers will be removed from the channel, and the embankment length will be reduced, to create more natural flow conditions.

# 5 Mitigation

## 5.1 Construction Impacts – Standard Mitigation

5.1.1 'Standard' mitigation for the shorter term construction impacts of the Proposed Scheme has been introduced throughout and the measures outlined in **Table 9**: are relevant to the hydromorphological aspects of the proposed works.

*Table 9: Standard mitigation relevant to Hydromorphology*

| Mitigation Item | Approximate Chainage/ Location | Timing of Measure | Description | Mitigation Purpose/Objective | Specific Consultation or Approval Required |
|---|---|---|---|---|---|
| **Standard A9 Mitigation** | | | | | |
| SMC-W1 | Throughout proposed scheme | Design, Pre-construction & Construction | In relation to authorisations under CAR, the Contractor will be required to provide a detailed Construction Method Statement which will include proposed mitigation measures for specific activities including any requirements identified through the pre-CAR application consultation process. | To mitigate construction impacts on the water environment. | CAR applications require approval from SEPA |
| SMC-W2 | Throughout proposed scheme | Pre-construction & Construction | In relation to flood risk, the Contractor will implement the following mitigation measures during construction:<br>• The Flood Response Plan (as part of the CEMP) will set out the following mitigation measures to be implemented when working within the functional floodplain (defined here as the 0.5% AEP (200-year) flood extent):<br>  • Routinely check the Met Office Weather Warnings and the SEPA Floodline alert service for potential storm events (or snow melt), flood alerts and warnings relevant to the area of the construction works.<br>  • During periods of heavy rainfall or extended periods of wet weather (in the immediate locality or wider river catchment) river levels will be monitored using for example SEPA Water Level Data when available/visual inspection of water features. The Contractor will assess any change from base flow condition and be familiar with the normal dry weather flow conditions for the water feature, and be familiar with the likely hydrological response of the water feature to heavy rainfall (in terms of time to peak, likely flood extents) and windows of opportunity to respond should river levels rise.<br>  • Should flooding be predicted, works close or within the water features should be immediately withdrawn (if practicable) from high risk areas (defined as: within the channel or within the bankfull channel zone - usually the 50% (2-year) AEP flood extent). Works should retreat to above the 10% AEP (10-year) flood extent) with monitoring and alerts for further mobilisation outside the functional floodplain should river levels continue to rise.<br>• Plant and materials will be stored in areas outside the functional floodplain where practicable, with the aim for temporary construction works to be resistant or resilient to flooding impacts, to minimise/prevent movement or damage during potential flooding events.<br>• Stockpiling of material within the functional floodplain, if unavoidable, will be carefully controlled with limits to the extent of stockpiling within an area, to prevent compartmentalisation of the floodplain, and stockpiles will be located >10m from watercourse banks. | To reduce the risk of flooding impacts on construction works. | None required |

| Mitigation Item | Approximate Chainage/ Location | Timing of Measure | Description | Mitigation Purpose/Objective | Specific Consultation or Approval Required |
|---|---|---|---|---|---|
| | | | • Temporary drainage systems will be implemented to alleviate localised surface water flood risk and prevent obstruction of existing surface runoff pathways. Where practicable, temporary haul routes will be located outside of the functional floodplain. | | |
| SMC-W3 | Throughout proposed scheme | Pre-construction, Construction & Post-Construction/ Operation | In relation to construction site runoff and sedimentation, the Contractor will adhere to GPPs/PGGs (SEPA, 2006-2017) and other good practice guidance and implement appropriate measures which will include, but may not be limited to:<br>• avoiding unnecessary stockpiling of materials and exposure of bare surfaces, limiting topsoil stripping to areas where bulk earthworks are immediately programmed;<br>• installation of temporary drainage systems/SuDS systems (or equivalent) including pre-earthworks drainage;<br>• treatment facilities to be scheduled for construction early in the programme, to allow settlement and treatment of any pollutants contained in site runoff and to control the rate of flow before water is discharged into a receiving watercourse;<br>• the adoption of silt fences, check dams, settlement lagoons, soakaways and other sediment trap structures as appropriate;<br>• the maintenance and regrading of haulage route surfaces where issues are encountered with the breakdown of the existing surface and generation of fine sediment;<br>• provision of wheel washes at appropriate locations (in terms of proposed construction activities) and >10m from water features;<br>• protecting soil stockpiles using bunds, silt fencing and peripheral cut-off ditches, and location of stockpiles at distances >10m; and<br>• restoration of bare surfaces (seeding and planting) throughout the construction period as soon as possible after the work has been completed, or protecting exposed ground with geotextiles if to be left exposed | To implement appropriate controls for site runoff and sedimentation and reduce impacts on the water environment. | If flocculants are considered necessary to aid settlement of fine suspended solids, such as clay particles, the chemicals used must first be approved by SEPA.<br>Where required, temporary discharge consents to be obtained from SEPA through the Water Environment (Controlled Activities) (Scotland) Regulations 2011. |
| SMC-W4 | Throughout proposed scheme | Pre-construction & Construction | In relation to in-channel working, the Contractor will adhere to GPPs/PPGS (SEPA, 2006-2017) and other good practice guidance, and implement appropriate measures which will include, but may not be limited to:<br>• undertaking in-channel works during low flow periods (i.e. when flows are at or below the mean average) as far as reasonably practicable to reduce the potential for sediment release and scour;<br>• no in-channel working during the salmonid spawning seasons unless permitted within any CAR licence; | To reduce impacts on the water environment during in-channel working. | Method statements for in-channel working may require approval by SEPA |

| Mitigation Item | Approximate Chainage/ Location | Timing of Measure | Description | Mitigation Purpose/Objective | Specific Consultation or Approval Required |
|---|---|---|---|---|---|
| | | | • minimise the length of channel disturbed and size of working corridor, with the use of silt fences or bunds where appropriate to prevent sediment being washed into the water feature;<br>• limit the removal of vegetation from the riparian corridor, and retaining vegetated buffer zone wherever reasonably practicable; and<br>• limit the amount of tracking adjacent to watercourses and avoid creation of new flow paths between exposed areas and new or existing channels. | | |
| SMC-W5 | Throughout proposed scheme | Construction | Where channel realignment is necessary, the Contractor will adhere to good practice guidance and implement appropriate measures which will include, but may not be limited to:<br>• Once a new channel is constructed, the flow should, where practicable, be diverted from the existing channel to the new course under normal/low flow conditions;<br>• diverting flow to a new channel should be timed to avoid forecast heavy rainfall events at the location and higher up in the catchment (the optimum time will be the spring and early summer months to allow vegetation establishment to help stabilise the new channel banks);<br>• with offline realignments, the flow will be diverted with a steady release of water into the newly constructed realignment to avoid entrainment of fine sediment or erosion of the new channel; and<br>• any proposed realignment works will be supervised by a suitably qualified fluvial geomorphologist. | To reduce impacts on the water environment where channel realignment is proposed. | Consultation with SEPA |
| SMC-W6 | Throughout proposed scheme | Construction | In relation to refuelling and storage of fuels, the Contractor will adhere to GPPs/PPGs (SEPA, 2006-2017) and other good practice guidance and implement appropriate measures which will include, but may not be limited to:<br>• only designated trained and competent operatives will be authorised to refuel plant;<br>• refuelling will be undertaken at designated refuelling areas (e.g. on hardstanding, with spill kits available, and >10m from water features) where practicable;<br>• appropriate measures will be adopted to avoid spillages (refer to Mitigation Item SMC-W7); and<br>• compliance with the Pollution Incident Control Plan (refer to Mitigation Item SMC-S1). | To avoid spillages and reduce impacts on the water environment in relation to refuelling. | None required |
| SMC-W9 | Throughout proposed scheme | Construction | In relation to concrete, cement and grout, the Contractor will adhere to GPPs/PPGs (SEPA, 2006-2017) and other good practice guidance and implement appropriate | To reduce impacts on the water environment in relation | Permission required from Scottish Water. |

| Mitigation Item | Approximate Chainage/ Location | Timing of Measure | Description | Mitigation Purpose/Objective | Specific Consultation or Approval Required |
|---|---|---|---|---|---|
| | | | measures which will include, but may not be limited to:<br>• concrete mixing and washing areas will:<br>  • be located more than 10m from water bodies;<br>  • have settlement and re-circulation systems for water reuse; and<br>  • have a contained area for washing out and cleaning of concrete batching plant or ready-mix lorries.<br>• wash-water will not be discharged to the water environment and will be disposed of appropriately either to the foul sewer (with permission from Scottish Water), or through containment and disposal to an authorised site;<br>• where concrete pouring is required within a channel, a dry working area will be created;<br>• where concrete pouring is required within 10m of a water feature or over a water feature, appropriate protection will be put in place to prevent spills entering the channel (e.g. isolation of working area, protective sheeting); and<br>• quick setting products (cement, concrete and grout) will be used for structures that are in or near to watercourses. | to concrete, cement and grout. | Consultation with SEPA. |
| SMC-W13 | Throughout proposed scheme | Design | In relation to bank reinforcement, design principles and mitigation measures will adhere to good practice (SEPA, 2008), which will include, but may not be limited to:<br>• non-engineering solutions and green engineering (e.g. vegetation, geotextile matting) to be the preference during options appraisal;<br>• requirements for grey engineering to control/prevent scour (e.g. rock armour, rip-rap, gabion baskets) to be minimised; and<br>• post project appraisal to identify if there are issues that can be investigated and addressed at an early stage. | To reduce impacts of in-channel structures on the water environment. | Consultation with SEPA |
| SMC-W14 | Throughout proposed scheme | Design | In relation to outfalls, specimen and detailed design will ensure compliance with good practice (e.g. CIRIA, 2015; The Highways Agency et al., 2004; SEPA, 2008), which will include, but may not be limited to:<br>• directing each outfall downstream to minimise impacts to flow patterns;<br>• avoiding projecting the outfall into the watercourse channel;<br>• avoid installation of outfalls at locations of known historical channel migration;<br>• avoid positioning in flow convergence zones or where there is evidence of active bank erosion/instability;<br>• directing an outfall away from the banks of a river to minimise any potential risk of erosion (particularly on the opposite bank); | To reduce impacts of outfalls on the water environment. | Consultation with SEPA |

| Mitigation Item | Approximate Chainage/ Location | Timing of Measure | Description | Mitigation Purpose/Objective | Specific Consultation or Approval Required |
|---|---|---|---|---|---|
| | | | • minimising the size/extent of the outfall headwall where possible to reduce the potential impact on the banks; and<br>• post project appraisal to identify if there are issues that can be investigated and addressed at an early stage as per mitigation Item SMC-W13. | | |
| SMC-W15 | Throughout proposed scheme | Design | In relation to culverts, specimen and detailed design will ensure compliance with good practice (SEPA, 2010), which will include, but may not be limited to:<br>• Detailed design shall mitigate flood risk impacts through appropriate hydraulic design of culvert structures. Flood risk shall be assessed against the 0.5%AEP (200-year) plus an allowance for climate change design flood event. Widening of the scheme footprint may lead to loss of existing floodplain storage volume. Detailed design shall mitigate this where required by appropriate provision of compensatory storage. Where culvert extension is not practicable or presents adverse impact on the water environment, appropriately designed replacement culverts may be installed.<br>• Detailed design shall mitigate impacts on the water environment through appropriate design of culvert structures and watercourse modifications (e.g. realignments) with respect to fluvial geomorphology, and both riparian and aquatic ecology.<br>• Detailed design of culverts and associated watercourse modifications shall incorporate wherever practical:<br>  • adherence to design standards and good practice guidance (Section 11.2);<br>  • allowance for the appropriate conveyance of water and sediment for a range of flows (including at low flow conditions);<br>  • maintenance of the existing channel gradient to avoid erosion at the head (upstream) or tail (downstream) end of a culvert;<br>  • avoidance of reduction of watercourse length through shortening of watercourse planform;<br>  • minimisation of culvert length;<br>  • close alignment of the culvert with the existing water feature;<br>  • depressing the invert of culverts to allow for formation of a more natural bed (embedment of the culvert invert to a depth of at least 0.15m to 0.3m); and<br>  • roughening of culvert inverts to help reduce water velocities. | To reduce impacts of culverts on the water environment. | Consultation with SEPA |
| SMC-W16 | Throughout proposed scheme | Design & Construction | In relation to channel realignments, specimen and detailed design will ensure compliance with good practice, which will include, but may not be limited to:<br>• minimising the length of the realignment, with the existing gradient maintained | To reduce impacts of channel realignment on the water environment. | Consultation with SEPA |

| Mitigation Item | Approximate Chainage/ Location | Timing of Measure | Description | Mitigation Purpose/Objective | Specific Consultation or Approval Required |
|---|---|---|---|---|---|
| | | | where possible;<br>• design of the realignment in accordance with channel type and gradient;<br>• if required, low flow channels or other design features to reduce the potential for siltation and provide an opportunity to improve the geomorphology of the water feature;<br>• realignment designs will be led by a suitably qualified fluvial geomorphologist;<br>• where realignments result in an increase or decrease of channel gradient, the following principles will be applied:<br>  • an increased gradient within the channel (resulting in higher stream energies) will require mitigation in the form of energy dissipation, which could include the creation of a step-pool sequence; boulder bed-checks; plunge pools at culvert outlets; and/or; increased sinuosity; and<br>  • a decrease in gradient within the channel will require mitigation in the form of the construction of a low flow channel to minimise the impacts on locally varying flow conditions and reduce the risk of siltation of the channel. | | |
| SMC-W17 | Throughout proposed scheme | Design & Construction | In relation to SuDS, the following mitigation measures will be implemented where possible:<br>• detailed design to adhere to design standards and good practice guidance, including The SuDS Manual (CIRIA, 2015) and SuDS for Roads (SCOTS, 2010);<br>• for each drainage run, a minimum of two levels of SuDS treatment within a 'treatment train' to limit the volume of discharge and risk to water quality, in agreement with SEPA and SNH;<br>• management of vegetation within ponds and drains through grass cutting, pruning of any marginal or aquatic vegetation (as appropriate to the SuDS component) and removal of any nuisance plants, especially trees;<br>• SuDS retention ponds will be designed with an impermeable liner to maintain a body of standing water and provide treatment volume;<br>• inspect inlets, outlets, banksides, structures and pipework for any blockage and/or structural damage and remediate where appropriate; and<br>• regular inspection and removal of accumulated sediment, litter, and debris from inlets, outlets, drains and ponds to avoid sub-optimal operation of SuDS. | To reduce impacts of drainage discharges on the water environment. | Where required, authorisation for the road drainage discharge under CAR 2011 (as amended) would be obtained from SEPA |

## 5.2 Operational Impacts - Embedded Mitigation

5.2.1 Mitigation for the long term operational impacts of the Proposed Scheme have been identified and incorporated into the developing Scheme Design (**Drawings 5.1 to 5.12, Volume 3**). These have been identified as 'embedded' mitigation. This mitigation is documented below for each of the identified impacts. The assessment has been repeated with the embedded mitigation in place (demonstrating the effect of the embedded mitigation) and the significance assigned to each catchment is summarised in **Table 8**.

5.2.2 As shown in the Hydromorphological Assessment Tables in **Annex 11.4.5**, there is no change in the significance of the impacts with the embedded mitigation in, as none of this mitigation reduces the extent or time of the impacts. However, mitigation requirements follows best practice required for statutory approvals (e.g. to ensure CAR authorisation).

### Loss of Natural Bed Form and Sediment Inputs

5.2.3 The following mitigation will compensate for the loss of natural bed form and sediment inputs to the channel caused by the various elements of the works. This has been embedded into the design for all watercourses:

- Use bridges or arch culverts where feasible to allow existing natural bed formation and vertical adjustment of the channel
- Depress the invert of pipe and box culverts to allow for the formation of a more natural bed (300mm) and add additional sediment if required
- Ensure that the natural bed is retained under bridges

### Loss of Natural Bank Form and Sediment Inputs

5.2.4 The following mitigation will compensate for the loss of natural bank form and sediment inputs to the channel caused by the various elements of the works. This has been embedded into the design:

- Set back Spey bridge abutments from river banks to reduce the extent of 'in-channel' engineering and remove piers from the channel to allow natural channel adjustment
- Safeguard watercourses from bank through sustainable channel realignment design and positioning of bridges, channel realignments, embankments (mainline and track) and SuDS basins, to ensure minimal disturbance to the channel banks

### Fixing Channel Position

5.2.5 The following mitigation will minimise the extent to which the position of the watercourses are fixed by the scheme:

- Minimise the size/ extent of the outfall headwall where possible to reduce potential impacts on the bed and banks
- Design outfalls and diversions to take into account changes in bank and bed position at their confluence with the "main river". Use 'green' engineering techniques and design to allow for adjustments in channel positon over time, for both the main channel they are feeding into, and the outfall/ diversion channel

- Ensure that bank erosion protection requirements are minimised on the watercourse through sustainable design of bridges, channel realignments, embankments and SuDS basins, to ensure channels can move laterally

### Change in Flow Conditions

5.2.6 The following mitigation will ensure minimal changes in flow conditions are caused by the various elements of the works. This mitigation has been embedded into the design:

- Allow for the passage of water and sediment for a range of flows (including at low flow conditions) by creating or ensuring the retention of a low flow channel/ slot within culverts and bridges, to ensure a suitable depth of flow in all conditions
- Avoid a change in river length through change in planform
- Design culverts, bridges and realignments to maintain appropriate flows and velocities by retaining channel length and slope
- Remove bridge piers from the Spey channel, and cut back the embankment to allow natural flows under a range of conditions

### Change in Continuity of Sediment Transfer

5.2.7 The following mitigation will ensure minimal changes in sediment transfer are caused by the various elements of the works. This mitigation has been embedded into the design:

- Allow for the passage of water and sediment for a range of flows (including at low flow conditions) by creating a low flow channel within the culvert in all locations, to ensure a suitable depth of flow in all conditions through the culvert
- Remove bridge piers from the Spey channel, and cut back the embankment to allow natural flows under a range of conditions

### Change in Sediment Dynamics

5.2.8 The following mitigation will ensure minimal changes in sediment dynamics that are caused by the various elements of the works. This mitigation has been embedded into the final Proposed Scheme design:

- Maintain natural channel gradient where possible to avoid erosion at the head or tail (downstream) end of the culvert and any realignments at all locations, to ensure stability of the culvert and to reduce the likely hood of a change in sediment transport
- Limit changes in channel length due to alteration in channel planform, potentially impacting on channel gradient and consequentially flow and sediment dynamics at all locations;
- Avoid a change in river length through change in planform
- Keep the length of culvert to a minimum and align the culvert with the existing watercourse at all locations, to ensure stability of the culvert and to reduce the likely hood of a change in sediment transport
- Areas of erosion protection to prevent long term excessive sediment supply
- Erosion protection to the channel or infrastructure, where this has been deemed to be a medium or high risk from fluvial erosion (**Annex 11.4.2**)

- Areas of erosion protection to bridge abutments where these are within the 1:200 year floodplain to prevent excessive erosion and sediment supply to the channel
- Remove bridge piers from the Spey channel, and cut back the embankment to allow natural flows and sediment transport under a range of conditions

## 5.3 Operational Impacts – Additional Project Specific Mitigation

5.3.1 'Additional' mitigation requirements have been identified following assessment of the developed Scheme Design and the assessment re-run, assuming this additional mitigation is in place. The significance of impacts for each watercourse is summarised in **Table 7**: in **Section 3** of this appendix giving the residual significance. (Note: the additional mitigation items identified follows best practice required for statutory approvals (e.g. to ensure CAR authorisation)). Additional mitigation is outlined below and shown on **Drawings 11.26-11.37** (**Volume 3**).

### Loss of Natural Bed Form and Sediment Inputs

5.3.2 The following additional mitigation will compensate for the loss of natural bed form and sediment inputs to the channel caused by the various elements of the works:

- For all channel realignments, incorporate varied bed profiles to help create diverse morphological form and resultant flow, processes and habitats. This variety will also help create more sustainable and stable channels, less likely to have a negative impact on the stability of the A9 embankments and crossings. **Annex 11.4.3** outlines the river morphology types that should be included for each channel diversion, with the details of these channel types in **Annex 11.4.6.**
- Remove existing hard engineered bed from the channel and replace with re-profiled natural banks, where previous engineering has been undertaken as part of the A9 and where this is within the scheme boundary
- Ensure all channel realignments have natural bed material of suitable size, shape, grade and geology for the watercourse, ideally from the bed of the channel that has been diverted, to allow for varied flow and sediment transport regime that help to support a wide range of habitats. Having bed material in the channel also helps to dissipate energy, creating a more sustainable channel
- Ensure that any imported bed material is of suitable size, shape grade and geology for the watercourse at detailed at detailed design stage. Where possible use material from the existing bed to ensure the continuation of downstream sediment movement. The quality and quantity of material should be determined on a site by site basis and this should take into account changes in the energy regime within the realigned watercourse
- Minimise the size/ extent of hard engineering on the outfall headwalls at all channels and use green engineering to reduce potential impact on the bed and banks. Ensure that outfalls are designed with anticipation for erosion and bed level change of the receiving channel over time as the channel they feed into changes position
- Increase the roughness of all culvert inverts to help reduce water velocities, dissipate energy and keep bed material in the culverts. Baffles or embedded cobbles may be required on steeper channel crossings (**see Annex 11.4.3.1)**
- Ensure that the natural bed material is retained/reinstated under all bridges

- For culverts include scour pools on exit to dissipate energy and reduce the extent of hard engineering required to the channel bed

### Loss of Natural Bank Form and Sediment Inputs

5.3.3 The following additional mitigation will compensate for the loss of natural bank form and sediment inputs to the channel caused by the various elements of the works:

- Incorporate varied bank profiles and varied channel bed and bank widths in channel realignments to allow the dissipation of energy through the creation of a range of form and flow conditions. This will create varied habitat as well as creating a suitable and stable channel
- Remove existing hard engineered banks from the channel and replace with re-profiled natural banks, where previous engineering has been undertaken as part of the A9 and where this is within the scheme boundary
- Minimise the size/extent of hard engineering on the outfall headwall to that which is absolutely required to reduce potential impact on the bed and banks

### Fixing Channel Position

5.3.4 The following additional mitigation will reduce the degree to which the channel is fixed by engineering and to create a more stable and sustainable system of watercourses:

- Design stable channel realignments with a suitable slope and form, that allow channel adjustment and reduce the need for hard engineering. For example on steep realignments ensure energy dissipation through the incorporating of larger clasts and step-pool sequences, on lower slopes create plane bed and plane-riffle channels (see **Annex 11.4.6** for the suggested river type for each realignment)
- Design outfalls allow for changes in bank and bed position at their confluence with the "main river". Use green engineering and design to allow for adjustments in channel position for both the main channel they are feeding into, and the outfall/diversion channel. This ensures that the engineering is not damaged as well as allowing the channel to migrate across its floodplain
- Ensure the confluences of realigned channels are designed to allow a degree of adjustment (vertical and lateral), as the receiver channel moves within its floodplain
- Ensure bridges are wide enough to allow lateral and vertical channel change, in order to reduce the need for erosion protection and to minimise damage to the structures
- Restore a more natural planform, bed and bank morphology to channels previously straightened as part of the construction of the original A9, within the scheme boundary
- Use green bank protection works where feasible as per SEPA's '*Reducing River Bank erosion- A Best Practice Guide for Farmers'*, as well as other more traditional green engineering solutions such as biodegradable geotextile or rip rap toe protection or log revetments to the bank toe

### Change in Flow Conditions

5.3.5 The following additional mitigation will limit the impacts on changes to flow conditions:

- Direct the flow from outfalls downstream to minimise impacts to flow patterns and to reduce the risk of erosion to the structure
- Direct the flows from outfalls away from the banks of the river to minimise any potential risk of erosion (particularly the opposite bank)
- Bridges should have a low flow channel and natural bed material in order to allow a suitable depth of flow under a range of flow conditions

### Change in Continuity of Sediment Transfer

5.3.6 The following additional mitigation will allow the continuity of downstream sediment transfer:

- Provide natural bed material in culverts, under bridges and in channel realignments for all channels, to ensure the continued downstream movement of sediment, as well as allowing damaged habitat to repair
- Add buried bed checks under steep channel realignments, through erodible material to reduce the risk of incision of the channel undermining and damaging the road, and production of excess sediment
- Resection channels that are currently experiencing excessive incision to create a more sustainable and stable channel and reduce excessive downstream sediment supply and reducing the risk of damage to the scheme within the scheme boundary
- Add scour pools at the downstream end of culverts to dissipate energy and control downstream erosion

### Change in Sediment Dynamics

5.3.7 The following additional mitigation will limit negative changes in sediment dynamics:

- Add buried bed checks under steep channel realignments, through erodible material to reduce the risk of incision of the channel undermining and damaging the road, and production of excess sediment
- Backfill channels after they have been diverted to reduce the risk of high flows entering the old channels and causing scour
- Ensure scour pools are designed on a site by site basis at the end of all culverts to dissipate excess energy
- Design in energy dissipation measures in culverts on a site by site basis to help retain bed material and reduce downstream scour

# 6 Residual Impacts

6.1.1 Residual impacts are those which remain following the implementation of all mitigation measures. **Table 8** summarises the significance of the residual impacts for the scheme, with the detail of the assessment presented in **Annex 11.4.5**, and this shows the Proposed Scheme will have neutral or beneficial impacts. As with the embedded mitigation there are few watercourses where the additional mitigation changes the significance of the impacts, however it follows best practice and will reduce the risk of damage to the infrastructure from the water environment.

# 7 Combined Effects

7.1.1 Within this appendix the impacts of each part of the works on each catchment have been assessed individually and then together to give the combined effects of the Proposed Scheme on each waterbody considered (See **Annex 11.4.5**). However, further combined effects within the Proposed Scheme will affect the hydromorphology of the channels within the scheme extent but not downstream. There will be multiple small changes to sediment transfer, discharge and velocity within the tributaries that flow into the River Truim and Spey. These have the potential to impact the form and processes of the Rivers Truim and Spey over long timescales.

7.1.2 Elements of the Proposed Scheme (e.g. increasing culvert and bridge capacity and providing a natural bed within culverts and under bridges) will increase sediment transfer from tributaries to the River Truim and Spey, creating more natural conditions than the baseline and returning the systems to something closer to those pre-dating the present trunk road. Whilst this will have a beneficial combined effect on the hydromorphology of the tributaries and the River Truim, localised erosion and deposition may occur in the short-term as the size, shape and location of channels adapt to changes in sediment and flow regimes.

7.1.3 The magnitude of the increases in sediment and water are unlikely to be great, and any adjustment of the River Truim and Spey are likely to be limited as the larger tributaries are unaffected by the existing A9 and the Proposed Scheme will still be adding water and sediment to the Spey. The magnitude of these inputs will also become reduced proportionally as downstream watercourses continue to input more sediment and water.

# 8 Monitoring Recommendations

8.1.1 Geomorphological post-project monitoring should be undertaken on all watercourses where works have been undertaken as part of routine maintenance and inspection to verify that the Proposed Scheme and mitigation are functioning as intended in relation the watercourses. Areas where the watercourse is having an unexpected impact on the Proposed Scheme should be identified, as well as areas where the Proposed Scheme is having an unexpected negative impact on waterbodies.

8.1.2 Monitoring on completion of the Proposed Scheme and periodically thereafter as well as after high flow events will provide a means to qualitatively assess geomorphological change in-channel and on the floodplain between successive surveys. It also enables a rapid, factual, and low-cost verification method. Monitoring locations should be chosen on completion of construction and should ensure generic coverage of the channel corridor and floodplain environment.

# 9 References

SEPA, 2011. Supporting Guidance (WAT-SG-21), Environmental Standards for River Morphology

SEPA, 2015. Supporting Guidance (WAT-SG-67), Assessing the Significance of Impacts - Social, Economic, Environmental

# Annex 11.4.1

## Initial Hydromorphological Scoping Assessment

| ID | Easting | Northing | Type | Upstream | | At crossing | | Downstream | | Initial Screening (in or out) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Erosion | Deposition | Erosion | Deposition | Erosion | Deposition | |
| 133 | 269009 | 794517 | other | Med | Low | Low | Low | Low | Low | In |
| 134 | 269167 | 795018 | minor | Low | Low | Low | Low | Low | Low | In |
| 135 | 269069 | 794600 | other | Low | Low | Low | Low | Low | Low | Out |
| 136 | 269209 | 795239 | minor | Low | Med | Low | Low | Low | Med | In |
| 140 | 270935 | 797287 | minor | Low | Low | Low | Low | Low | Low | In |
| 142 | 271172 | 797403 | minor | Low | Low | Low | Low | Low | Low | In |
| 143 | 271530 | 797516 | minor | Low | Low | Low | Med | Low | Med | In |
| 148 | 275060 | 799008 | minor | Low | Low | Low | Low | Low | Low | In |
| 149 | 275357 | 799172 | other | Low | Low | Low | Low | Low | Low | Out |
| 152 | 276440 | 800507 | major | High | High | High | High | High | High | In |
| 155 | 276859 | 801499 | major | Low | Med | Low | Med | Low | Med | in |
| 156 | 277042 | 801637 | minor | Low | Low | Low | Low | Low | Low | In |
| 157 | 277280 | 801734 | major | Low | High | Low | Low | Low | High | In |
| 158 | 277449 | 801793 | other | Low | Low | Low | Low | Low | Low | Out |
| 159 | 278203 | 801961 | minor | Low | Low | Low | Low | Low | Low | In |
| 161 | 278414 | 802016 | minor | Low | Low | Low | Low | Low | Low | In |
| 162 | 278960 | 802188 | major | Low | Med | Low | High | Low | High | In |
| 163 | 279339 | 802523 | other | Low | Low | Low | Low | Low | Low | Out |
| 164 | 279478 | 802669 | other | Low | Low | Low | Low | Low | Low | Out |
| 165 | 279673 | 802834 | minor | Low | Low | Low | Low | Low | Low | In |
| 166 | 280367 | 803311 | minor | Low | Low | Low | Low | Low | Low | In |
| 167 | 280589 | 803372 | other | Low | Low | Low | Low | Low | Low | Out |
| 168 | 280671 | 803470 | minor | Low | Low | Low | Low | Low | Low | In |
| 170 | 281173 | 803742 | major | Low | Low | Low | Low | Low | Low | In |
| 138_1 | 269416 | 795971 | other | Low | Low | Low | Low | Low | Med | In |
| 138_2 | 269711 | 796518 | minor | Med | Med | Low | Med | Med | Med | In |
| 139_1 | 270141 | 796889 | other | Low | Low | Low | Low | Low | Low | Out |
| 144_1 | 271686 | 797649 | minor | Low | Low | Low | Low | Low | Low | In |
| 144_3 | 272368 | 798064 | other | Low | Low | Low | Low | Low | Low | Out |
| 145_1 | 272808 | 798256 | major | Med | Med | Med | Med | Med | Med | In |
| 145_3 | 273090 | 798377 | other | Low | Low | Low | Low | Low | Low | Out |
| 146_1 | 273135 | 798428 | minor | Med | Med | Med | High | Med | Med | In |
| 146_3 | 274214 | 798791 | other | Low | Low | Low | Low | Low | Low | Out |
| 147_1 | 274403 | 798827 | major | Med | Med | Med | Med | Med | Med | In |

# Annex 11.4.2

## Erosion Risk Assessment

*Introduction*

11.4.2.1 Watercourse channels in the Proposed Scheme extent can be laterally and vertically dynamic. They adjust their position (vertical and lateral) and channel shape, size and slope overtime due to changes in water and sediment supply and move across their floodplains over time. This ongoing adjustment of the river channel has potential to damage the infrastructure associated with the A9. A review of erosion risk from the watercourses was undertaken and guidance provided to the design team to assist with development of the Scheme Design.

*Methodology*

11.4.2.2 A review of channel change in the vicinity of the developing Scheme Design was undertaken by a Hydromorphologist using OS mapping, aerial photography and the proposed design in GIS to highlight areas where the channel has recently migrated across its floodplain and where it is in close proximity to the existing and proposed infrastructure, or where the channel is eroding vertically (lowering) and this could undermine the infrastructure.

11.4.2.3 A risk assessment has been undertaken as follows for these locations relative to the developed Scheme Design:

- A 'channel stability' score between 1 and 3 has been assigned to each area of infrastructure as per **Table 1**, with 3 being an area of the least stable channel. Note that a score of 1 still indicates some instability in the channel.
- A 'proximity of infrastructure' score be score between 1 and 3 has been assigned to each area of infrastructure as per **Table 1**. The distance is based on the distance of the infrastructure to the bank top of the channel with measurements taken from the 2015 aerial photography (as the most recent dataset).
- A 'consequence of damage score' has then been assigned to each area as per **Table 1** based on the infrastructure at risk and its importance to the ongoing function of the A9.
- Likelihood of erosion at asset location has been calculated based on:
  - 'channel stability' + 'proximity of infrastructure' [score] / 2
  - (averaged to achieve equal weighting between the likelihood and consequence)
- A risk score has then been calculated based on Likelihood x Consequence Risk scores have been grouped as follows and results and scoring are presented in **Table 2**:
  - High risk: greater than 6
  - Medium risk: greater than 3, less than 6
  - Low Risk: less than 3

*Table 1: Scoring and reasoning for the difference elements of the risk assessment*

| Risk assessment element | Score | Reason |
|---|---|---|
| **Channel stability** | | |
| Very unstable | 3 | Evidence of channel change between current OS 1:10K and AP or evidence of instability from AP's (large bars and hillside erosion) |
| Unstable | 2 | Some change likely to have occurred but not mapped or change expected due to works (i.e. removal of hard bed) |
| Relatively stable | 1 | Little/ no evidence of channel change but potential for future change |
| Proximity of infrastructure to channel | | |
| - | 3 | Less than 5m to bank top |
| - | 2 | Between 5 and 10m to bank top |
| - | 1 | More than 10m to bank top |
| Consequence of damage | | |
| High | 3 | Will involve road being closed/ high cost to fix |
| Medium | 2 | Some impact on function of the road/ scheme and will require some cost to fix |
| Low | 1 | Little impact on function of the road |

### *Results*

11.4.2.4 Ten areas of 'at risk' infrastructure were identified during initial assessments, where the ongoing movement of a watercourse has the potential to impact the infrastructure (during the design life of the project). These areas are presented in **Figures 1 to 5** and in **Table 2** below along with high level guidance as to how to mitigate the erosion risk. This information has then been used by the design team to inform the Scheme Design.

11.4.2.5 It should be noted that these areas all have a likelihood of erosion to the assets over the life of the project assuming that current processes and patterns continue to occur. The works associated with the Proposed Scheme also have the potential to initiate new areas of erosion over the life of the scheme and these have not been considered here. The extent of the areas identified highlighted the asset at risk and should not been seen as the full extent of intervention required.

11.4.2.6 The following hierarchy should be used when considering the management options:

- Move infrastructure back from the watercourse where possible
- Set back protection from the watercourse to protect toe of embankment from scour rather than stopping the bank from moving
- Use green engineering techniques for in channel stabilisation
- Use hard engineering techniques for in channel stabilisation

*Table 2: Erosion risk assessment*

| Monitoring ID | Infrastructure age | Infrastructure type | Channel stability | Distance to asset from bank top (based on AP) | Consequence of damage | Channel stability score | Distance score | Likelihood score (Distance + Channel stability/2) | Consequence score | Risk (Likelihood x Consequence) | Risk | Potential management options |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | New | SUD's Outfall | Relatively stable | 0 | Low | 2 | 3 | 5 | 1 | 2.5 | Low | Move outfall to more stable location and/or ensure outfall is designed to allow change in channel position |
| 2 | Existing- but new channel realignment | Embankment | Relatively stable | 4 | High | 2 | 3 | 2.5 | 3 | 7.5 | High | Realign channel to the south away from the embankment and/or Ensure toe protection on embankment to ensure that channel realignment does not cause excessive erosion |
| 3 | New | Outfall | Relatively stable | 0 | Low | 2 | 3 | 2.5 | 1 | 2.5 | Low | Monitor outfall for blockage or erosion |
| 4 | New | SUD's Pond | Relatively stable | 21 | Low | 2 | 1 | 1.5 | 1 | 1.5 | Low | Undertake a stability assessment on the impact of the SUDs and drainage on the valley side to ensure there is no reduction in slope stability due to SUDs basin |

| Monitoring ID | Infrastructure age | Infrastructure type | Channel stability | Distance to asset from bank top (based on AP) | Consequence of damage | Channel stability score | Distance score | Likelihood score (Distance + Channel stability/2) | Consequence score | Risk (Likelihood x Consequence) | Risk | Potential management options |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | New | Outfall | Relatively stable | 0 | Low | 2 | 3 | 2.5 | 1 | 2.5 | Low | Monitor outfall for blockage or erosion |
| 6 | New | Tempoary SUD's outfall | Very unstable | 0 | Low | 3 | 3 | 3 | 1 | 3 | Medium | Monitor outfall for blockage or erosion |
| 7 | New | Bridge | Very unstable | 20 | High | 3 | 1 | 2 | 3 | 6 | High | Ensure that pier/abutment design is such that engineering of the channel is not required |
| 8 | New | SUD's Outfall | Very unstable | 0 | Low | 3 | 3 | 3 | 1 | 3 | Medium | Move outfall to more stable location on the Spey |
| 9 | New | SUD's Outfall | Very unstable | 0 | Low | 3 | 3 | 3 | 1 | 3 | Medium | Move outfall to more stable location on the Spey |
| 10 | New | Embankment | Relatively stable | 16 | High | 2 | 1 | 1.5 | 3 | 4.5 | Medium | Realign channel to the north away from the embankment and/or Ensure toe protection on embankment to ensure that channel does not cause excessive erosion |

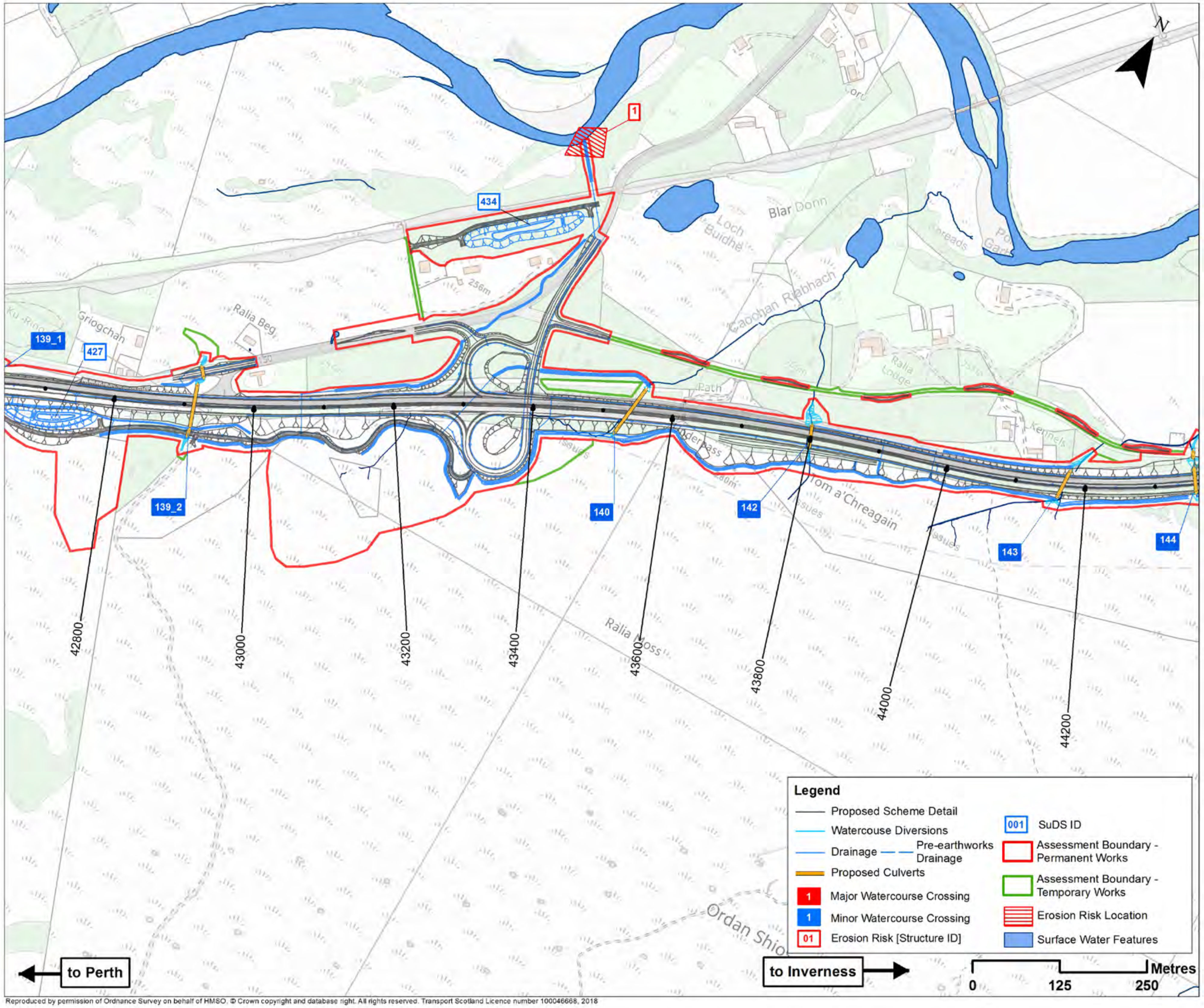


*Figure 1: Areas of erosion risk 1*

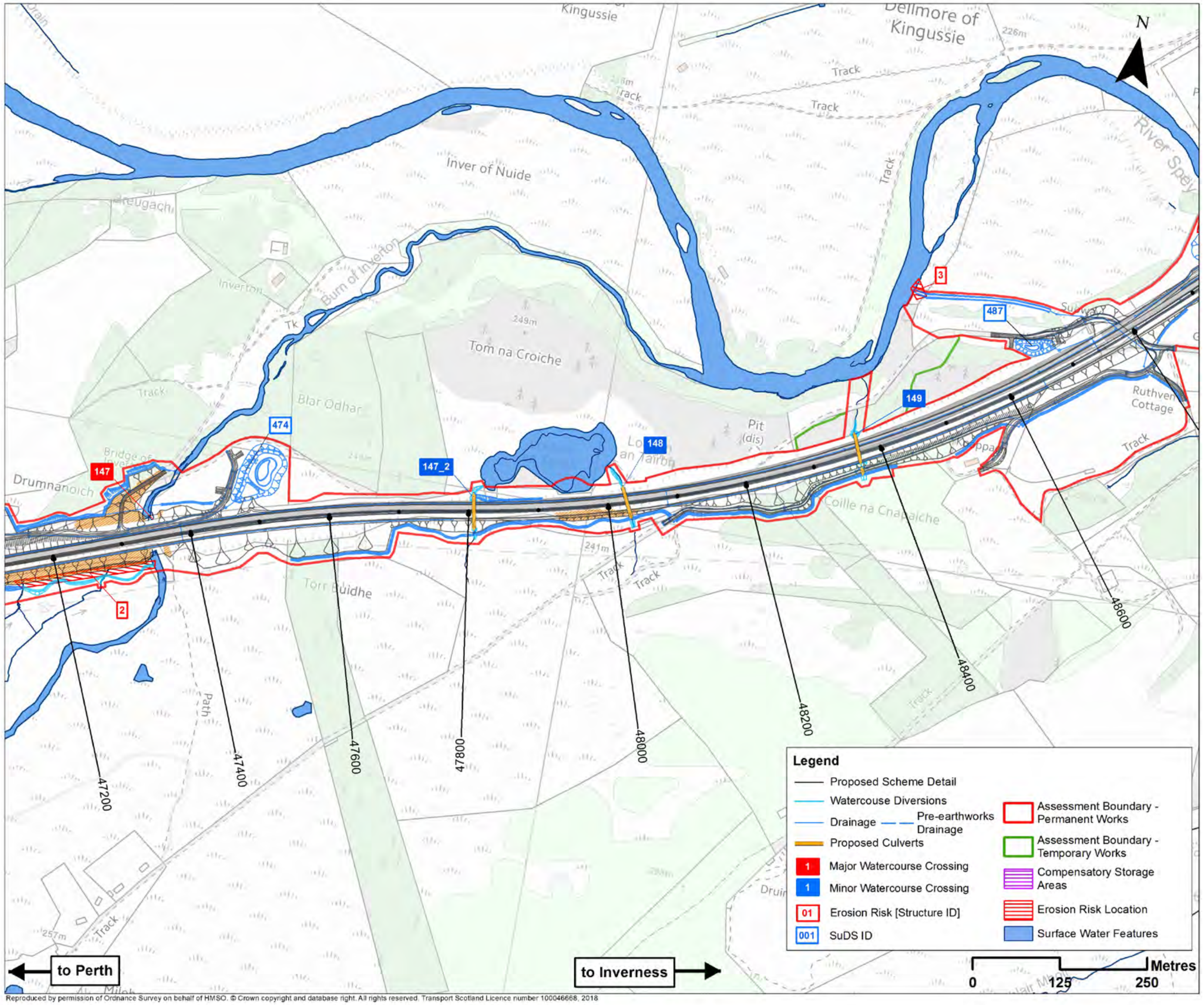


*Figure 2: Areas of erosion risk 2-3*

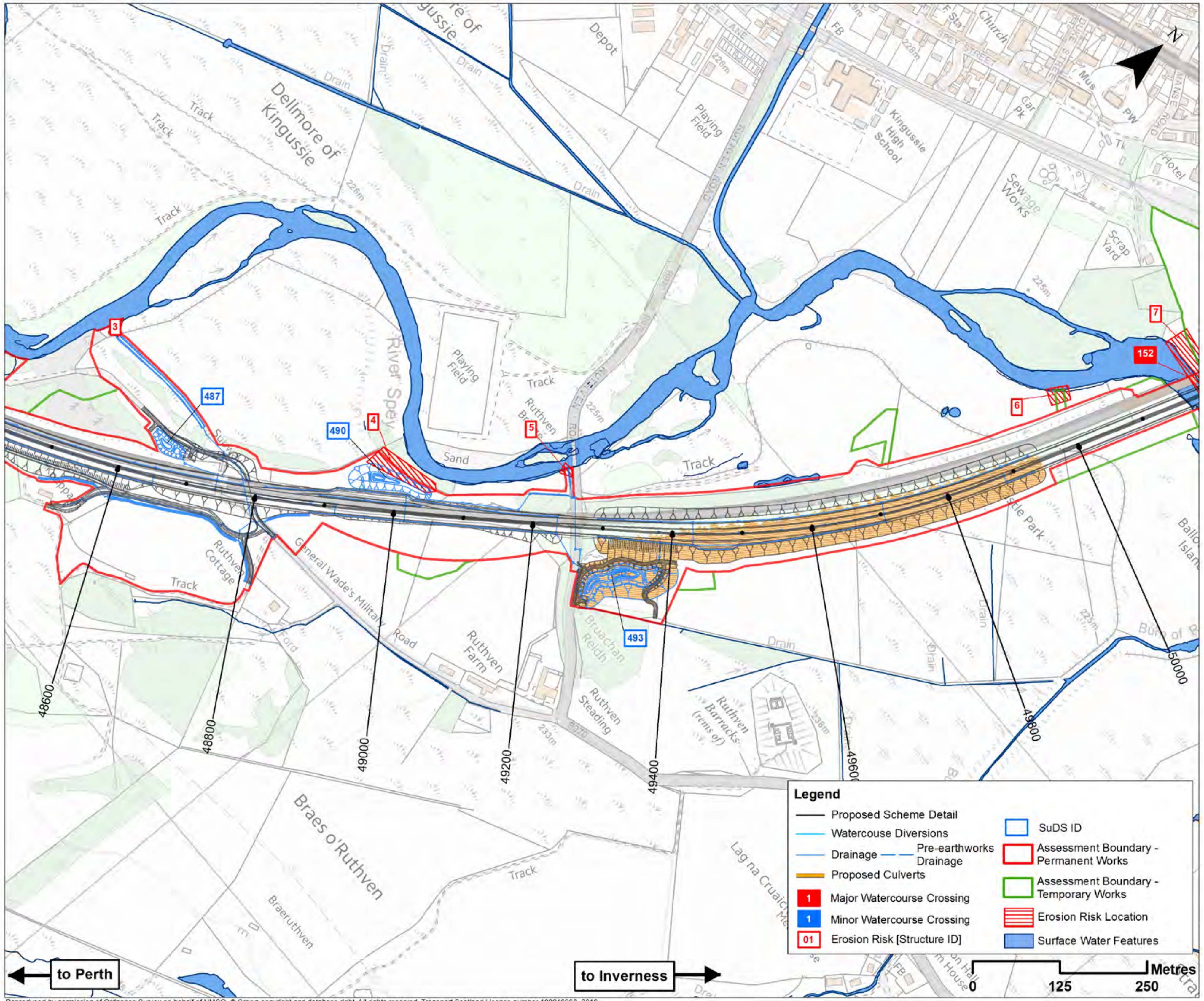



*Figure 3: Areas of erosion risk 3- 6*

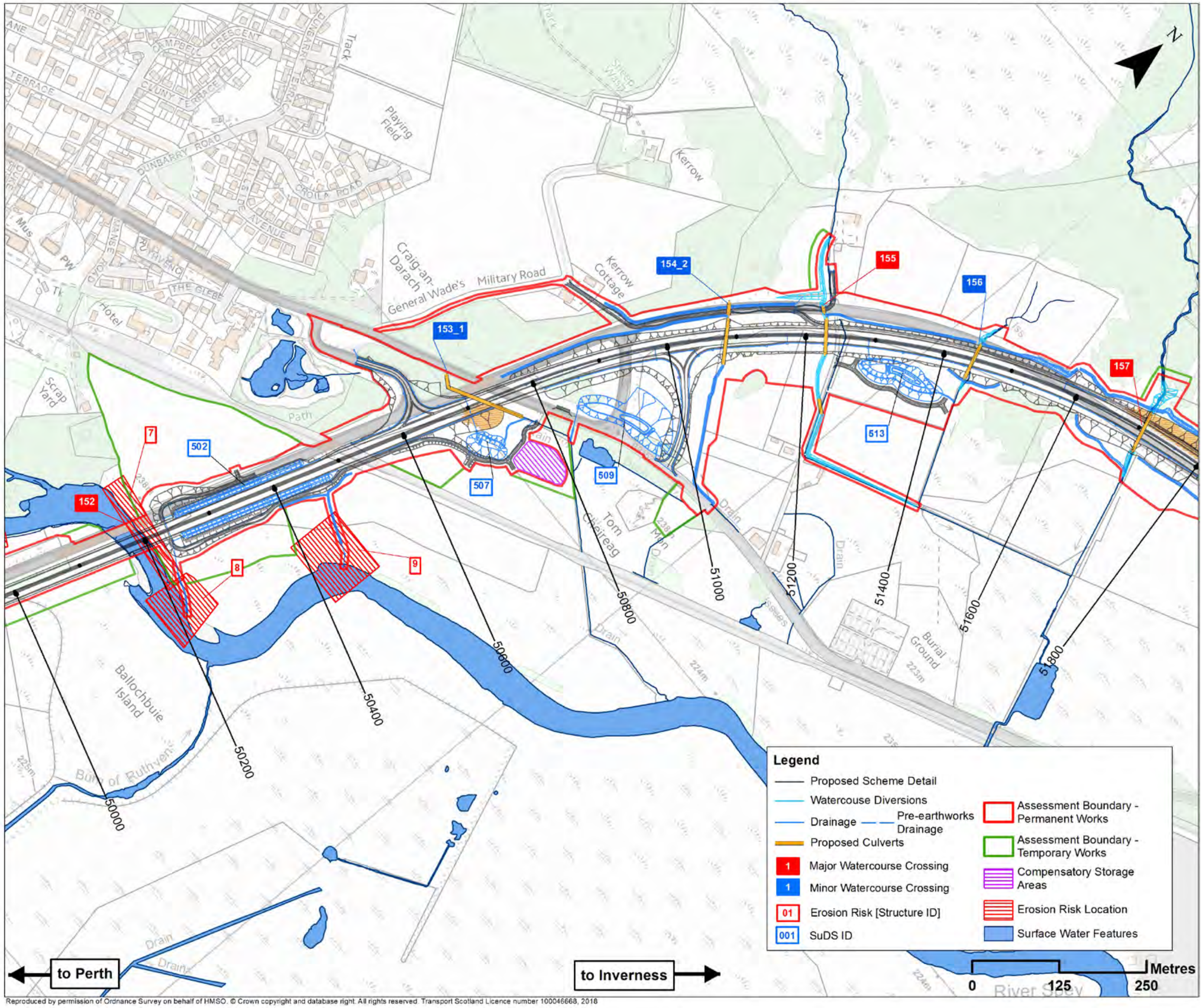


*Figure 4: Areas of erosion risk 7- 9*

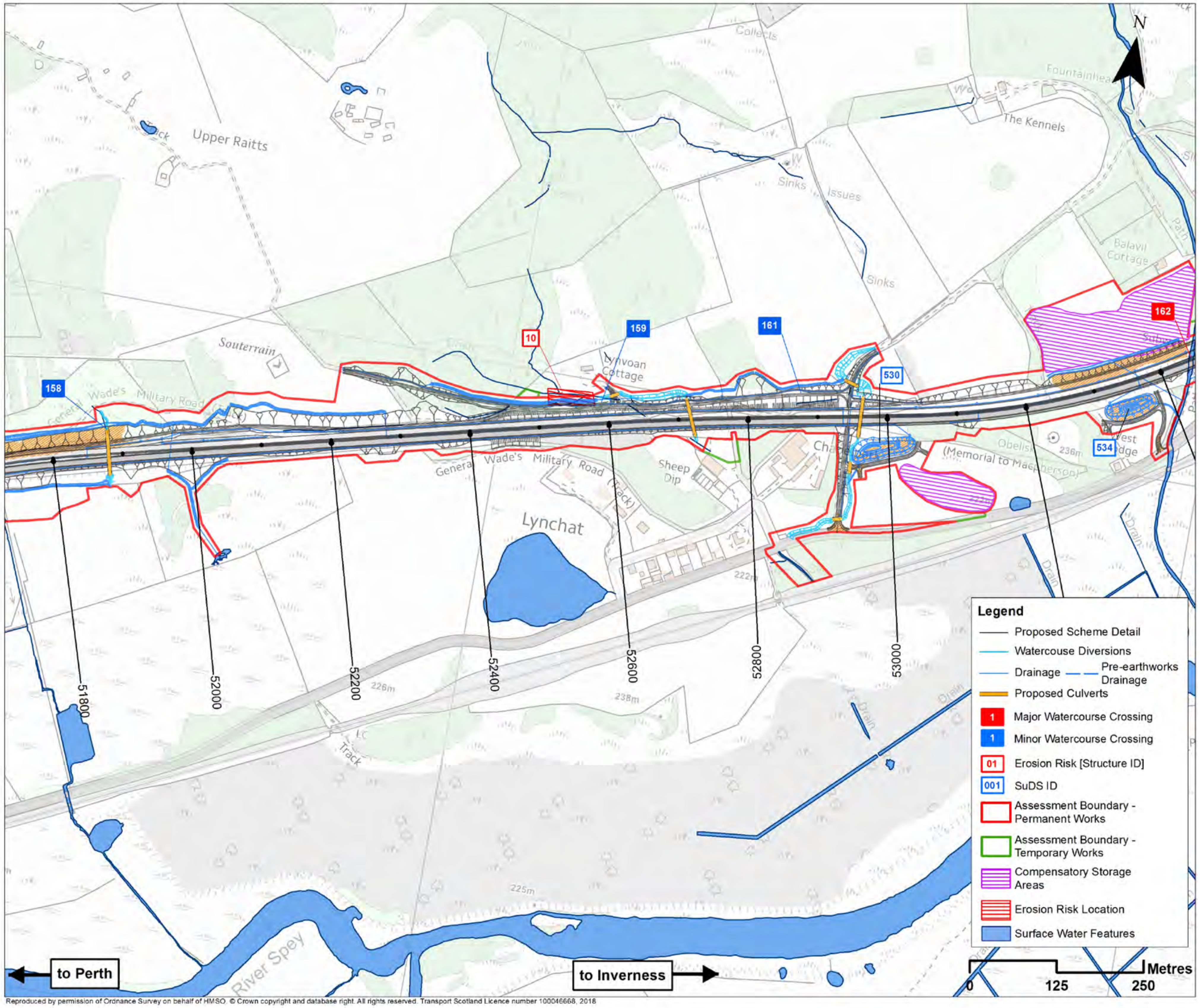


*Figure 5: Areas of erosion risk 10*

# Annex 11.4.3

## Details of the Design

### 11.4.3.1 Design information for river crossings

*Mainline crossings*

| Chainage | Hydro ID | DMRB2 watercourse classification | Mammal crossing provision | Bed material to be included in culvert | Culvert size (mm) | Upstream watercourse bed level | Downstream watercourse bed level | Culvert structure length | Gradient 1:X | Retaining wall at inlet [height (m)] | Scour pool [inlet/outlet] | Energy dissipation required |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40+450 | 134 | Minor | | Y | 1200 | 280.401 | 278.210 | 49.79 | 23 | | Outlet | Yes |
| 40+760 | 136 | Minor | Y | Y | 1500x1500 | 277.554 | 275.957 | 39.93 | 25 | Y [3.945] | Outlet | Yes |
| 42+050 | 138_2 | Major | | Y | 1500 | 261.490 | 261.14 | 40.13 | 118 | Y [3.070] | Outlet | |
| 42+900 | 139_2 | Other | | Y | 1500 | 255.061 | 254.228 | 58.27 | 71 | | Outlet | |
| 43+535 | 140 | Minor | Y | Y | 1500x1250 | 254.029 | 253.287 | 74.11 | 100 | | Outlet | |
| 43+800 | 142 | Minor | | Y | 1500 | 258.938 | 258.639 | 30.78 | 100 | Y [3.350] | Outlet | |
| 44+160 | 143 | Minor | | Y | 1350 | 262.250 | 260.422 | 42.03 | 23 | | Outlet | Yes |
| 44+375 | 144 | Minor | | Y | 1200 | 261.555 | 260.120 | 35.06 | 24 | Y [3.000] | Outlet | Yes |
| 45+650 | 145 | Major | | Y | 2700X2100 | 246.488 | 245.670 | 76.77 | 91 | | Outlet | |
| 46+040 | 146 | Minor | | Y | 1500x1800 | 236.365 | 233.368 | 72.62 | 24 | | Outlet | Yes |
| 47+350 | 147 | Major | | - | BRIDGE | - | - | - | - | | Outlet | |
| 47+800 | 147_2 | Other | | - | 900 | 234.763 | 234.294 | 46.85 | 100 | | Outlet | |
| 48+040 | 148 | Minor | | Y | 1350 | 237.330 | 235.570 | 36.86 | 21 | | Outlet | Yes |
| 48+360 | 149 | Other | Y | Y | 1375x1000 | 240.227 | 239.819 | 40.28 | 100 | Y [3.415] | Outlet | |
| 50+175 | 152 | Major | | Y | BRIDGE | - | - | - | - | | - | |
| 50+750 | 153_1 | Other | | - | 750 | TBC | TBC | TBC | TBC | | - | |
| 51+100 | 154_2 | Other | | Y | 1200 | 225.552 | 225.005 | 54.32 | 100 | | - | |
| 51+250 | 155 | Major | | Y | 2400x1800 | 227.077 | 226.629 | 46.73 | 100 | | Outlet | |
| 51+450 | 156 | Minor | | Y | 1200 | 227.987 | 226.762 | 46.24 | 38 | | Outlet | |
| 51+710 | 157 | Major | Y | Y | 3300 x 2400 | 227.903 | 225.470 | 60.61 | 25 | | Outlet | Yes |

| Chainage | Hydro ID | DMRB2 watercourse classification | Mammal crossing provision | Bed material to be included in culvert | Culvert size (mm) | Upstream watercourse bed level | Downstream watercourse bed level | Culvert structure length | Gradient 1:X | Retaining wall at inlet [height (m)] | Scour pool [inlet/outlet] | Energy dissipation required |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51+890 | 158 | Other | | Y | 1200 | 227.689 | 226.813 | 65.36 | 77 | | Outlet | |
| 52+600 | 159 | Minor | | Y | 2400x1800 | 231.442 | 229.396 | 51.19 | 25 | Y [4.430] | Outlet | Yes |
| 52+800 | 161 | Minor | | | 1500 | 224.969 | 224.457 | 50.90 | 100 | Y [1.590] | Outlet | |
| 53+450 | 162 | Major | | - | BRIDGE | - | - | - | - | - | - | |
| 54+395 | 165 | Minor | Y | Y | 1200x1200 | 233.804 | 233.041 | 76.25 | 100 | Y [4.430] | Outlet | |
| 55+270 | 166 | Minor | | Y | 1500x1500 | 242.912 | 242.523 | 38.43 | 25 | Y [4.570] | Outlet | Yes |
| 55+590 | 168 | Minor | | Y | 2400x1800 | 240.638 | 240.217 | 43.11 | 100 | Y [2.300] | Outlet | |
| 56+150 | 170 | Major | | Y | 1500 | 224.638 | 223.992 | 64.74 | 100 | | - | |

*Other crossings*

| Hydro ID | DMRB2 watercourse classification | Bed material to be included in culvert | Culvert Size | Upstream watercourse bed level | Downstream watercourse bed level | Culvert length | Gradient 1:X | Retaining wall at inlet [height (m)] | Scour pool [inlet/outlet] | Energy dissipation required |
|---|---|---|---|---|---|---|---|---|---|---|
| 138_2 - AT1 | Minor | Y | 1500 | 255.674 | TBC | 12.35 | TBC | | Outlet | |
| 139_2 - AT1 | Minor | Y | 1500 | 255.206 | 255.135 | 7.11 | 100 | | Outlet | |
| 139_2 - AT2 | Minor | Y | 1350 | 254.068 | 253.216 | 12.87 | 15 | | Outlet | |
| 144 - AT1 | Minor | Y | 1200 | 250.81 | 250.692 | 6.97 | 59 | | Outlet | |
| 149 - AT1 | Minor | Y | 1375x1000 | 244.923 | 244.838 | 8.38 | 100 | Y [1.615] | Outlet | |
| 154_2 – AT1 | - | Y | 1200 | 225.858 | 225.610 | 24.39 | 100 | | Outlet | |
| 155 - AT1 | Major | Y | 2400x1800 | 227.15 | 227.090 | 6.98 | 111 | Y [1.640] | Outlet | |
| 155 - AT2 | Major | | 900 | 225.47 | 225.177 | 17.98 | 63 | | Outlet | |
| 159 – AT1 | Minor | Y | 2400x1800 | 236.453 | 236.149 | 9.34 | 31 | | Outlet | Yes |
| 161 – AT1 | Minor | Y | 1500 | 226.551 | 226.455 | 13.16 | 130 | Y [0.600] | Outlet | |
| 161 – AT2 | Minor | Y | 1500 | 222.100 | 222.038 | 8.45 | 100 | Y [0.750] | Outlet | |
| 161 – AT3 | Minor | | 900 | 220.152 | 220.055 | 9.27 | 100 | Y [0.600] | Outlet | |
| 166 - AT1 | Minor | Y | 1500x1500 | 243.161 | 242.997 | 16.31 | 100 | Y [2.700] | Outlet | |
| 168 - AT1 | Minor | Y | 2400 x 1500 | 245.989 | 245.849 | 16.94 | 120 | | Outlet | |
| 168 – AT2 | Minor | Y | 2400 x 1200 | 220.22 | 219.764 | 11.34 | 25 | | Outlet | Yes |

| Chainage | Hydro ID | DMRB2 watercourse classification | Mammal crossing provision | Bed material to be included in culvert | Culvert size (mm) | Upstream watercourse bed level | Downstream watercourse bed level | Culvert structure length | Gradient 1:X | Retaining wall at inlet [height (m)] | Scour pool [inlet/outlet] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 40+450 | 134 | Minor | | Y | 1200 | 280.401 | 278.210 | 49.79 | 23 | | Outlet |
| 40+010 | 135 | Other | | - | - | - | - | - | - | | - |
| 40+760 | 136 | Minor | Y | Y | 1500x1500 | 277.554 | 275.957 | 39.93 | 25 | Y [3.945] | Outlet |
| 42+060 | 138_1 | Other | | - | - | - | - | - | - | | - |
| 42+050 | 138_2 | Major | | Y | 1500 | 261.490 | 261.14 | 40.13 | 118 | Y [3.070] | Outlet |
| 42+640 | 139_1 | Other | | - | - | - | - | - | - | | |
| 42+900 | 139_2 | Other | | Y | 1500 | 255.061 | 254.228 | 58.27 | 71 | | Outlet |
| 43+535 | 140 | Minor | Y | Y | 1500x1250 | 254.029 | 253.287 | 74.11 | 100 | | Outlet |
| 43+800 | 142 | Minor | | Y | 1500 | 258.938 | 258.639 | 30.78 | 100 | Y [3.350] | Outlet |
| 44+160 | 143 | Minor | | Y | 1350 | 262.250 | 260.422 | 42.03 | 23 | | Outlet |
| 44+375 | 144 | Minor | | Y | 1200 | 261.555 | 260.120 | 35.06 | 24 | Y [3.000] | Outlet |
| 45+650 | 145 | Major | | Y | 2700X2100 | 246.488 | 245.670 | 76.77 | 91 | | Outlet |
| 46+040 | 146 | Minor | | Y | 1500x1800 | 236.365 | 233.368 | 72.62 | 24 | | Outlet |
| 47+350 | 147 | Major | | - | BRIDGE | - | - | - | - | | Outlet |
| 47+800 | 147_2 | Other | | - | 900 | 234.763 | 234.294 | 46.85 | 100 | | Outlet |
| 48+040 | 148 | Minor | | Y | 1350 | 237.330 | 235.570 | 36.86 | 21 | | Outlet |
| 48+360 | 149 | Other | Y | Y | 1375x1000 | 240.227 | 239.819 | 40.28 | 100 | Y [3.415] | Outlet |
| 50+175 | 152 | Major | | Y | BRIDGE | - | - | - | - | | - |
| 50+750 | 153_1 | Other | | - | 750 | TBC | TBC | TBC | TBC | | - |
| 51+100 | 154_2 | Other | | Y | 1200 | 225.552 | 225.005 | 54.32 | 100 | | - |
| 51+250 | 155 | Major | | Y | 2400x1800 | 227.077 | 226.629 | 46.73 | 100 | | Outlet |
| 51+450 | 156 | Minor | | Y | 1200 | 227.987 | 226.762 | 46.24 | 38 | | Outlet |
| 51+710 | 157 | Major | Y | Y | 3300 x 2400 | 227.903 | 225.470 | 60.61 | 25 | | Outlet |
| 51+890 | 158 | Other | | Y | 1200 | 227.689 | 226.813 | 65.36 | 77 | | Outlet |
| 52+600 | 159 | Minor | | Y | 2400x1800 | 231.442 | 229.396 | 51.19 | 25 | Y [4.430] | Outlet |

| Chainage | Hydro ID | DMRB2 watercourse classification | Mammal crossing provision | Bed material to be included in culvert | Culvert size (mm) | Upstream watercourse bed level | Downstream watercourse bed level | Culvert structure length | Gradient 1:X | Retaining wall at inlet [height (m)] | Scour pool [inlet/outlet] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52+800 | 161 | Minor | | | 1500 | 224.969 | 224.457 | 50.90 | 100 | Y [1.590] | Outlet |
| 53+450 | 162 | Major | | - | BRIDGE | - | - | - | - | - | - |
| 53+975 | 163 | Other | | - | - | - | - | - | - | | |
| 54+160 | 164 | Other | | - | - | - | - | - | - | | |
| 54+395 | 165 | Minor | Y | Y | 1200x1200 | 233.804 | 233.041 | 76.25 | 100 | Y [4.430] | Outlet |
| 55+270 | 166 | Minor | | Y | 1500x1500 | 242.912 | 242.523 | 38.43 | 25 | Y [4.570] | Outlet |
| 55+590 | 168 | Minor | | Y | 2400x1800 | 240.638 | 240.217 | 43.11 | 100 | Y [2.300] | Outlet |
| 56+150 | 170 | Major | | Y | 1500 | 224.638 | 223.992 | 64.74 | 100 | | |

### *11.4.3.2 Scheme Design information for channel realignments*

| Hydro ID | Location (i.e. upstream or downstream of the A9) | Channel base width (m) | Minimum channel depth (m) | Channel side slopes (1:x) | Diversion length (m) | Longitudinal slope (1:x) | Longitudinal slope (m/m) | Top width (m) | Flow area ($m^2$) | Velocity (1:200 year flow) | Channel capacity | 200-year design flow ($m^3/s$) | Channel type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 142 | US | 0.5 | 0.5 | 2 | 22.11 | 2.2 | 0.4545 | 2.5 | 0.75 | 5.69 | 4.27 | 0.74 | Cascade |
| 144 | US | 0.5 | 0.5 | 2 | 12.29 | 2.49 | 0.4016 | 2.5 | 0.75 | 5.35 | 4.01 | 0.39 | Cascade |
| 149 | US AT | 0.5 | 0.5 | 2 | 7.46 | 7.63 | 0.1311 | 2.5 | 2.74 | 0.75 | 3.05 | 0.28 | Cascade |
| 149 | US | 0.5 | 0.5 | 2 | 7.46 | 7.63 | 0.1311 | 2.5 | 0.75 | 6.82 | 5.11 | 0.28 | Cascade |
| 159 | US | 0.5 | 0.5 | 2 | 7.06 | 1.53 | 0.6536 | 3 | 1 | 3.54 | 3.54 | 3.06 | Cascade |
| 166 | US | 1 | 0.5 | 2 | 15.32 | 20 | 0.0500 | 1.5 | 0.5 | 1.83 | 0.91 | 0.7 | Step-Pool |
| 168 | US | 0.5 | 0.75 | 1 | 95.52 | 9.09 | 0.1100 | 3.5 | 1.5 | 3.54 | 5.3 | 4.48 | Cascade |
| 144 | DS | 0.5 | 0.5 | 2 | 14.75 | 1.59 | 0.6289 | 2.5 | 0.75 | 6.7 | 5.02 | 0.39 | Cascade |
| 145 | DS | 1 | 1.1 | 2 | 14.91 | 59.88 | 0.0167 | 5.4 | 3.52 | 1.83 | 6.43 | 6.2 | Plane bed or Plane- Riffle depending on sinuosity |
| 146 | DS | 0.75 | 0.6 | 2 | 40.26 | 26.32 | 0.0380 | 3.15 | 1.17 | 1.9 | 2.23 | 2.13 | Step-Pool |
| 165 | DS | 0.5 | 0.5 | 2 | 52.45 | 24.39 | 0.0410 | 2.5 | 0.75 | 1.71 | 1.28 | 0.35 | Step-Pool |
| 166 | DS | 0.5 | 0.5 | 2 | 52.08 | 3.92 | 0.2551 | 2.5 | 0.75 | 4.26 | 3.2 | 0.7 | Cascade |
| 168 | DS | 0.5 | 0.5 | 2 | 38.81 | 1.94 | 0.5155 | 2.5 | 0.75 | 6.06 | 4.54 | 3.63 | Cascade |
| 134 | US | 0.5 | 0.5 | 2 | 49.55 | 100 | 0.0100 | 2.5 | 0.75 | 0.84 | 0.63 | 0.47 | Plane bed or Plane- Riffle depending on sinuosity |
| 136 | US | 0.5 | 0.5 | 2 | 81.61 | 58.82 | 0.0170 | 2.5 | 0.75 | 1.1 | 0.83 | 0.48 | Plane bed or Plane- Riffle depending on sinuosity |
| 136 | US VERGE | 0.5 | 0.6 | 1 | 55.78 | 90.91 | 0.0110 | 1.7 | 0.66 | 0.94 | 0.62 | 0.48 | Plane bed or Plane- Riffle depending on sinuosity |
| 138_2 | US | 1 | 0.71 | 2 | 102.73 | 14.08 | 0.0710 | 3.82 | 1.7 | 2.94 | 4.99 | 4.21 | Step-Pool |
| 138_2 | DS | 1 | 0.5 | 2 | 38.15 | 6.99 | 0.1431 | 3 | 1 | 3.46 | 3.46 | 4.21 | Cascade |
| 139_2 | US AT | 0.5 | 0.5 | 2 | 21.58 | 5.78 | 0.1730 | 2.5 | 0.75 | 3.51 | 2.63 | 0.92 | Cascade |
| 139_2 | US | 0.5 | 0.5 | 2 | 3.48 | 47.62 | 0.0210 | 2.5 | 0.75 | 1.22 | 0.92 | 0.92 | Plane bed or Plane- Riffle depending on sinuosity |
| 139_2 | DS | 0.5 | 0.6 | 2 | 13.44 | 83.33 | 0.0120 | 2.9 | 1.02 | 1.03 | 1.05 | 0.92 | Plane bed or Plane- Riffle depending on sinuosity |
| 139_2 | DS AT | 0.5 | 0.5 | 2 | 17.28 | 19.61 | 0.0510 | 2.5 | 0.75 | 1.91 | 1.43 | 0.92 | Step-Pool |
| 140 | US | 0.5 | 0.5 | 2 | 5.23 | 5.05 | 0.1980 | 2.5 | 0.75 | 3.76 | 2.82 | 0.66 | Cascade |
| 140 | DS | 0.5 | 0.5 | 2 | 7.4 | 100 | 0.0100 | 2.5 | 0.75 | 0.84 | 0.63 | 0.66 | Plane bed or Plane- Riffle depending on sinuosity |
| 142 | DS | 0.5 | 0.5 | 3 | 11.24 | 8.06 | 0.1241 | 3.5 | 1 | 2.96 | 2.96 | 0.74 | Cascade |
| 143 | US_1 | 0.5 | 0.5 | 2 | 18.1 | 9.8 | 0.1020 | 2.5 | 0.75 | 2.7 | 2.02 | 0.7 | Cascade |
| 143 | US_2 | 0.5 | 0.5 | 2 | 10.07 | 20.41 | 0.0490 | 2.5 | 0.75 | 1.87 | 1.4 | 0.7 | Step-Pool |
| 143 | DS | 0.5 | 0.5 | 3 | 41.05 | 33.33 | 0.0300 | 3.5 | 1 | 1.46 | 1.46 | 0.7 | Step-Pool |
| 144 | DS AT | 0.5 | 0.5 | 2 | 23.69 | 125 | 0.0080 | 2.5 | 0.75 | 0.75 | 0.57 | 0.39 | Plane bed or Plane- Riffle depending on sinuosity |
| 145 | DS | 1.2 | 0.8 | 2 | 64.93 | 13 | 0.0769 | 4.4 | 2.24 | 3.37 | 7.75 | 6.2 | Step-Pool |
| 146 | US | 0.5 | 0.5 | 2 | 41.51 | 8.62 | 0.1160 | 2.5 | 0.75 | 2.87 | 2.16 | 2.51 | Cascade |
| 147 | US | 0.75 | 0.7 | 2 | 191.47 | 100 | 0.0100 | 3.55 | 1.51 | 1.06 | 1.6 | - | Plane bed or Plane- Riffle depending on sinuosity |
| 147_2 | US | 0.5 | 0.5 | 2 | 13.65 | 25 | 0.0400 | 2.5 | 0.75 | 1.69 | 1.27 | - | Step-Pool |
| 147_2 | DS | 0.5 | 0.5 | 2 | 18.95 | 37.04 | 0.0270 | 2.5 | 0.75 | 1.39 | 1.04 | - | Plane bed or Plane- Riffle depending on sinuosity |
| 148 | US | 0.5 | 0.5 | 2 | 14.61 | 6.25 | 0.1600 | 2.5 | 0.75 | 3.38 | 2.53 | 0.74 | Cascade |
| 148 | DS | 0.5 | 0.5 | 2 | 32.29 | 8.33 | 0.1200 | 2.5 | 0.75 | 2.92 | 2.19 | 0.74 | Cascade |
| 149 | DS | 0.5 | 0.5 | 2 | 35.21 | 7.09 | 0.1410 | 2.5 | 0.75 | 3.17 | 2.38 | 0.28 | Cascade |
| 149 | DS AT | 0.5 | 0.5 | 2 | 39.41 | 3.29 | 0.3040 | 2.5 | 0.75 | 4.65 | 3.49 | 0.28 | Cascade |
| 155 | US AT | 1.2 | 0.7 | 1 | 102.54 | 22.73 | 0.0440 | 2.6 | 1.33 | 2.35 | 3.12 | 2.53 | Step-Pool |
| 155 | US | 1.2 | 1 | 1 | 9.62 | 90.91 | 0.0110 | 3.2 | 2.2 | 1.4 | 3.08 | 2.53 | Plane bed or Plane- Riffle depending on |

| Hydro ID | Location (i.e. upstream or downstream of the A9) | Channel base width (m) | Minimum channel depth (m) | Channel side slopes (1:x) | Diversion length (m) | Longitudinal slope (1:x) | Longitudinal slope (m/m) | Top width (m) | Flow area ($m^2$) | Velocity (1:200 year flow) | Channel capacity | 200-year design flow ($m^3/s$) | Channel type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | sinuosity |
| 155 | DS | 1.2 | 1 | 1 | 66.09 | 166.67 | 0.0060 | 3.2 | 2.2 | 1.04 | 2.28 | 2.53 | Plane bed or Plane- Riffle depending on sinuosity |
| 155 | DS AT 1 | 1.2 | 1 | 1 | 47.95 | 166.67 | 0.0060 | 3.2 | 2.2 | 1.04 | 2.28 | 2.53 | Plane bed or Plane- Riffle depending on sinuosity |
| **155** | **DS AT 2** | **1.2** | **0.8** | **2** | **137.38** | **100** | **0.0100** | **4.4** | **2.24** | **1.08** | **2.7** | **2.53** | Plane bed or Plane- Riffle depending on sinuosity |
| 156 | US | 0.5 | 0.5 | 2 | 33.66 | 31.25 | 0.0320 | 2.5 | 0.75 | 1.51 | 1.13 | 0.25 | Step-Pool |
| 156 | DS | 0.5 | 0.5 | 2 | 18.69 | 22.22 | 0.0450 | 2.5 | 0.75 | 1.79 | 1.34 | 0.25 | Step-Pool |
| 157 | US | 1.3 | 0.9 | 2 | 51.744 | 9.9 | 0.1010 | 4.9 | 2.79 | 4.29 | 11.97 | 10.26 | Cascade |
| 157 | DS | 1.2 | 1.2 | 2 | 37.06 | 30.3 | 0.0330 | 6 | 4.32 | 2.75 | 11.87 | 10.26 | Step-Pool |
| 158 | US | 0.5 | 0.5 | 1 | 29.62 | 11.36 | 0.0880 | 1.5 | 0.5 | 2.42 | 1.21 | 0.3 | Step-Pool |
| 158 | DS | 0.5 | 0.5 | 1 | 13.06 | 3.38 | 0.2959 | 1.5 | 0.5 | 4.45 | 2.22 | 0.3 | Cascade |
| 159 | US | 1 | 1 | 2 | 103.3 | 30.3 | 0.0330 | 3.8 | 1.68 | 1.99 | 3.35 | 3.06 | Step-Pool |
| 159 | US AT | 0.9 | 0.65 | 2 | 12.13 | 22.22 | 0.0450 | 3.5 | 1.43 | 2.21 | 3.16 | 3.06 | Step-Pool |
| 159 | DS | 0.75 | 0.7 | 2 | 9.464 | 4 | 0.2500 | 2.75 | 0.88 | 4.41 | 3.86 | 3.06 | Cascade |
| 161 | US | 0.5 | 0.5 | 1 | 66.56 | 13.51 | 0.0740 | 1.5 | 0.5 | 2.22 | 1.11 | 0.35 | Step-Pool |
| 161 | DS | 0.5 | 0.5 | 1 | 24.35 | 38.46 | 0.0260 | 1.5 | 0.5 | 1.32 | 0.66 | 0.35 | Plane bed or Plane- Riffle depending on sinuosity |
| 165 | US_2 | 0.5 | 0.5 | 2 | 42.86 | 16.95 | 0.0590 | 2.5 | 0.75 | 2.05 | 1.54 | 0.35 | Step-Pool |
| 168 | DS of B9152 | 1.5 | 1.5 | 2 | 137.26 | 625 | 0.0016 | 7.5 | 6.75 | 0.7 | 4.74 | 3.63 | Plane- Riffle |
| 170 | US | 1 | 0.6 | 3 | 40.59 | 12.15 | 0.0823 | 4.6 | 1.68 | 2.85 | 4.79 | 4.84 | Step-Pool |
| 170 | DS | 1.05 | 0.7 | 1 | 3.83 | 7.41 | 0.1350 | 2.45 | 1.23 | 4.02 | 4.92 | 4.84 | Cascade |