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 7 – Glen Garry to Dalwhinnie of the A9 Dualling Programme. It supports the summarised findings presented in **Chapter 11** of the Environmental Statement. The Proposed Scheme that was assessed is described in **Chapter 5** of the Environmental Statement.

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 and River Tay catchments. Often '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 at any given site 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 Project 7 (**Section 2**: Approach and Methods). It documents the baseline conditions that represent the current environmental state of the water features within the study area without the construction and operation of the Proposed Scheme (**Section 3**: Baseline Conditions).

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**: Potential Impacts).

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

2 Approach and Methods

2.1.1 This section of the report provides an explanation of the process that has been followed in order to undertake the hydromorphological assessment of the scheme proposals.

Establishing Baseline Conditions

2.1.2 In total, 58 watercourses have been identified as crossing the A9 between Glen Garry and Dalwhinnie. All are potentially impacted by the Project 7 works with 8 additional watercourses located in the proposed tie-in section to the south (**Figure 1**).

2.1.3 These watercourses have been identified from remotely sensed data and Ordnance Survey (OS) mapping, and subsequently verified via site walkover surveys. Each of these watercourses has been given a unique ID number that is used throughout this appendix and its annexes.

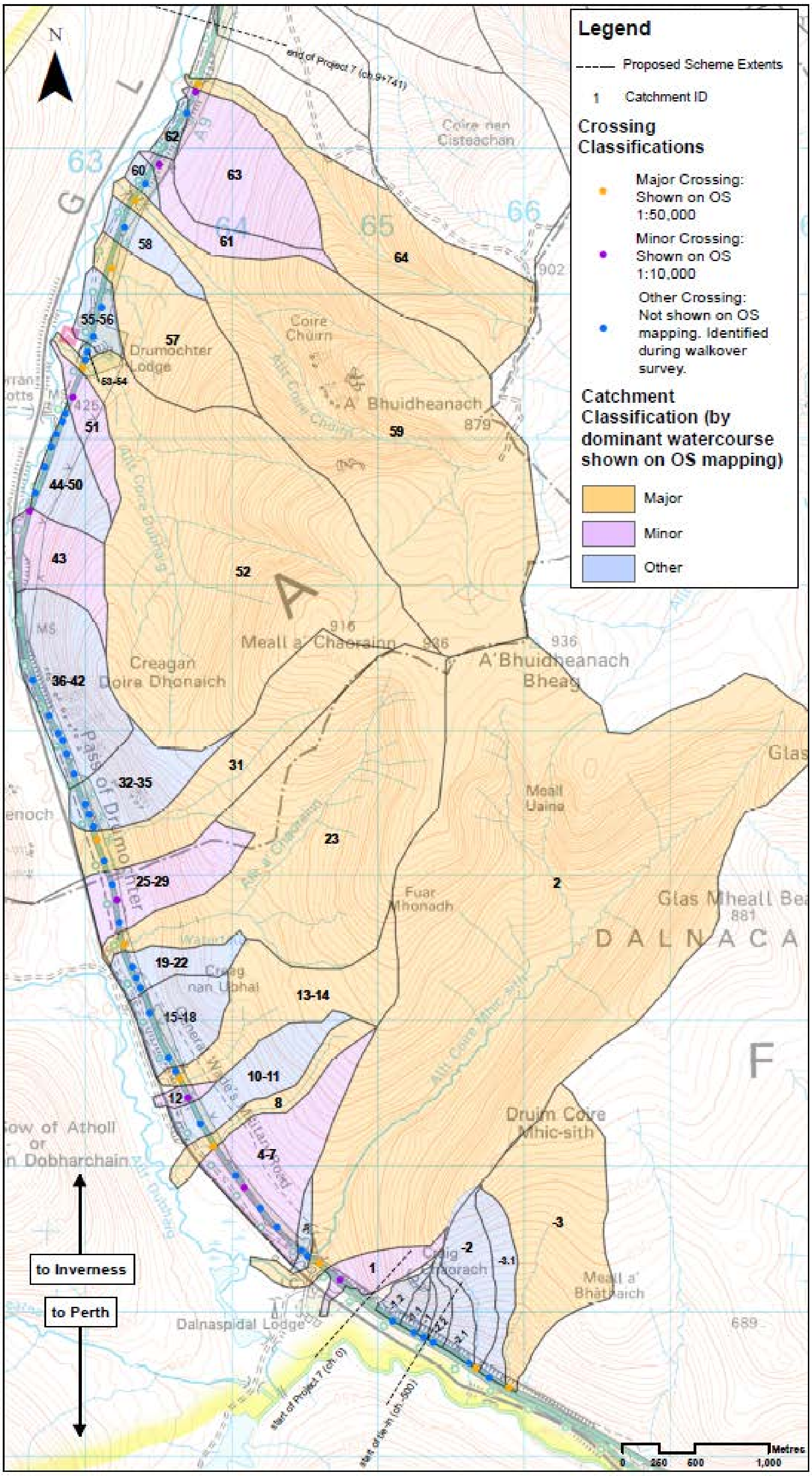

Figure 1:Watercourse catchment ID's

2.1.4 For the purposes of the hydromorphological assessment each of these watercourses has then been classified as either ‘Major’, ‘Minor’ or ‘Other’ based on how the watercourse is depicted on OS mapping:

- ‘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’ watercourse crossings are those not shown on OS mapping but identified during walkover surveys

2.1.5 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. It should be noted that 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.

2.1.6 The first phase of the hydromorphological baseline condition assessment 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.

2.1.7 All crossings that were 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 in the vicinity of the crossing were excluded from the more detailed assessment. In general terms the channels excluded from the scope of the detailed assessment are short, manmade drains and have small catchments, little sediment availability and no evidence for recent hydromorphological activity. Many are drains created during the construction of the existing A9. This has resulted in 26 watercourses being scoped out, leaving 32 included in the second phase of assessment.

2.1.8 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 posed to any structures, earthworks or other built features within the catchments were also identified.

2.1.9 As well as 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 (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 (BGS) Data (1:50,000)
- Scottish Natural Heritage (SNH) Environmental Designation Data
- historical mapping (1800s)
- SEPA's Water Framework Directive (WFD) information.

2.1.10 For each catchment included in the scope of the detailed assessment, the above data have been used 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 (Highland Mainline (HML) railway, Non-Motorised User (NMU) routes, residences, water supply infrastructure).

2.1.11 A walkover survey of the Major crossings and some Minor and Other crossings was undertaken between the 24th and 28th August 2015. During this walkover a number of georeferenced photographs were taken. Current form, processes and channel behaviour were noted for the area upstream, downstream and at the crossings (these have been included in the baseline).

Sensitivity of Channels

2.1.12 The hydromorphological assessment of the DMRB Stage 3 EIA has been undertaken for 33 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.

2.1.13 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.

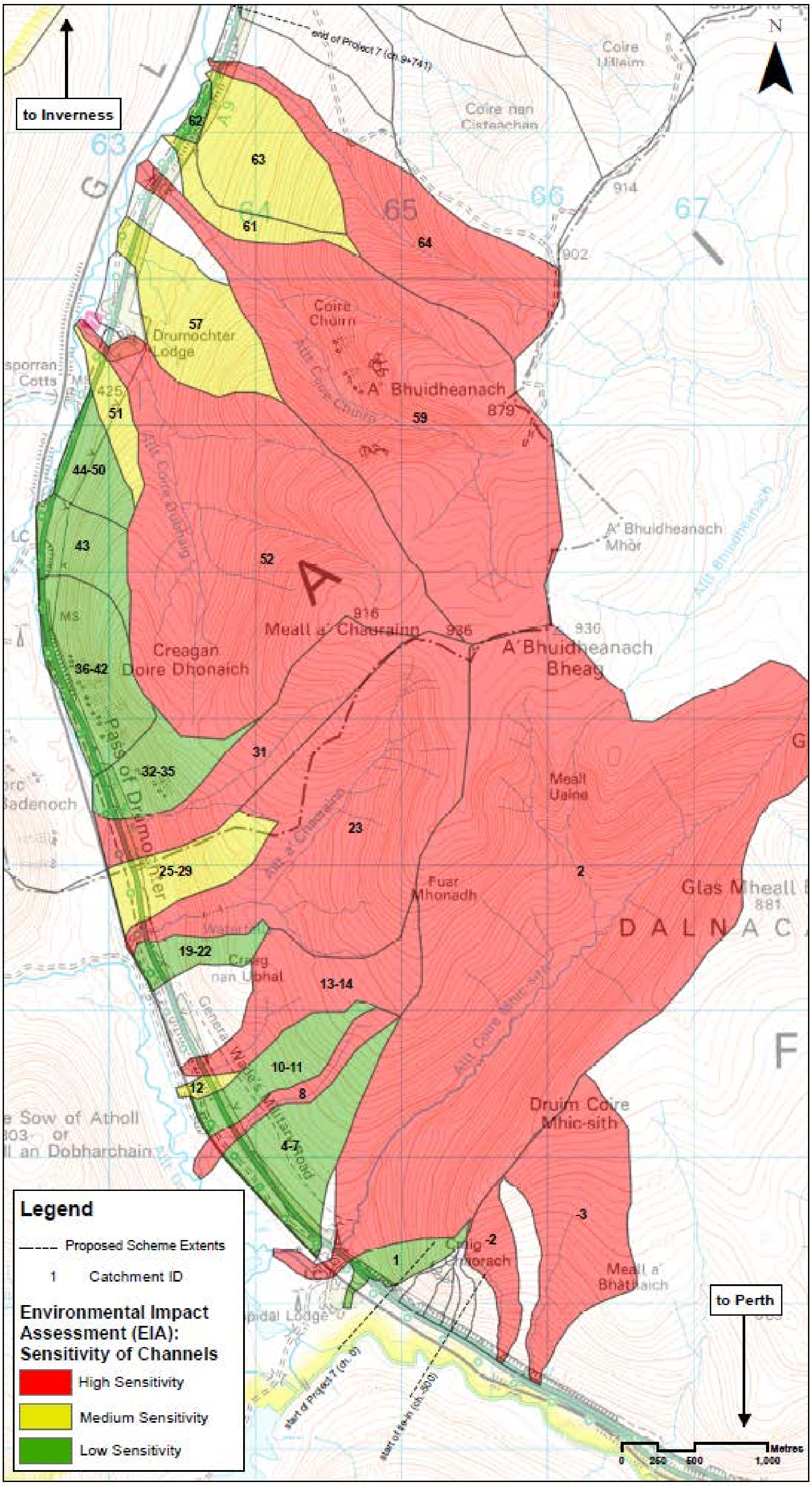

Figure 2: Sensitivity of watercourses

Table 1: Sensitivity classifications for watercourses

Sensitivity	Criteria/ Indicator of Value
Very High	**Sediment Regime** 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. **Channel Morphology** Water feature includes varied morphological features (e.g. pools, riffles, bars, natural bank profiles) with no sign of channel modification. **Natural Fluvial Processes** 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** 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. **Channel Morphology** 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. **Natural Fluvial Processes** 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** 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. **Channel Morphology** 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). **Natural Fluvial Processes** 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** 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. **Channel Morphology** 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. **Natural Fluvial Processes** 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.

Erosion Risk Assessment

2.1.14 The 4th and 6th iteration 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**, but the process has resulted in the movement of some infrastructure back from the watercourses and the addition of erosion protection measures in some locations in the 7th iteration (Assessment Design).

Establishing Changes in Conditions

2.1.15 The 4th Iteration 'Design Freeze' **(Annex 11.4.3)** has been reviewed and used as the design to undertake the initial (pre-mitigation) impact 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:

- culverts and bridges sized for 1:200 year flow
- bridges or box culverts adopted for all major watercourse crossings
- bridge abutments set back from channel banks
- minimise hard-engineered in-channel scour and erosion protection.

2.1.16 The 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.

2.1.17 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. It has been assumed that all culverts and bridges will be designed to take 1:200 year flow, and this will involve upsizing of some culverts and bridges.

2.1.18 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. These have also been designed to take 1:200 year flow.

2.1.19 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.

2.1.20 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 (hard) engineering headwall and bed protection.

2.1.21 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.

Magnitude and Significance of Impacts

2.1.22 The initial assessment of the magnitude of impacts has been undertaken based on SEPA guidance (2015) by combining the potential change in WFD status (based on the 4th Iteration Design

Freeze), spatial extent of the impacts on watercourse and timescale of the impact to give the magnitude.

2.1.23 Firstly, the potential change in WFD status has been assessed for the works on each watercourse using the 'Threshold of Significant Impact' (ToSI) test. The thresholds (**Table 2**) are regarded as the maximum extent of an individual pressure (type of engineering work) which, on its own, would cause a significant and long term impact on the water environment and cause a downgrade in WFD status.

2.1.24 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.

2.1.25 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.

2.1.26 Despite no watercourses likely to experience a change in WFD status due to the works, 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, there is not expected to be a change in WFD status caused by the works, so the assessment is assuming more than a worst case.

Table 2: Threshold of significant impacts for different river types (note: numbers are lengths of works in metres at or over which the threshold is crossed)

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

Activity	Bedrock or Cascade	Step pool or Plane bed	Braided, Wandering or Plane riffle	Active Meandering	Passive Meandering
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

2.1.27 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.

2.1.28 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.

2.1.29 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 ToSI 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.

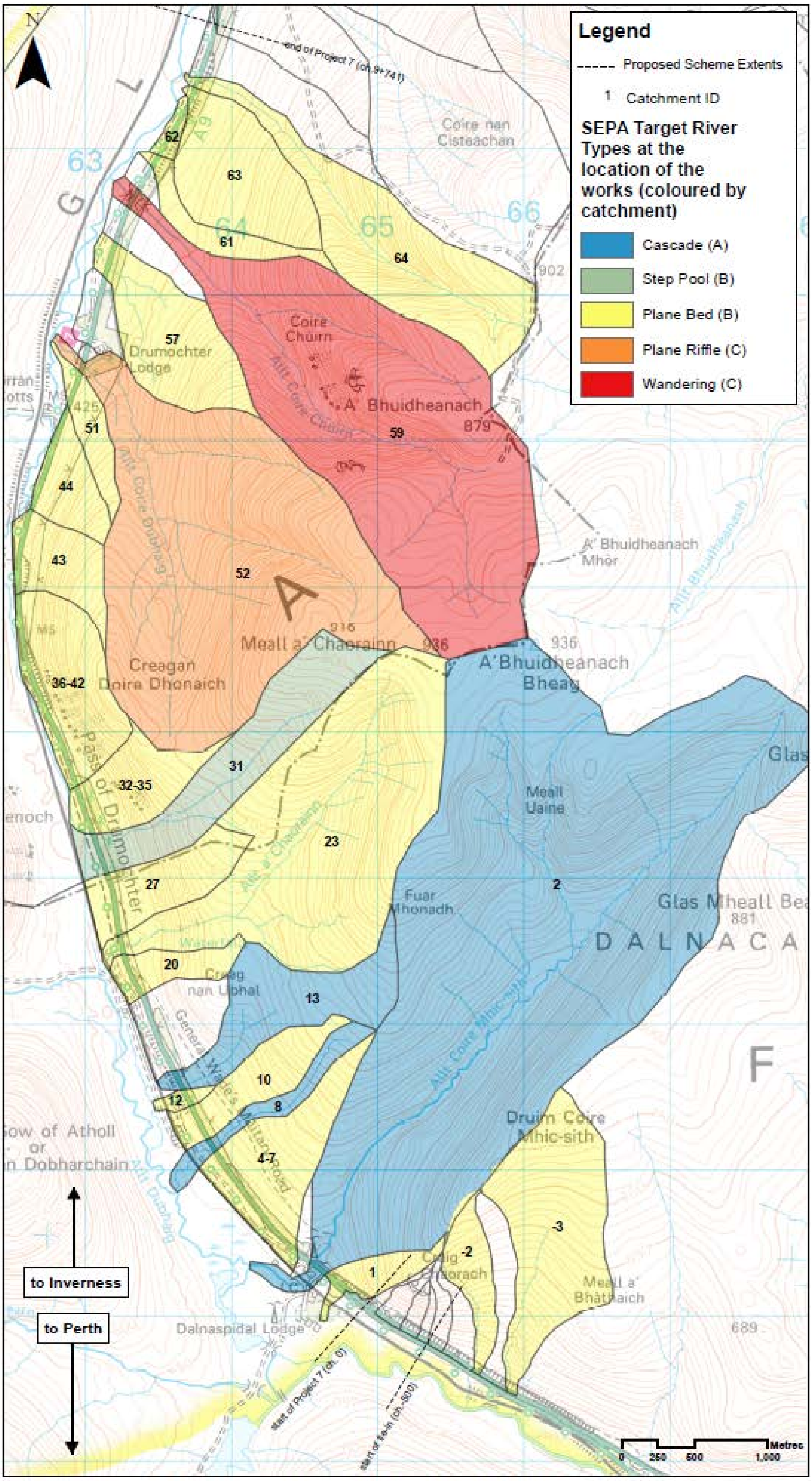

Figure 3: SEPA Target River Types

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 **Moderate ↔ Poor** **High → Moderate** **Poor ↔ Bad**	Negligible - Very Small	Very Small - Small	Small	Medium	Medium - Large	Large
High → Poor **Good ↔ Poor** **Moderate ↔ Bad**	Very Small	Small	Medium	Medium - Large	Large - Very Large	Large - Very Large
Good ↔ Bad **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

2.1.30 These SEPA guidance tables (**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 the purpose of 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.

2.1.31 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 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** 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. **Channel Morphology** 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. **Natural Fluvial Processes** Significant shift away from baseline conditions with potential to alter processes at the catchment scale. **Condition Status** 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 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** 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. **Channel Morphology** 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. **Natural Fluvial Processes** A shift away from baseline conditions with potential to alter processes at the reach or multiple reach scale. **Condition Status** 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 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** 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. **Channel Morphology** 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. **Natural Fluvial Processes** Minimal shift away from baseline conditions with typically localised impacts up to the reach scale. **Condition Status** 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 <0.5km of channel affected 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 0.5-1.5km of channel impacted, with little to no change in WFD status.	**Sediment Regime** Partial improvement to sediment processes at the reach scale, including reduction in siltation and localised recovery of sediment transport processes. **Channel Morphology** Partial improvements include enhancements to in-channel habitat, riparian zone and morphological diversity of the bed and/or banks. **Natural Fluvial Processes** Slight improvement on baseline conditions with potential to improve flow processes at the reach scale. **Condition Status** 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 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** Reduction in siltation and recovery of sediment transport processes at the reach or multiple reach scale. **Channel Morphology** 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. **Natural Fluvial Processes** Notable improvements on baseline conditions and recovery of fluvial processes at the reach or multiple reach scale. **Condition Status** 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 Impacts improve much of the waterbody (10km or over) by one WFD status or 5-10km by 2 WFD status.	**Sediment Regime** Improvement to sediment processes at the catchment scale, including recovery of sediment supply and transport processes. **Channel Morphology** 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. **Natural Fluvial Processes** 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.

Significance of Impacts (without Mitigation)

2.1.32 The magnitude and sensitivity that have been assigned are then multiplied as per **Table 6** to give the initial, pre-mitigation impact significance (based on the 4th Iteration Design Freeze (**Annex 11-4-3**). Where there is a difference between the differing elements considered the worst case significance is taken.

Table 6: Definitions of the 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

Significance of Impacts (with Embedded Mitigation)

2.1.33 Mitigation required to reduce or eliminate adverse impacts of the 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 Assessment Design (**Drawing 5.1-5.7**, 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.

Significance of Impacts (with Project Specific Mitigation)

2.1.34 A schedule of Project Specific Mitigation (i.e. that not included in the Assessment Design) to mitigate these impacts, has then been created and the assessment process run for a third time as discussed in **Section 5** 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 many 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 for each 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 Europe by 2027. In order to achieve this, River Basin Management Plans (RBMP) have been created for all European catchments. The watercourses within the Project 7 extent are part of the wider River Tay and River Spey catchments. Larger watercourses have been individually assigned WFD ecological status by 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 water course	Ecological Status	Water flows and levels classification	Physical condition classification	Tributaries to watercourse (ID)
6912: River Garry	Bad	Bad	Good	-3 to 0
6610: Allt Coire Dhomhain (Allt Dubhaig)	Poor	Good	High	1-30
23638: River Truim from source to Allt Cuaich	Good	Good	Good	31 to 64

3.1.5 The smaller 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. As such, 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

Construction impacts

4.1.2 This section describes the potential impacts of the activities that will be carried out during construction of the Proposed Scheme. By their nature, culverts, bridges, channel realignments outfalls and associated erosion protection 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. The exact construction methods are currently unknown, but the potential impacts likely to be caused by construction are considered below.

Damage to Bank Form

4.1.3 Any works involving engineering within the channel (culverts, bank protection, realignment, bridges and headwalls) will 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 man-made 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.

4.1.4 Vegetation clearance will 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, that will have a medium-term duration.

Damage to Bed Form

4.1.5 Construction works within the channel will damage the existing bed forms (including areas of gravel bars, pools and steps), bed armouring and sediment composition of the bed over the duration of construction, 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. They will also release fine sediment during construction that may smother gravels at the site and further downstream.

Increased Sediment Supply

4.1.6 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

4.1.7 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

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

Change in Sediment Dynamics

4.1.9 The works are likely to temporarily increase local supply from the affected 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.

Operational Impacts

4.1.10 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.

4.1.11 The initial impact assessment has been undertaken on the 4th Iteration Design Freeze (**Annex 11.4.3**). Works proposed on each watercourse have been identified, and grouped per waterbody catchment. These have then been 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**. The impacts are documented below.

Table 8: Summary of Hydromorphology assessment results

ID	Sensitivity	Significance of impact (Design Freeze - 4th iteration)	Significance of impact (Assessment Design)	Residual significance of impact (after Project Specific Mitigation is applied)
-3	High	NO WORKS	NO WORKS	NO WORKS
-2	High	Neutral	Neutral	Neutral
1	Low	Neutral	Neutral	Neutral
2	High	Slight adverse	Slight adverse	Slight beneficial
4	Low	Neutral	Neutral	Neutral
5	Low	Neutral	Neutral	Neutral
6	Low	Neutral	Neutral	Neutral
7	Low	Neutral	Neutral	Neutral
8	High	Neutral	Neutral	Neutral
10	Low	Neutral	Neutral	Neutral
12	Medium	Neutral	Neutral	Slight beneficial
13	High	Slight beneficial	Slight adverse	Slight beneficial
14	Medium	Slight beneficial	Slight beneficial	Slight beneficial
20	Low	Neutral	Neutral	Neutral
23	High	Neutral	Neutral	Neutral
27	Medium	Neutral	Neutral	Neutral
28	Medium	Neutral	Neutral	Neutral
31	High	Neutral	Neutral	Neutral
34	Low	Neutral	Neutral	Neutral
39	Low	Neutral	Neutral	Neutral
40	Low	Neutral	Neutral	Neutral
43	Low	Slight adverse	Slight adverse	Slight beneficial
44	Low	Neutral	Neutral	Neutral
46	Low	Neutral	Neutral	Neutral
49	Low	Neutral	Neutral	Neutral
51	Medium	Neutral	Neutral	Neutral
52	High	Neutral	Neutral	Neutral
57	Medium (artificial channel)	Neutral	Neutral	Neutral
59	High	Neutral	Neutral	Neutral
61	Medium	Neutral	Neutral	Neutral
62	Low	Neutral	Neutral	Neutral
63	Medium	Neutral	Neutral	Neutral
64	High	Neutral	Neutral	Neutral
32/33	Low	Neutral	Neutral	Neutral
42a	Low	Neutral	Neutral	Neutral
Beul an Sporain	High	Neutral	Neutral	Neutral
Truim	High	Neutral	Slight adverse	Slight adverse

Loss of Natural Bed Form and Sediment Inputs

4.1.12 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, 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. 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.

4.1.13 Box culverts are replacing current pipe culverts in some locations, improving the current conditions by encouraging a more natural bed to form over the long term. The loss of natural bed will reduce the morphological diversity of the channel bed and will alter the sediment supply from the bed.

4.1.14 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

4.1.15 In some instances, the natural bed form of the channel will be replaced by the Proposed Scheme, for example, where a pipe culvert is to be replaced with a box culvert and where alterations to bridges are proposed to allow more natural bed forms.

4.1.16 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

4.1.17 The permanent loss of natural bank form will occur through the installation of erosion protection, head walls, channel realignment 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.

4.1.18 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

4.1.19 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).

4.1.20 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

4.1.21 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.

4.1.22 In some locations, the existing culverts and bridges are reducing downstream discharge under high flow events. The 4th Iteration Design Freeze upsized all to take the 1:200 year flow, removing this pressure as part of the scheme, and having a beneficial impact, naturalising flows within watercourse where the structure sits (upstream and downstream), as well as in the receiving downstream watercourse with the potential to improve morphology and processes.

Change in Continuity of Sediment Transfer

4.1.23 Significant steps, culverts and channel diversions have the potential to alter the continuity of sediment transfer, by causing excessive erosion or deposition. For example, significant abrupt changes in vertical alignment (e.g. at steps, catch pits, weirs etc.) hold back the sediment, reducing its downstream transfer. Undersized culverts hold back the flow, causing sediment to drop out upstream (creating an 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.

4.1.24 The upsizing of culverts will improve the downstream continuity of sediment transfer, 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.

4.1.25 The removal of catchment pits and other significant steps as part of the design has been undertaken where possible. This has the potential to increase the continuity of downstream sediment transfer, improving downstream morphology and processes and having a beneficial impact on the waterbodies.

4.1.26 The change of culverts from pipe to 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.

Change in Sediment Dynamics

4.1.27 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.

4.1.28 Excessive erosion of the earthworks embankments has 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.

5 Mitigation

Construction Impacts

5.1.2 Standard A9 Mitigation for the shorter-term construction impacts of the Proposed Scheme has been introduced and the measures outlined in **Table 9** are relevant to the hydromorphological aspects of the works. As well as these, additional measures listed below will help to reduce damage to the bed and banks and reduce the release and transport of fine sediment downstream.

- keep as much riparian vegetation as possible to help maintain bank stability and habitat
- keep tree root balls within the banks to help maintain stability
- retain existing bed material from channel for re-use in diversions
- ensure temporary structures are set back from the bank top and do not impact high or low flows or damage bank integrity.

Table 9: Standard A9 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: • The Flood Response Plan (as part of the CEMP, refer to Mitigation Item SMC-S1 in Table 21-1 of Chapter 21 (Schedule of Environmental Commitments)) 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): ➢ 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. ➢ 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. ➢ 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. • 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. Where this is not possible, agreement will be required with the Environmental Clerk of Works (EnvCoW). • 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. • Temporary drainage systems will be implemented to alleviate localised surface water flood risk	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
			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 (Section 11.2), and implement appropriate measures which will include, but may not be limited to: • avoiding unnecessary stockpiling of materials and exposure of bare surfaces, limiting topsoil stripping to areas where bulk earthworks are immediately programmed; • installation of temporary drainage systems/SuDS systems (or equivalent) including pre-earthworks drainage; • 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; • the adoption of silt fences, check dams, settlement lagoons, soakaways and other sediment trap structures as appropriate; • the maintenance and regrading of haulage route surfaces where issues are encountered with the breakdown of the existing surface and generation of fine sediment; • provision of wheel washes at appropriate locations (in terms of proposed construction activities) and >10m from water features; • protecting soil stockpiles using bunds, silt fencing and peripheral cut-off ditches, and location of stockpiles at distances >10m; and • 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. Where required, temporary discharge consents to be obtained from SEPA through the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended).
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 (Section 11.2), and implement appropriate measures which will include, but may not be limited to: • 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; • no in-channel working during the salmonid spawning seasons unless permitted within any CAR licence; • 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; • limit the removal of vegetation from the riparian corridor, and retaining vegetated buffer zone wherever reasonably practicable; and • limit the amount of tracking adjacent to watercourses and avoid creation of new flow paths between exposed areas and new or existing channels.	To reduce impacts on the water environment during in-channel working.	Method statements for any in-channel working require approval by SEPA

Mitigation Item	Approximate Chainage/ Location	Timing of Measure	Description	Mitigation Purpose/Objective	Specific Consultation or Approval Required
SMC-W5	Throughout Proposed Scheme	Construction	Where channel realignment is necessary, the Contractor will adhere to good practice guidance (Section 11.2) and implement appropriate measures which will include, but may not be limited to: • 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; • 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); • 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 • 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 (Section 11.2), and implement appropriate measures which will include, but may not be limited to: • only designated trained and competent operatives will be authorised to refuel plant; • refuelling will be undertaken at designated refuelling areas (e.g. on hardstanding, with spill kits available, and >10m from water features) where practicable; • appropriate measures will be adopted to avoid spillages (refer to Mitigation Item SMC-W7); and • 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 (Section 11.2), and implement appropriate measures which will include, but may not be limited to: • concrete mixing and washing areas will: ➢ be located more than 10m from water bodies; ➢ have settlement and re-circulation systems for water reuse; and ➢ have a contained area for washing out and cleaning of concrete batching plant or ready-mix lorries. • 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; • where concrete pouring is required within a channel, a dry working area will be created; • 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	To reduce impacts on the water environment in relation to concrete, cement and grout.	Permission required from Scottish Water. Consultation with SEPA.

Mitigation Item	Approximate Chainage/ Location	Timing of Measure	Description	Mitigation Purpose/Objective	Specific Consultation or Approval Required
			• quick setting products (cement, concrete and grout) will be used for structures that are in or near to watercourses.		
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: • non-engineering solutions and green engineering (e.g. vegetation, geotextile matting) to be the preference during options appraisal; • requirements for grey engineering to control/prevent scour (e.g. rock armour, rip-rap, gabion baskets) to be minimised; and • 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: • directing each outfall downstream to minimise impacts to flow patterns; • avoiding projecting the outfall into the watercourse channel; • avoid installation of outfalls at locations of known historical channel migration; • avoid positioning in flow convergence zones or where there is evidence of active bank erosion/instability; • directing an outfall away from the banks of a river to minimise any potential risk of erosion (particularly on the opposite bank); • minimising the size/extent of the outfall headwall where possible to reduce the potential impact on the banks; and • 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.	To reduce impacts of outfalls on the water environment.	Consultation with SEPA
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: • 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. • 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.	To reduce impacts of culverts on the water environment.	Consultation with SEPA

Mitigation Item	Approximate Chainage/ Location	Timing of Measure	Description	Mitigation Purpose/Objective	Specific Consultation or Approval Required
			• Detailed design of culverts and associated watercourse modifications shall incorporate wherever practical: ➢ adherence to design standards and good practice guidance (Section 11.2); ➢ allowance for the appropriate conveyance of water and sediment for a range of flows (including at low flow conditions); ➢ maintenance of the existing channel gradient to avoid erosion at the head (upstream) or tail (downstream) end of a culvert; ➢ avoidance of reduction of watercourse length through shortening of watercourse planform; ➢ minimisation of culvert length; ➢ close alignment of the culvert with the existing water feature; ➢ 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 ➢ roughening of culvert inverts to help reduce water velocities.		
SMC-W16	Throughout Proposed Scheme	Design & Construction	In relation to <u>channel realignments,</u> specimen and detailed design will ensure compliance with good practice (Section 11.2), which will include, but may not be limited to: • minimising the length of the realignment, with the existing gradient maintained where possible; • design of the realignment in accordance with channel type and gradient; • 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; • realignment designs will be led by a suitably qualified fluvial geomorphologist; • where realignments result in an increase or decrease of channel gradient, the following principles will be applied: ➢ 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 ➢ 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.	To reduce impacts of channel realignment on the water environment.	Consultation with SEPA
SMC-W17	Throughout Proposed Scheme	Design & Construction	In relation to <u>SuDS</u>, the following mitigation measures will be implemented: • detailed design to adhere to design standards and good practice guidance (Section 11.2 of Chapter 11 Road Drainage and the Water Environment), including The SuDS Manual (CIRIA, 2015) and SuDS for Roads (SCOTS, 2010); • for each drainage run, a minimum of two levels of SuDS treatment within a 'treatment train' (see	To reduce impacts of drainage discharges on the water environment.	Where required, authorisation for the road drainage discharge under CAR 2011 (as amended)

Mitigation Item	Approximate Chainage/ Location	Timing of Measure	Description	Mitigation Purpose/Objective	Specific Consultation or Approval Required
			Table 1 of Appendix 11.2 for further details) to limit the volume of discharge and risk to water quality, in agreement with SEPA and SNH; • 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; • SuDS retention ponds will be designed with an impermeable liner to maintain a body of standing water and provide treatment volume; • inspect inlets, outlets, banksides, structures and pipework for any blockage and/or structural damage and remediate where appropriate; and • regular inspection and removal of accumulated sediment, litter and debris from inlets, outlets, drains and ponds to avoid sub-optimal operation of SuDS; and • adherence to the maintenance plans specific to each SuDS component type as detailed in The SuDS Manual (CIRIA, 2015)		would be obtained from SEPA

Operational Impacts - Embedded Mitigation

5.1.3 Mitigation for the long term operational impacts of the Proposed Scheme have been identified and incorporated into the design where possible to give the Assessment Design (**Drawing 5.1-5.7**, **Volume 3**). These have been identified as embedded mitigation. This mitigation is documented below for each of the identified impacts. The assessment has been re-run with the embedded mitigation in place (based on the Design Fix) and the significance assigned to each catchment is summarised in **Table 8**.

5.1.4 There is no change in the significance of the impacts with the mitigation in place for most waterbodies. This is because the significance is largely determined by the extent (length) of the impact, and in most cases while the mitigation lessens the extent of the impact, it does not fully remove it or change it to the category down.

Loss of Natural Bed Form and Sediment Inputs

5.1.5 The following mitigation is required to 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 thick) on medium, high and very high sensitivity channels
- for steep culverts (over 4%) put in pools at the upstream and downstream end to dissipate energy into and out of the culvert, to reduce the extent of hard engineering required to the channel bed
- ensure that the natural bed is retained under bridges.

Loss of Natural Bank Form and Sediment Inputs

5.1.6 The following mitigation is required to 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 bridge abutments away from bank tops to reduce the extent of hard engineering within the channel, and to allow natural channel adjustment to occur
- ensure that minimal bank erosion protection is installed on the watercourse through sustainable 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

5.1.7 The following mitigation is required to minimise the extent to which it 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

- ensure that minimal bank erosion protection is installed on the watercourse through sustainable design and positioning of bridges, channel realignments, embankments (mainline and track) and SUDs basins, to ensure channels can move laterally across their floodplain.

Change in Flow Conditions

5.1.8 The following mitigation is required to 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.

Change in Continuity of Sediment Transfer

5.1.9 The following mitigation is required to 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
- for steep culverts (over 4%) put in pools at the upstream and downstream end to dissipate energy, and reduce the extent of excessive erosion of and sediment supply to the channel.

Change in Sediment Dynamics

5.1.10 The following mitigation is required to ensure minimal changes in sediment dynamics that are caused by the various elements of the works. This mitigation has been embedded into the design:

- maintain or ensure a channel gradient 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 embankment toes to prevent long term excessive sediment supply to the channel where infrastructure has been deemed as at 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

Operational Impacts – Project Specific Mitigation

5.1.11 Project Specific Mitigation has then been identified following assessment of the Assessment Design and the assessment has been re-run for a third time, assuming this Project Specific Mitigation is in place for hydromorphology and from all other disciplines. The significance of impacts for each watercourse is summarised in **Table 7, Section 2** of this document giving the residual significance. While in the case of this project the Project Specific Mitigation does not greatly change the significance of impact, it will be required in order to ensure that a CAR licence for the works is granted. It should therefore be noted that this mitigation should be applied to the respective works on all watercourses, on a site by site basis at specimen design stage, regardless of the significance of impacts of the Proposed Scheme. This Project Specific Mitigation is outlined below and shown on **Drawings 11.16-11.22** (contained in **Volume 3**).

Loss of Natural Bed Form and Sediment Inputs

5.1.12 The following Project Specific Mitigation is required to compensate for the loss of natural bed form and sediment inputs to the channel caused by the various elements of the works:

- incorporate varied bed profiles in all channel realignments to help create diverse morphological form and resultant flow, processes and habitats in medium, high and very high sensitivity channels. 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 11.4.3.3** outlines the river morphology that should be included for each channel diversion, with the guidance for details of these channel types in **Annex 11.4.6**. These realignments should be designed on a channel by channel basis by a suitably qualified Hydromorpholoist, and they should ensure that natural channel widths are used for realignments, through bridge and culverts and that these are designed to take the 1:2 year flow
- remove the existing concrete bed and replace with natural bed were possible within the extents of the Proposed Scheme
- ensure all channel realignments have natural bed material, 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 the same size and geology of that existing and is detailed at specimen design stage, and where possible use material from the existing bed to ensure the continuation of downstream movement of sediment. The calibre 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 watercourse
- minimise the size/ extent of hard engineering on the outfall headwall to that which is absolutely required to and use green engineering reduce potential impact on the bed and banks. Ensure that outfalls on high sensitivity and active watercourses are designed with anticipation for erosion and bed level change over time as the channel they feed into changes position

- increase the roughness of the culvert inverts to help reduce water velocities and keep bed material in the culverts using baffles or embedded cobbles on medium, high and very high sensitively channels.

Loss of Natural Bank Form and Sediment Inputs

5.1.13 The following Project Specific Mitigation is required to 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 widths in channel realignments to allow the dissipation of energy through the creation of a range of form and flow conditions in all channel realignments. This will create varied habitat as well as creating a suitable and stable channel
- remove the existing concrete banks and replace with reprofiled banks were possible
- 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

5.1.14 The following Project Specific Mitigation is required to 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 for that slope, 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 (**Annex 11.4.3.3)**
- restore a more natural planform and morphology to channels previously straightened as part of the construction of the original A9
- design outfalls (SUDs, drains and realignments) and diversions to take into account 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 across its floodplain
- use green bank protection works were feasible as per SEPA’s ‘*Reducing River Bank erosion - A Best Practice Guide for Farmers’*
- ensure bridges allow lateral and vertical channel change, in order to reduce the need for erosion protection and minimise damage to the structures.

Change in Flow Conditions

5.1.15 The following Project Specific Mitigation is required to limit the impacts on flow conditions from the works:

- 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)
- ensure bridges 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

5.1.16 The following Project Specific Mitigation is required to allow the continuity of downstream sediment transfer:

- ensure a natural bed 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 (In the vicinity of channels 2, 7, 8, 12, 13, 14, 63 and 64).

Change in Sediment Dynamics

5.1.17 The following Project Specific Mitigation is required to 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 and valleys after they have been diverted to reduce the risk of high flows entering into old channel 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 and increased sediment supply
- realign some of the upstream length of channel 64 to reduce risk of excessive erosion and avulsion if channel floods down cutting.

6 Residual Impacts

6.1.1 Residual impacts are those which remain following the implementation of all mitigation measures. **Table 8** gives the significance of the residual impacts for the construction phase of the scheme, and this shows the scheme to have neutral or beneficial impacts. As with the embedded mitigation there are few watercourses where the Project Specific 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 and will be required inorder to obtain a CAR licence for the works to the channels.

7 Cumulative Impacts

7.1.1 Within this appendix the impacts of the works on each catchment have been assessed together to give the cumulative impacts of the Proposed Scheme on each waterbody considered. However, further cumulative impacts within Project 7 will affect the hydromorphology of the channels. There will be multiple small changes to sediment transfer, discharge and velocity within the tributaries that flow into the River Truim and to a lesser extent to the Garry and Allt Coire Dhomhain. These have the potential to impact the form and processes of the Rivers Truim, Garry and potentially the Spey and Tay over long timescales.

7.1.2 Many of the proposed works (increasing culvert capacity, providing a natural bed within culverts and under bridges and removing catchpits) will be increasing the discharge and potential volume of sediment from the tributaries to the River Truim, creating more natural conditions than the baseline by returning the systems to something closer to those that were present before the A9 was originally constructed. This will have a beneficial cumulative impact on the hydromorphology of the tributaries and the River Truim. However these increases in sediment and water supply may cause change to the location of erosion and deposition within the River Truim, and ultimately the size, shape and location of the channel as it adjusts to these changes.

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

8 Monitoring Requirements

8.1.1 Geomorphological post-project monitoring is recommended on all watercourses where works have been undertaken to verify that the Proposed Scheme and mitigation are functioning as intended in relation to the watercourses, and to identify areas where the watercourse is having an unexpected negative impact on the Proposed Scheme and the Proposed Scheme may be at risk, as well as areas where the Proposed Scheme is having an unexpected negative impact on the waterbodies.

8.1.2 This monitoring should be undertaken in the form of repeat fixed point photography to 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 method of verifying information.

8.1.3 The fixed point photograph locations should be chosen on completion of construction and should ensure generic coverage of the channel corridor and floodplain environment. Each fixed point photograph location should be recorded with a metal peg in the ground with a unique number at its location. The national grid reference (NGR) of this location should be recorded and entered into GIS, as well as the photo characteristics (i.e. bearing, landscape/ portrait orientation, field of view etc.). Photographs between surveys should be compared and incorporated into reporting to identify areas of excessive change where future management may be required.

8.1.4 Monitoring should be undertaken on completion of the Proposed Scheme and periodically thereafter (timing to be agreed with SEPA) as well as after high flow events (levels to be agreed with SEPA).

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	Crossing location (BNG)		Type	Likelihood of future behaviour based on current behaviour as observed from site photographs						Initial screening (in or out)
				Upstream		At crossing		Downstream		
	Easting	Northing		Erosion	Deposition	Erosion	Deposition	Erosion	Deposition	
1	264741	773220	minor	High	High	Low	Low	High	Med	In
2	264599	773334	major	Med	Low	Low	Med	High	High	In
3	264497	773399	other	Low	Low	Med	Low	Med	Low	Out
3a	264475	773425	other	Med	Low	Low	Low	Low	Low	Out
4	264309	773583	other	Med	Low	Low	Low	Low	Low	In
5	264195	773712	other	High	Low	Low	Low	med	Med	in
6	264084	773854	minor	Low	Low	Low	Low	Low	Low	In
7	264024	773937	other	Low	Low	Low	Low	High	High	in
8	263873	774138	major	Low	Med	Med	Low	High	Med	in
10	263784	774295	other	Low	Low	Low	High	Low	Low	In
11	263699	774399	other	Low	Low	Low	Low	Low	Low	Out
12	263699	774469	minor	High	Med	High	Med	High	Low	In
13	263643	774604	major	High	High	Low	Low	High	High	In
14	263615	774653	other	Med	Low	Low	Med	High	Low	In
15	263565	774745	other	Low	Low	Low	Low	Low	Low	Out
17	263404	774996	minor	No data	No data	No data	High	No data	No data	Out
18	263434	775054	other	Low	Low	Low	Low	Low	Low	Out
19	263300	775200	other	Low	Low	Low	Low	Low	Low	Out
20	263373	775225	other	Med	Low	Low	Low	Low	Low	In
21	263346	775295	other	Low	Low	Low	Low	Low	Low	Out
22	263318	775369	other	Low	Low	Low	Low	Low	Low	Out
23	263263	775523	major	Med	Med	Low	Low	Med	Med	In
25	263228	775676	other	Low	Low	Low	Low	Low	Low	Out
27	263213	775829	minor	Med	Low	Low	Med	Low	Low	In
28	263180	775935	other	Med	Low	Low	Low	Low	Low	In
30	263126	776109	other	Low	Low	Low	Low	Low	Low	Out
31	263077	776252	major	Low	Low	Med	High	Low	Low	In
32	263135	776330	other	Med	Low	Low	Low	Low	Low	In
33	263052	776331	other	Low	Low	Low	Low	Low	Low	Out
34	263024	776419	other	Low	Low	Low	Med	Low	Low	In
35	262997	776496	other	Low	Low	Low	Low	Low	Low	Out
36	262920	776708	other	Low	Low	Low	Low	Low	Low	Out
37	262870	776844	other	Low	Low	Low	Low	Low	Low	Out
38	262842	776937	other	Low	Low	Low	Low	Low	Low	Out
39	262811	776986	other	Low	Low	Low	Med	Low	Low	In
40	262748	777106	other	Med	Low	Low	Low	Low	Low	In
42	262636	777349	other	Low	Low	Low	Low	Low	Low	Out
43	262614	778509	minor	Low	Low	Low	Low	Low	Low	In
44	262655	778636	other	Low	Low	Low	Med	Low	Low	In
45	262718	778814	other	Low	Low	Low	Low	Low	Low	Out
46	262763	778952	other	High	Low	Low	Low	Low	Low	In
47	262797	779035	other	Low	Low	Low	Low	Low	Low	Out
49	262844	779140	other	Low	Low	Low	Low	Med	Low	In
50	262860	779182	other	Low	Low	Low	Low	Low	Low	Out
51	262912	779293	minor	Low	Low	Low	Med	Low	Low	In
52	262987	779504	major	Med	Low	Low	Med	Low	Med	In
53	263004	779548	other	Low	Low	Low	Low	Low	Low	Out
54	263009	779563	other	Low	Low	Low	Low	Low	Low	Out
55	263052	779710	other	Low	Low	Low	Low	Low	Low	Out
56	263108	779909	other	Low	Low	Low	Low	Low	Low	Out
57	263176	780178	major	Low	Low	Low	Low	Low	Med	In
58	263265	780459	other	Low	Low	Low	Low	Low	Low	Out
59	263340	780644	major	High	High	Low	High	Med	High	In
60	263407	780771	other	Low	Low	Low	Low	Low	Low	Out
61	263502	780894	minor	Low	Low	Low	Low	Low	Low	In
62	263690	781256	other	Low	Low	Low	Low	Low	Med	In
63	263757	781409	minor	Low	Low	Low	Low	High	Med	In
64	263769	781433	major	Med	Med	Low	Med	High	High	In

Annex 11.4.2 Erosion Risk Assessment

Introduction

The watercourses within Project 7 drain small, steep catchments, are high energy systems and are often 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 the potential to damage the infrastructure associated with the A9. A review of the erosion risk from the watercourses was therefore undertaken during the Environmental Assessment and is documented in this note. This guidance has then been provided to the design team and incorporated into the Assessment Design.

Methodology

A review of channel change along the 4th and 6th iteration designs was undertaken by a Hydromorphologist using OS mapping, aerial photography and the proposed design (6th Iteration) 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.

A risk assessment has been undertaken for these locations based on the Assessment Design as follows:

- 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 1/2 x (Channel stability score + Proximity of infrastructure). This is ½ to ensure equal weighting in the risk calculation between the likelihood and consequence)
- A risk score has then been calculated based on Likelihood x Consequence, and these have been grouped as follows. Results and scoring are demonstrated in **Table 2**:
    - High risk- 6.1-9
    - Medium risk- 3.1-6
    - Low Risk- 2-3

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	5-10m to bank top
	1	10m+ to bank top
Consequence of damage		
High	3	Will involve road being shut/high cost to fix
Medium	2	Some impact on function of the road/scheme but will require some cost to fix
Low	1	Little impact on function of the road

Results

46 areas of at risk infrastructure (including bridges, outfalls and embankments) were identified in the 6th iteration design, 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 4 to 10,** and in **Table 2** along with high level guidance as to how to mitigate the erosion risk. This information has then been taken by the design team and integrated into the Assessment Design.

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 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.

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 eg 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

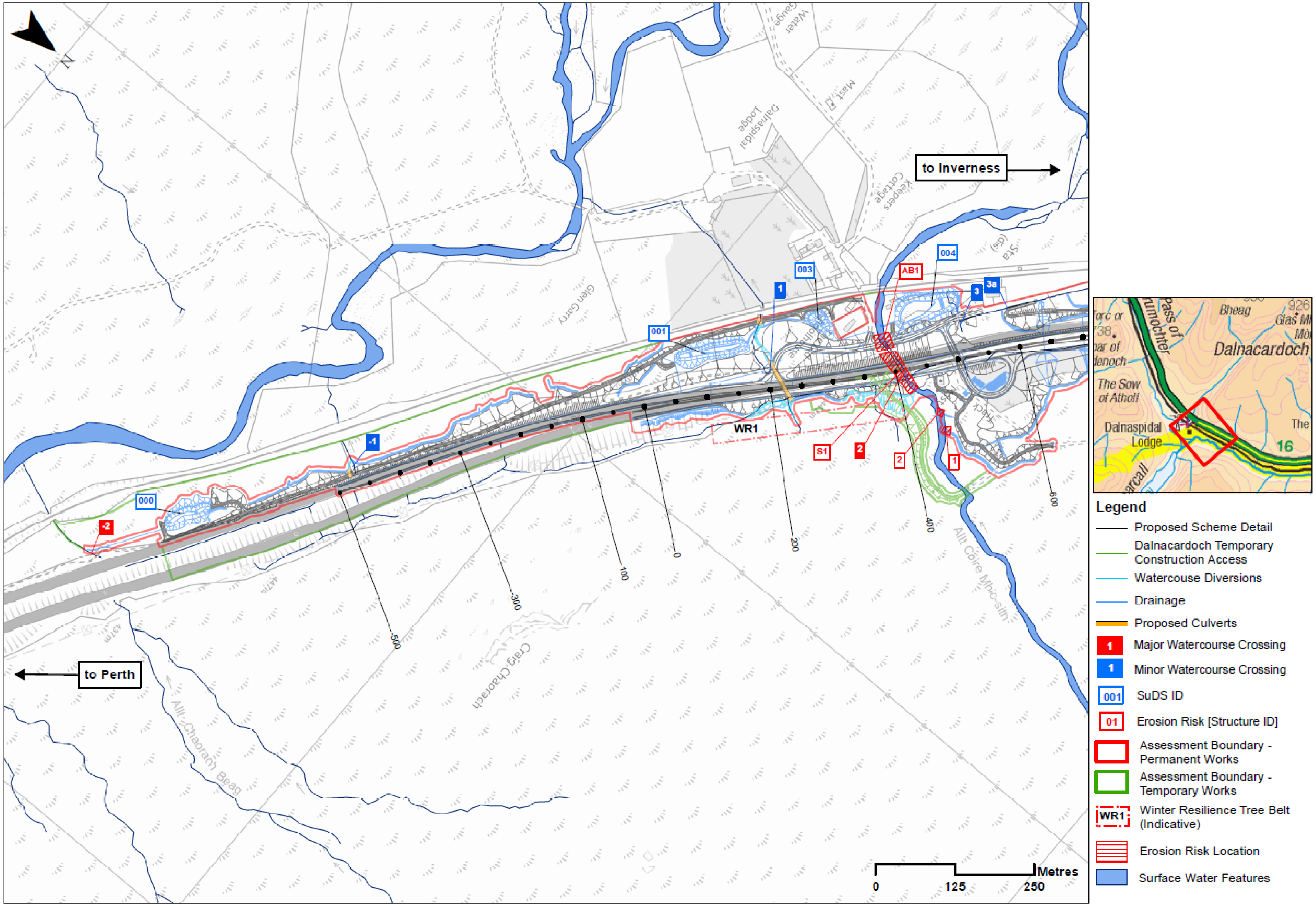

Figure 4:Locations at risk of fluvial erosion, Chainage -600 to 600

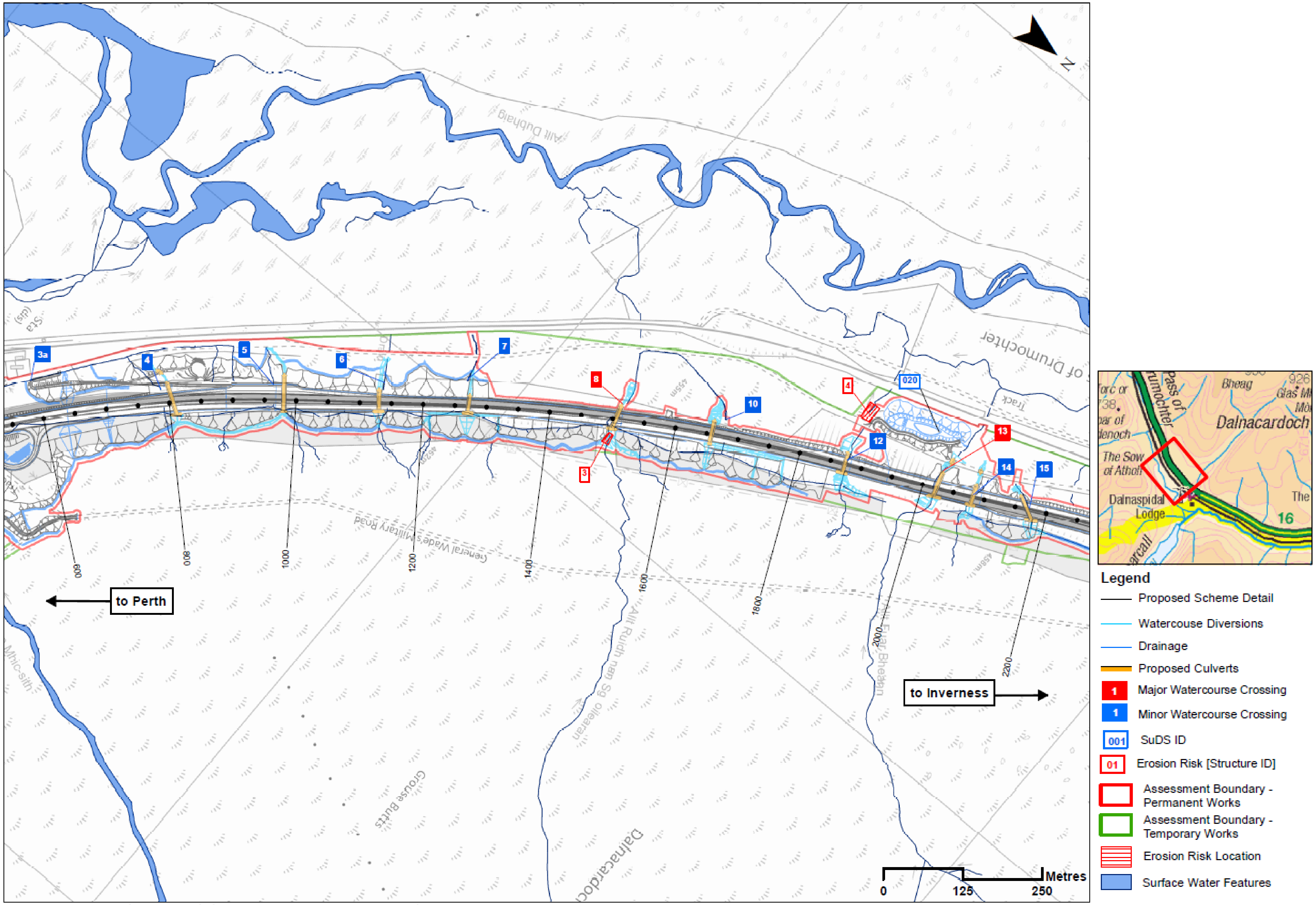

Figure 5: Locations at risk of fluvial erosion, Chainage 600 to 2200

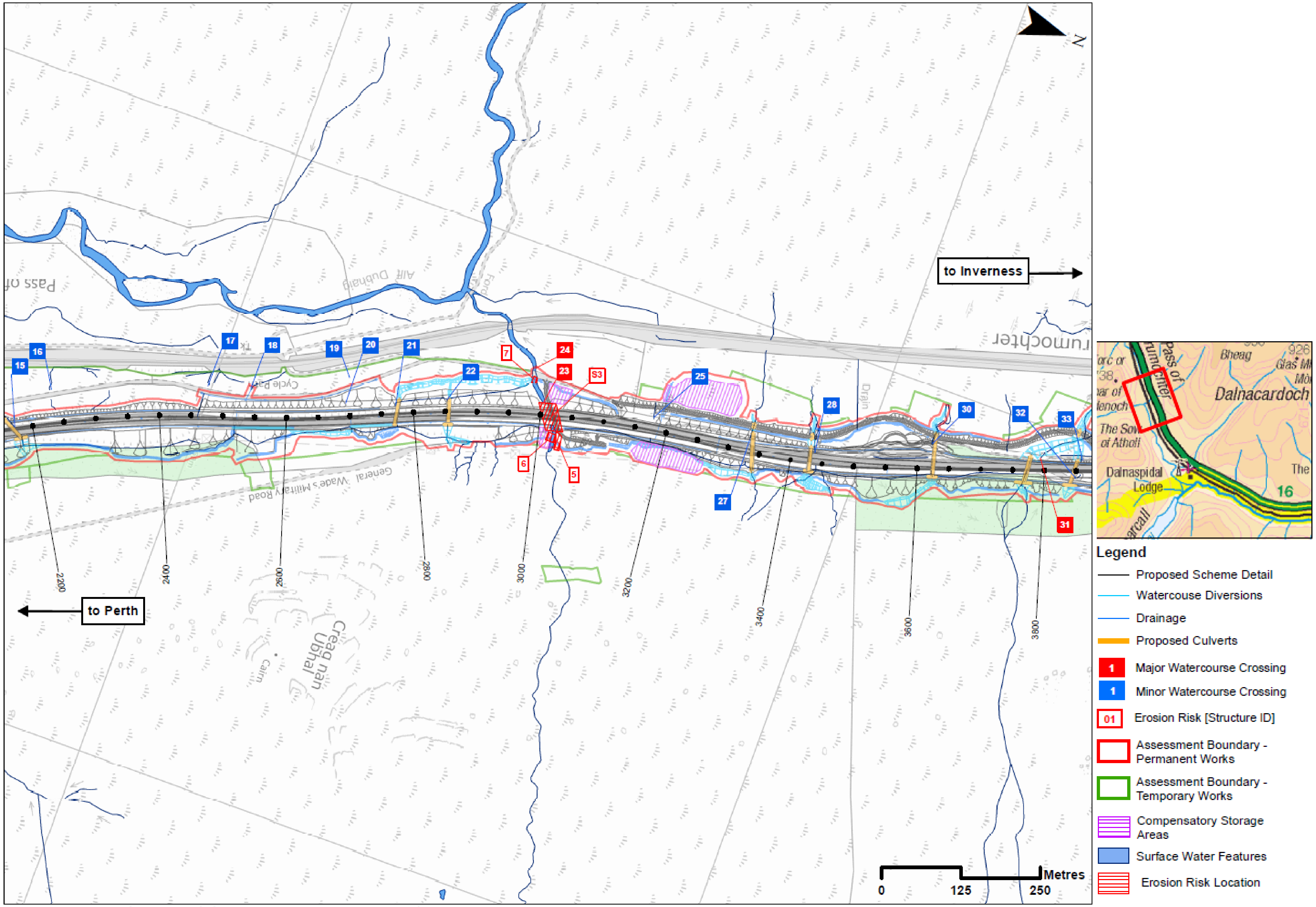

Figure 6: Locations at risk of fluvial erosion, Chainage 2200 to 3800

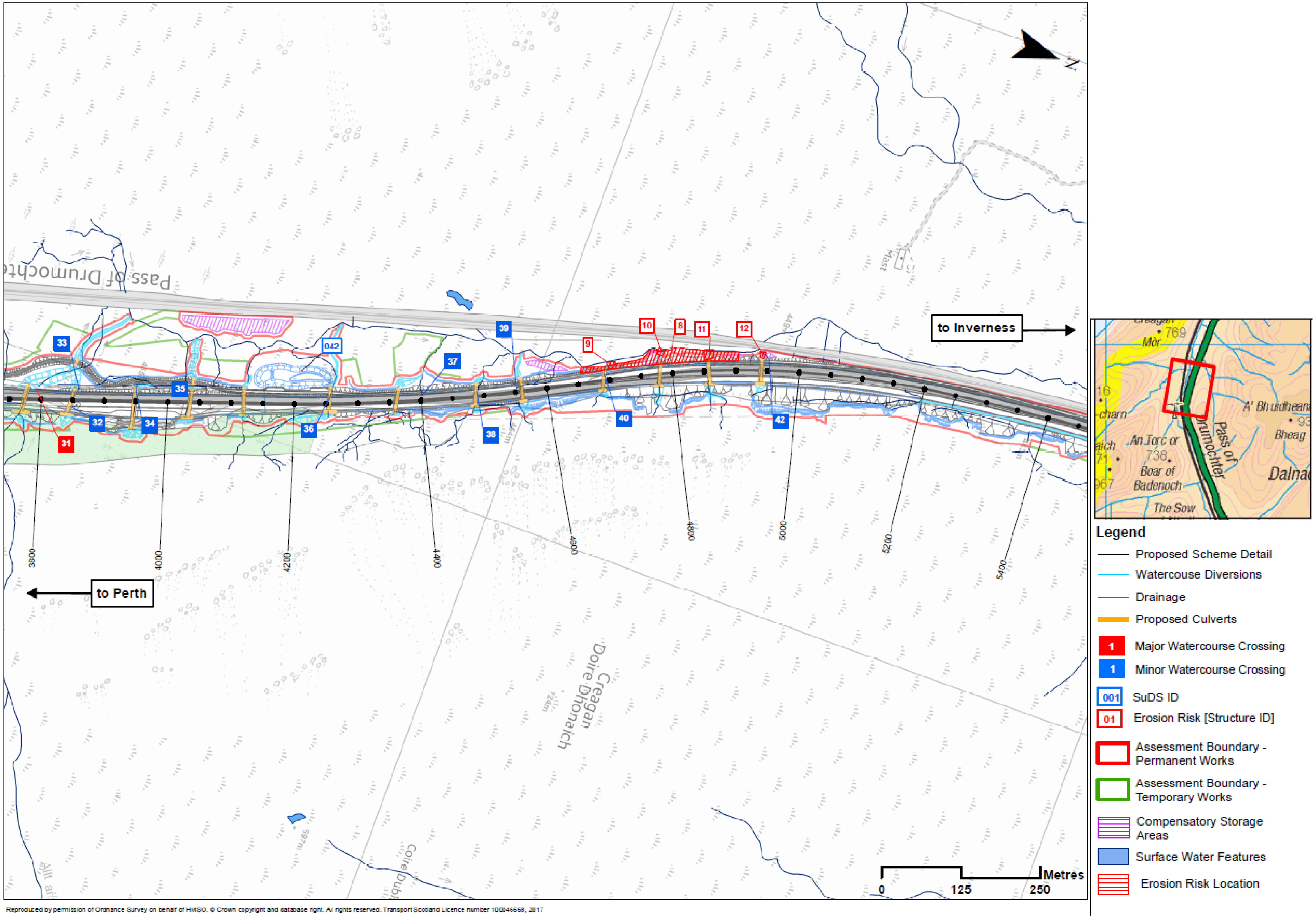

Figure 7: Locations at risk of fluvial erosion, Chainage 3800 to 5400

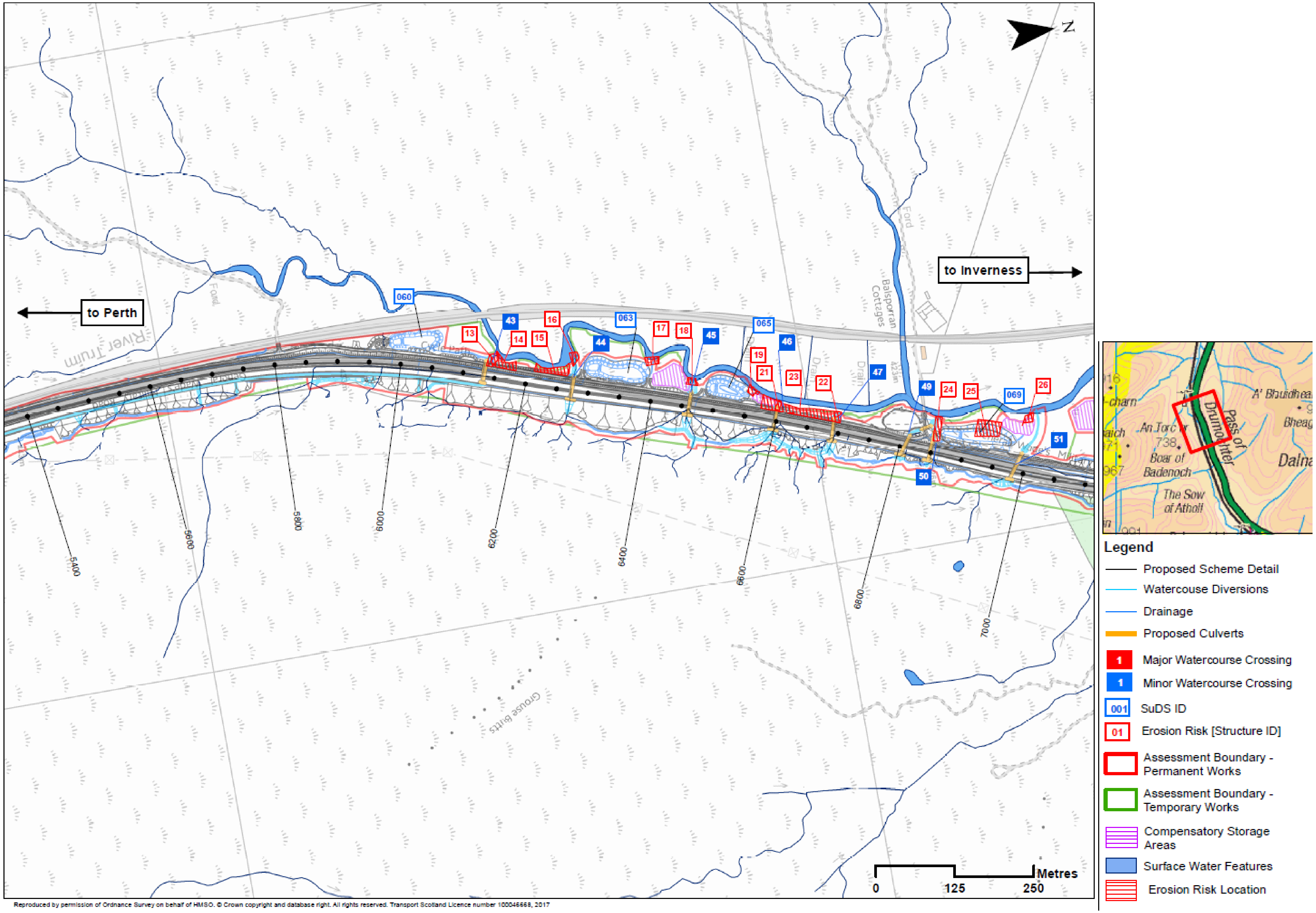

Figure 8: Locations at risk of fluvial erosion, Chainage 5400 to 7000

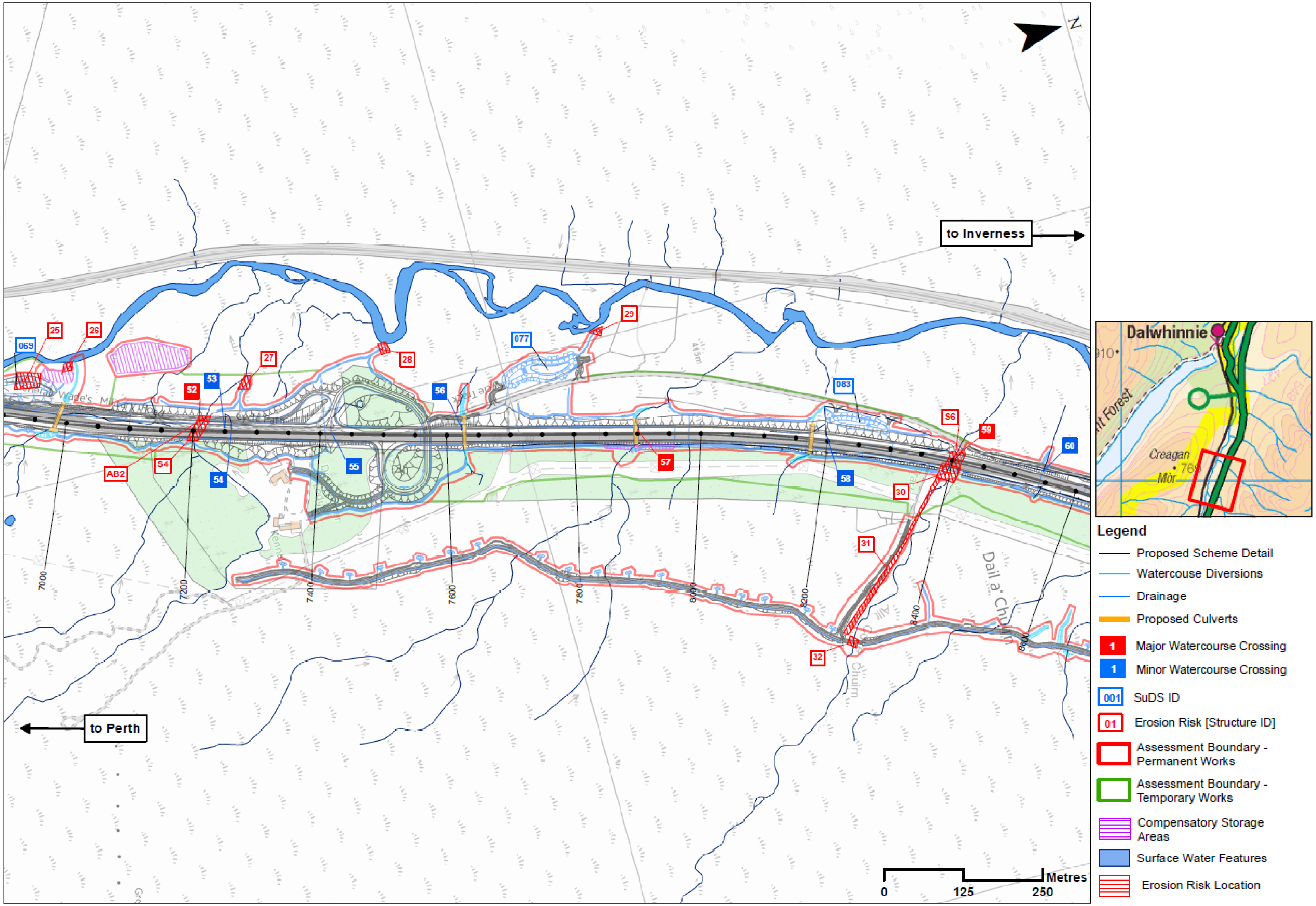

Figure 9: Locations at risk of fluvial erosion, Chainage 7000 to 8600

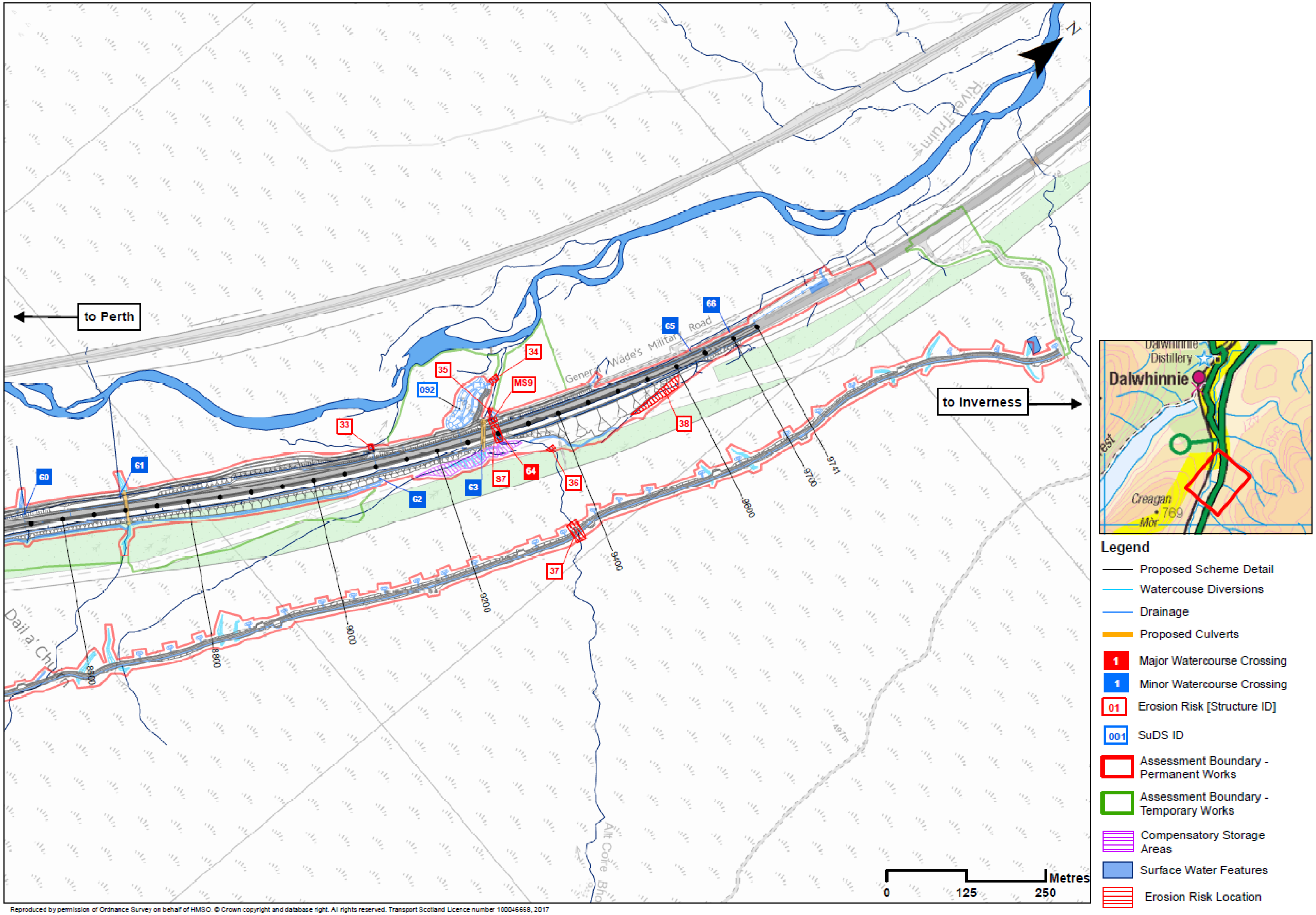

Figure 10: Locations at risk of fluvial erosion, Chainage 8600 to 9741

Table 2. Erosion risk assessment results

Risk assessment 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	Comments	Potential management options	Engineering response
1	New	Outfall	Relatively stable	In channel	Low	1	3	**2**	1	2	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
2	New	Outfall	Relatively stable	In channel	Low	1	3	**2**	1	2	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
3	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
4	New	SUDS track	Very unstable	2m	Medium	3	3	**3**	2	6	Medium	Track is less than 2m from bank top of unstable channel	Realign channel or Steepen embankment or In channel bank protection to protect toe	Proposal is to redesign SUDS track to move further away from watercourse and avoid impact on access track as a result of watercourse erosion.
5	Existing	Track	Very unstable	6m	Medium	3	2	**2.5**	2	5	Medium	Track is close (6m) to unstable channel, before channel enters engineered section	Steepen cutting or In channel bank protection to protect toe	Extend track upstand beyond bridge to point out with 1 in 200 year flood level
6	New	Outfall	Unstable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
7	New	Outfall	Relatively stable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
8	New	Mainline	Relatively stable	5m	High	2	3	2.5	3	7.5	High	Embankment extending towards channel, though channel appears stable the opportunity would be present to reinforce embankment toe	Steepen embankment ot In channel bank protection to protect toe or Set back protection of embankment	Embankment protection from chainage 4,650 to chainage 4,900 northbound as per standard detail.
9	New	Outfall	Relatively stable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
10	New	Outfall	Relatively stable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
11	New	Outfall	Relatively stable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
12	New	Outfall	Relatively stable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
13	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
14	Existing	Mainline	Very unstable	2m	High	3	3	3	3	9	High	No change from existing risk- May be existing bank protection	Continue current management practice or In channel bank protection or Reduce footprint of embankment	Embankment protection from chainage 6,135 to chainage 6,275 northbound as per standard detail.
15	Existing	Mainline	Very unstable	2m	High	3	3	3	3	9	High	No change from existing risk- May be existing bank protection	Continue current management practice or In channel bank protection or Reduce footprint of embankment	Embankment protection from chainage 6,135 to chainage 6,275 northbound as per standard detail.
16	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
17	New	Outfall	Unstable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
18	New	Outfall	Unstable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure

Risk assessment 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	Comments	Potential management options	Engineering response
19	New	SUDs	Unstable	3m	Medium	2	3	**2.5**	2	5	Medium	SUDs pond at risk of erosion -3m from bank	Set Suds pond back from channel or Add toe protection to Suds pond toe or Bank protection in channel	Bank protection in channel - Will require assessment.
20	New	Outfall	Unstable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
21	New	Outfall	Unstable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
22	New	Outfall	Unstable	In channel	Low	2	3	**2.5**	1	2.5	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
23	Existing	Mainline	Unstable	4m	High	2	3	2.5	3	7.5	High	No change from existing risk but opportunity to add toe protection to embankment during works Embankment is 6m from bank top	Continue current management practice or Protect embankment toe or In channel bank protection or Reduce footprint of embankment	Embankment protection from chainage 6,350 to chainage 6,700 northbound as per standard detail.
24	New	Outfall	Relatively stable	In channel	Low	1	3	**2**	1	2	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
25	New	SUDs	Unstable	27m	Medium	2	1	**1.5**	2	3	Low	Basin is some distance from main river put close to Paleochannel that may be reoccupied during the life of the road	Routine inspection of structure and/or Protect edge of basin	Routine inspection of structure
26	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
27	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
28	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
29	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
30	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	Routine inspection of structure
31	Existing/ New	Track	Very unstable	4m	Medium	3	3	**3**	2	6	Medium	Track not considered critical infrastructure	Routine inspection of structure	BDL Remove monitoring requirement
32	Existing	Track	Very unstable	In channel	Medium	3	3	**3**	2	6	Medium	Track not considered critical infrastructure	Further set back bridge from channel or Protect abutments or Routine inspection of structure	BDL Remove monitoring requirement
33	New	Outfall	Relatively stable	In channel	Low	1	3	**2**	1	2	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	
34	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	
35	New	Outfall	Very unstable	In channel	Low	3	3	**3**	1	3	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	
36	New	Outfall	Relatively stable	In channel	Low	1	3	**2**	1	2	Low	Outfalls are designed to accommodate change in river position	Routine inspection of structure	
37	Existing	Track	Unstable	In channel	Medium	2	3	**2.5**	2	5	Medium	Track not considered critical infrastructure	Routine inspection of structure	BDL Remove monitoring requirement
38	New structure	Mainline	Relatively stable	3m	High	1	3	**2**	3	6	Medium	Channel flows along top of cutting and could flow down cutting	Routine inspection and/or Realign channel	Embankment protection from chainage 9,500 to chainage 9,600 Southbound as per standard detail.

Risk assessment 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	Comments	Potential management options	Engineering response
S1	Extension of existing structure	Mainline Bridge	Very unstable	0m	High	3	3	3	3	9	High	Add step pool channel morphology upstream, under and downstream of structures to help with energy dissipation	Consider the need for erosion protection of abutments	
AB1	New structure	Track bridge	Very unstable	0m	Medium	3	3	3	2	6	Medium		Consider the need for erosion protection of abutments	
S3	Replacement structure	Mainline Bridge	Unstable	0m	High	2	3	2.5	3	7.5	High	Add step pool channel morphology upstream, under and downstream of structures to help with energy dissipation	Consider the need for erosion protection of abutments	
S4	Replacement structure	Mainline Bridge	Stable	2m	High	1	3	2	3	6	Medium	Abutment in 1:200 year but well out of channel. Well defined channel through crossing	Set back erosion protection of abutments	
AB2	New structure	Track bridge	Stable	0m	Medium	1	3	2	2	4	Low		Routine inspection of structure	
S6	Replacement structure	Mainline Bridge	Very unstable	0.5m	High	3	3	3	3	9	High	Abutments out of 1:200 year floodplain	Set back erosion protection of abutments Routine inspection of structure	
S7	Replacement structure	Mainline Bridge	Unstable	0.5m	High	2	3	2.5	3	7.5	High		Consider the need for erosion protection of abutments	
MS9	New structure	Track bridge	Very unstable	0m	Medium	3	3	3	2	6	Medium		Routine inspection of structure or Erosion protection of abutments	

Annex 11.4.3 Details of the Design

11.4.3.1 Design Freeze Information (4th iteration) for River Crossings and Outfall Locations

ID	Location	Current structure					New structure						Change (where +ve is increase and -ve is decrease)	
		Current structure type	Current structure length (m)	Current structure upstream bed level (mAOD)	Current structure downstream bed level (mAOD)	Current structure bed Slope (m/m)	Design structure type	Design structure length (m)	Design Upstream bed invert level (mAOD)	Design Downstream bed invert level (mAOD)	Design bed Slope (m/m)	Crossing to be upsized to take 1:200-year flow	Change in Length (m)	Change in Gradient
1	Track	New Structure	N/A	N/A	N/A	N/A	Box Culvert	8	No data	No data	No data	N/A	N/A	No data
1	Mainline	Pipe Culvert	46	required	436	No data	Box Culvert	87	441	432	0.092	Yes	41	No data
1		New Structure	N/A	N/A	N/A	N/A	SUDs Outfall	N/A	N/A	N/A	N/A	N/A	N/A	No data
2	Mainline	Bridge with concreate bed		No data	No data	No data	Bridge with concreate bed	No data	No data	No data	No data	Yes	No data	No data
2		New Structure	N/A	N/A	N/A	N/A	SUDs Outfall	N/A	N/A	N/A	N/A	N/A	N/A	No data
3		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
3	Track	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	7	437	437	0.002	N/A	N/A	No data
3	Mainline	Pipe Culvert	60	446	435	0.180	Pipe Culvert	33	445	445	0.009	Yes	-27	-0.172
4	Mainline	U/S: box culvert D/S: Pipe Culvert	29	447	446	0.038	Pipe Culvert	50	447	444	0.051	No	21	0.014
5		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
5	Mainline	Pipe Culvert	31	448	441	0.223	Pipe Culvert	65	448	442	0.099	No	34	-0.124
6	Mainline	Pipe Culvert	39	448	434	0.360	Box Culvert	30	449	448	0.010	No	-9	-0.351
6		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
6		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
7		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
7	Mainline	Pipe Culvert	51	No data	453	No data	Pipe Culvert	57	449	437	0.206	No	6	No data
8	Mainline	Pipe Culvert	37	452	No data	No data	Box Culvert	47	451	446	0.112	Yes	11	No data
8		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
8		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
10		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
10	Mainline	Pipe Culvert	35	454	453	0.025	Pipe Culvert	47	453	453	0.010	No	11	-0.015
12	Mainline	Pipe Culvert	17	455	454	0.071	Box Culvert	31	455	455	0.010	No	15	-0.061
13	Mainline	Pipe Culvert	49	453	No data	No data	Box Culvert	38	453	452	0.010	Yes	-11	No data
13		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
13		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
13		New Structure	N/A	N/A	N/A	N/A	SUDs Outfall	N/A	N/A	N/A	N/A	N/A	N/A	No data
14	Track	New Structure	N/A	N/A	N/A	N/A	Culvert	8	445	445	0.010	N/A	N/A	No data
14		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
14	Mainline	Pipe Culvert	22	456	455	0.048	Pipe Culvert	31	455	455	0.010	No	9	-0.039
15		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
15		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
15	Mainline	Pipe Culvert	19	457	455	0.079	Pipe Culvert	52	455	450	0.110	No	32	0.031
18		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data

ID	Location	Current structure					New structure						Change (where +ve is increase and -ve is decrease)	
		Current structure type	Current structure length (m)	Current structure upstream bed level (mAOD)	Current structure downstream bed level (mAOD)	Current structure bed Slope (m/m)	Design structure type	Design structure length (m)	Design Upstream bed invert level (mAOD)	Design Downstream bed invert level (mAOD)	Design bed Slope (m/m)	Crossing to be upsized to take 1:200-year flow	Change in Length (m)	Change in Gradient
18		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
21		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
21	Mainline	Pipe Culvert	30	460	445	0.485	Pipe Culvert	48	459	456	0.062	No	18	-0.422
22	Mainline	Pipe Culvert	37	460	454	0.150	Pipe Culvert	58	459	452	0.122	No	20	-0.028
23	Mainline	Arch culvert	38	No data	No data	No data	Bridge	No data	No data	No data	No data	No	No data	No data
23		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
25	Mainline	Pipe Culvert	30	458	456	0.082	Pipe Culvert	51	458	456	0.038	No	21	-0.044
27	Mainline	Pipe Culvert	34	456	455	0.033	Box Culvert	64	457	455	0.035	No	29	0.002
27		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
27		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
28		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
28		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
28	Mainline	Pipe Culvert	20	458	457	0.070	Pipe Culvert	39	457	455	0.045	No	20	-0.025
30		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
30		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
30	Mainline	Pipe Culvert	42	456	435	0.497	Pipe Culvert	53	455	454	0.024	Yes	11	-0.473
31	Mainline	Pipe Culvert	30	454	454	-0.001	Box culvert	37	453	452	0.010	Yes	7	0.012
33	Mainline	Pipe Culvert	20	453	453	0.019	Pipe Culvert	50	452	452	0.009	Yes	30	-0.010
34	Mainline	Pipe Culvert	25	452	452	-0.002	Pipe Culvert	58	451	451	0.009	Yes	33	0.010
35		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
35	Mainline	Pipe Culvert	24	451	451	-0.004	Pipe Culvert	60	451	451	0.014	Yes	36	0.018
36	Mainline	Pipe Culvert	15	453	452	0.023	Pipe Culvert	36	452	451	0.010	No	21	-0.013
37		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
37		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
37	Mainline	Pipe Culvert	17	453	452	0.035	Pipe Culvert	61	452	452	0.005	No	44	-0.029
38		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
38		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
38		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
38	Mainline	Pipe Culvert	No data	No data	452	No data	Pipe Culvert	36	452	452	0.012	No	No data	No data
39		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
39	Mainline	Pipe Culvert	20	451	451	0.003	Pipe Culvert	36	452	451	0.031	No	16	0.027
40		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
40		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
40	Mainline	Pipe Culvert	30	450	447	0.106	Pipe Culvert	36	450	448	0.068	No	6	-0.038
42		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
42		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
42		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
42	Mainline	Pipe Culvert	28	447	446	0.011	Pipe Culvert	48	447	446	0.024	No	20	0.013

ID	Location	Current structure					New structure						Change (where +ve is increase and -ve is decrease)	
		Current structure type	Current structure length (m)	Current structure upstream bed level (mAOD)	Current structure downstream bed level (mAOD)	Current structure bed Slope (m/m)	Design structure type	Design structure length (m)	Design Upstream bed invert level (mAOD)	Design Downstream bed invert level (mAOD)	Design bed Slope (m/m)	Crossing to be upsized to take 1:200-year flow	Change in Length (m)	Change in Gradient
43	Mainline	Pipe Culvert	20	427	427	0.022	Box Culvert	35	427	426	0.010	Yes	15	-0.012
43		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
43		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
44		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
44		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
44	Mainline	Pipe Culvert	17	426	426	0.021	Pipe Culvert	34	426	425	0.010	Yes	16	-0.011
45		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
45		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
45	Mainline	Pipe Culvert	18	426	425	0.031	Pipe Culvert	32	424	424	0.010	Yes	15	-0.021
46	Mainline	Pipe Culvert	20	424	424	0.020	Pipe Culvert	40	423	423	0.010	Yes	20	-0.010
47	Mainline	Pipe Culvert	25	424	423	0.058	Pipe Culvert	33	423	422	0.011	Yes	8	-0.046
49		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
49	Track	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	15	422	422	0.010	N/A	N/A	No data
49	Mainline	Pipe Culvert	27	424	No data	No data	Pipe Culvert	33	423	422	0.009	Yes	6	No data
50		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
50		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
50	Mainline	Pipe Culvert	20	423	423	0.033	Pipe Culvert	41	423	422	0.010	Yes	21	-0.023
51	Mainline	Pipe Culvert	20	424	423	0.007	Box Culvert	60	424	421	0.044	Yes	40	0.036
51		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
52	Mainline?	Bridge	No data	No data	No data	No data	Bridge	No data	No data	No data	No data	Yes	No data	No data
52		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
52		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
54		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
54	Mainline	Pipe Culvert	20	422	422	0.033	Pipe Culvert	47	423	422	0.029	Yes	27	-0.004
55	Track	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	11	No data	No data	No data	N/A	N/A	No data
55	Mainline	Pipe Culvert	19	422	421	0.036	Pipe Culvert	60	422	420	0.029	Yes	41	-0.008
56		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
56		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
56	Track	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	11	423	422	0.010	N/A	N/A	No data
56	Mainline	Pipe Culvert	24	421	418	0.113	Pipe Culvert	44	421	418	0.056	Yes	20	-0.057
57	Track	New Structure	N/A	N/A	N/A	N/A	Box Culvert	10	420	420	0.011	N/A	N/A	No data
57	Mainline	Pipe Culvert	19	418	418	0.018	Box Culvert	52	418	416	0.040	Yes	33	0.022
57		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
57		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
57		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
57		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
57		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
57		New Structure	N/A	N/A	N/A	N/A	SUDs Outfall	N/A	N/A	N/A	N/A	N/A	N/A	No data

ID	Location	Current structure					New structure						Change (where +ve is increase and -ve is decrease)	
		Current structure type	Current structure length (m)	Current structure upstream bed level (mAOD)	Current structure downstream bed level (mAOD)	Current structure bed Slope (m/m)	Design structure type	Design structure length (m)	Design Upstream bed invert level (mAOD)	Design Downstream bed invert level (mAOD)	Design bed Slope (m/m)	Crossing to be upsized to take 1:200-year flow	Change in Length (m)	Change in Gradient
58		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
58		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
58		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
58		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
58	Track	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	13	419	419	0.007	N/A	N/A	No data
58	Mainline	Pipe Culvert	22	417	416	0.018	Pipe Culvert	45	418	417	0.010	Yes	23	-0.008
58		New Structure	N/A	N/A	N/A	N/A	SUDs Outfall	N/A	N/A	N/A	N/A	N/A	N/A	No data
59	Mainline?	Bridge	No data	No data	No data	No data	Bridge	No data	No data	No data	No data	Yes	No data	No data
59	Track	New Structure	N/A	N/A	N/A	N/A	Bridge	20	No data	No data	No data	N/A	N/A	No data
59		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
59	Track	New Structure	N/A	N/A	N/A	N/A	Replacement bridge	13	N/A	N/A	N/A	N/A	N/A	No data
60		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
60		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
60	Mainline	Pipe Culvert	23	415	415	0.015	Pipe Culvert	46	415	415	0.010	Yes	23	-0.005
61	Track	New Structure	N/A	N/A	N/A	N/A	Box Culvert	6	413	413	0.010	N/A	N/A	No data
61	Track	New Structure	N/A	N/A	N/A	N/A	Box Culvert	19	No data	No data	No data	N/A	N/A	No data
61	Mainline	Pipe Culvert	45	412	411	0.009	Box Culvert	42	413	412	0.013	Yes	-3	0.004
61		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
61		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
61		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
61		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
62	Track	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	17	No data	No data	No data	N/A	N/A	No data
62	Track	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	11	No data	No data	No data	N/A	N/A	No data
62	Mainline	Pipe Culvert	29	404	402	0.053	Pipe Culvert	37	404	403	0.010	Yes	9	-0.043
64	Track	New Structure	N/A	N/A	N/A	N/A	Bridge	8	No data	No data	No data	N/A	N/A	No data

ID	Location	Current structure					New structure						Change (where +ve is increase and -ve is decrease)	
		Current structure type	Current structure length (m)	Current structure upstream bed level (mAOD)	Current structure downstream bed level (mAOD)	Current structure bed Slope (m/m)	Design structure type	Design structure length (m)	Design Upstream bed invert level (mAOD)	Design Downstream bed invert level (mAOD)	Design bed Slope (m/m)	Crossing to be upsized to take 1:200-year flow	Change in Length (m)	Change in Gradient
64	Track	New Structure	N/A	N/A	N/A	N/A	Bridge	28	No data	No data	No data	N/A	N/A	No data
64	Mainline	Pipe Culvert		No data	No data	No data	Bridge	No data	No data	No data	No data	Yes	No data	No data
64		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
35a	Track	New Structure	N/A	N/A	N/A	N/A	Culvert	45	451	450	0.026	N/A	N/A	No data
41a		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
41a	Mainline	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	39	452	449	0.087	N/A	N/A	No data
41b		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
41b		New Structure	N/A	N/A	N/A	N/A	Drain outfall	No data	N/A	N/A	N/A	N/A	N/A	No data
41b	Mainline	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	46	451	446	0.106	N/A	N/A	No data
42a	Mainline	New Structure	N/A	N/A	N/A	N/A	Pipe Culvert	-	-	-	No data	N/A	N/A	No data
Allt Beul an Sporain	Track	New Structure	N/A	N/A	N/A	N/A	Bridge	13	No data	No data	No data	N/A	N/A	No data
River Truim from source to Allt Cuaich		New Structure	N/A	N/A	N/A	N/A	5x Drain outfalls	No data	N/A	N/A	N/A	N/A	N/A	No data
River Truim from source to Allt Cuaich P7		New Structure	N/A	N/A	N/A	N/A	8x SUDs Outfall	N/A	N/A	N/A	N/A	N/A	N/A	No data
River Truim from source to Allt Cuaich P8	Track	New Structure	N/A	N/A	N/A	N/A	Bridge	7	No data	No data	No data	N/A	N/A	No data

11.4.3.2 Design Freeze Information (4th iteration) for Channel Realignments

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Lengths (m)	Longitudinal Gradient (s)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width	Stream power comments
1	US	0.25	0.40	5.11	2	43.48	0.289	3.46	1.85	2.04	0.42	3.75	1.58	Cascade	4461	Laterally dynamic - likely to recover sinuosity after straightening
1	DS	0.50	0.50	1.69	2	41.87	0.222	4.50	2.50	2.74	0.75	3.98	2.98	Cascade	6488	Laterally dynamic - likely to recover sinuosity after straightening
2	US (South)	0.50	0.50	14.97	2	65.89	0.100	10.00	2.50	2.74	0.75	2.67	2.00	Cascade	1962	Laterally dynamic - likely to recover sinuosity after straightening
2	US (North)	0.50	0.50	7.02	2	61.63	0.109	9.17	2.50	2.74	0.75	2.79	2.09	Cascade	2232	Laterally dynamic - likely to recover sinuosity after straightening
2	US	-	-	-	-	-	-	-	-	-	-	-	-	No design info	No design info	No design info
2	DS	-	-	-	-	-	-	-	-	-	-	-	-	No design info	No design info	No design info
3	DS (Access Track)	0.50	0.50	4.03	2	15.66	0.200	5.00	2.50	2.74	0.75	3.77	2.83	Cascade	5548	Laterally dynamic - likely to recover sinuosity after straightening
3	DS	0.50	0.50	6.87	2	30.43	0.260	3.85	2.50	2.74	0.75	4.30	3.23	Cascade	8224	Laterally dynamic - likely to recover sinuosity after straightening
3	US	0.50	0.50	-	2	59.09	0.315	3.17	2.50	2.74	0.75	4.74	3.55	Cascade	10967	Laterally dynamic - likely to recover sinuosity after straightening
4	US	0.50	0.50	-	2	87.47	0.659	1.52	2.50	2.74	0.75	6.85	5.14	Cascade	33184	Laterally dynamic - likely to recover sinuosity after straightening
4	DS	0.50	0.50	0.98	2	35.11	0.126	7.94	2.50	2.74	0.75	3.00	2.25	Cascade	2774	Laterally dynamic - likely to recover sinuosity after straightening
5	US	0.50	0.50	3.84	2	104.59	0.141	7.09	2.50	2.74	0.75	3.17	2.38	Cascade	3284	Laterally dynamic - likely to recover sinuosity after straightening
5	DS	0.50	0.50	3.90	2	42.93	0.264	3.79	2.50	2.74	0.75	4.34	3.25	Cascade	8414	Laterally dynamic - likely to recover sinuosity after straightening
6	DS	-	-	-	-	32.78	-	-	-	-	-	-	-	No design info	No design info	No design info
6	US	0.50	0.50	-	2	5.59	1.250	0.80	2.50	2.74	0.75	9.44	7.08	Cascade	86691	Laterally dynamic - likely to recover sinuosity after straightening
7	DS	0.50	0.50	5.88	2	78.37	0.090	11.11	2.50	2.74	0.75	2.53	1.90	Step-pool/cascade	1675	Laterally dynamic - likely to recover sinuosity after straightening
7	US	0.50	0.50	-	2		0.410	2.44	2.50	2.74	0.75	5.40	4.05	Cascade	16285	Laterally dynamic - likely to recover sinuosity after straightening
7	US	0.50	0.50	2.97	2		0.031	32.26	2.50	2.74	0.75	1.49	1.11	Step-pool	339	Laterally dynamic - likely to recover sinuosity after straightening
8	DS	0.50	0.50	10.05	2	26.90	0.063	15.87	2.50	2.74	0.75	2.12	1.59	Step-pool	981	Laterally dynamic - likely to recover sinuosity after straightening
8	US	0.50	0.50	-	2		0.406	2.46	2.50	2.74	0.75	5.38	4.03	Cascade	16047	Laterally dynamic - likely to recover sinuosity after straightening
10	DS	0.75	0.50	3.24	2	26.62	0.005	200.00	2.75	2.99	0.88	0.62	0.55	Plane- riffle	27	Laterally dynamic - likely to recover sinuosity after straightening
10	US	0.50	0.50	-	2	30.32	2.200	0.45	2.50	2.74	0.75	12.52	9.39	Cascade	202414	Laterally dynamic - likely to recover sinuosity after straightening
10	US	0.60	0.60	10.25	1	106.38	0.050	20.00	1.80	2.30	0.72	2.06	1.49	Step-pool	728	Laterally dynamic - likely to recover sinuosity after straightening
12	US	0.50	0.50	5.10	2	28.71	0.370	2.70	2.50	2.74	0.75	5.13	3.85	Cascade	13961	Laterally dynamic - likely to recover sinuosity after straightening

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Lengths (m)	Longitudinal Gradient (s)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width	Stream power comments
12	DS	0.50	0.50	6.66	2	28.38	1.120	0.89	2.50	2.74	0.75	8.93	6.70	Cascade	73525	Laterally dynamic - likely to recover sinuosity after straightening
13	US	-	-	-	-		-	-	-	-	-	-	-	No design info	No design info	No design info
13	DS	-	-	-	-		-	-	-	-	-	-	-	No design info	No design info	No design info
14	US	0.50	0.50	3.45	2	5.64	0.413	2.42	2.50	2.74	0.75	5.42	4.07	Cascade	16464	Laterally dynamic - likely to recover sinuosity after straightening
14	DS	0.50	0.50	10.08	2	19.42	0.370	2.70	2.50	2.74	0.75	5.13	3.85	Cascade	13961	Laterally dynamic - likely to recover sinuosity after straightening
15	DS	0.50	0.50	10.14	2	8.39	0.410	2.44	2.50	2.74	0.75	5.40	4.05	Cascade	16285	Laterally dynamic - likely to recover sinuosity after straightening
15	US	0.50	0.50	-	2	17.03	0.500	2.00	2.50	2.74	0.75	5.97	4.48	Cascade	21931	Laterally dynamic - likely to recover sinuosity after straightening
21	DS	0.75	0.50	3.63	2	216.84	0.039	25.64	2.75	2.99	0.88	1.74	1.52	Step-pool	583	Laterally dynamic - likely to recover sinuosity after straightening
22	US	0.50	0.50	2.57	2	6.56	0.220	4.55	2.50	2.74	0.75	3.96	2.97	Cascade	6401	Laterally dynamic - likely to recover sinuosity after straightening
22	DS	0.50	0.50	0.74	2	8.40	0.320	3.13	2.50	2.74	0.75	4.77	3.58	Cascade	11229	Laterally dynamic - likely to recover sinuosity after straightening
25	US	0.50	0.50	3.08	2	7.26	0.674	1.48	2.50	2.74	0.75	6.93	5.20	Cascade	34324	Laterally dynamic - likely to recover sinuosity after straightening
25	DS	0.50	0.50	0.98	3	53.49	0.100	10.00	3.50	3.66	1.00	2.66	2.66	Cascade	2609	Laterally dynamic - likely to recover sinuosity after straightening
27	DS	0.50	0.50	1.09	2	17.13	0.133	7.52	2.50	2.74	0.75	3.08	2.31	Cascade	3009	Laterally dynamic - likely to recover sinuosity after straightening
27	US	0.50	0.50	3.88	3	89.15	0.072	13.89	3.50	3.66	1.00	2.26	2.26	Step-pool	1594	Laterally dynamic - likely to recover sinuosity after straightening
28	DS	0.50	0.50	2.30	3	45.88	0.052	19.23	3.50	3.66	1.00	1.92	1.92	Step-pool	978	Laterally dynamic - likely to recover sinuosity after straightening
28	US	0.50	0.50	6.02	2	46.87	0.137	7.30	2.50	2.74	0.75	3.12	2.34	Cascade	3145	Laterally dynamic - likely to recover sinuosity after straightening
30	DS	0.50	0.50	6.85	2	10.53	0.029	34.48	2.50	2.74	0.75	1.44	1.08	Step-pool/Plane bed	306	Laterally dynamic - likely to recover sinuosity after straightening
30	US	0.50	0.50	2.64	2	63.62	1.440	0.69	2.50	2.74	0.75	10.13	7.60	Cascade	107189	Laterally dynamic - likely to recover sinuosity after straightening
31	DS	2.20	1.00	5.00	2	125.60	0.008	125.00	6.20	6.67	4.20	1.31	5.52	Step-pool/Plane bed	433	Laterally dynamic - likely to recover sinuosity after straightening
31	US	0.60	0.50	5.26	2	12.11	0.500	2.00	2.60	2.84	0.80	6.08	4.87	Cascade	23844	Laterally dynamic - likely to recover sinuosity after straightening
33	US	0.50	0.50	-	2	14.91	0.360	2.78	2.50	2.74	0.75	5.06	3.80	Cascade	13399	Laterally dynamic - likely to recover sinuosity after straightening
33	DS	0.50	0.50	2.10	2	68.00	0.002	500.00	2.50	2.74	0.75	0.38	0.28	Plane- riffle	6	Low energy- likely to experience sedimentation
34	US	0.50	0.50	-	2	4.01	0.634	1.58	2.50	2.74	0.75	6.72	5.04	Cascade	31314	Laterally dynamic - likely to recover sinuosity after straightening
35	US	0.50	0.50	-	2	15.81	0.877	1.14	2.50	2.74	0.75	7.90	5.93	Cascade	50946	Laterally dynamic - likely to recover sinuosity after straightening
36	DS	0.75	0.50	2.55	2	8.38	0.019	52.63	2.75	2.99	0.88	1.22	1.06	Step-pool/Plane bed	198	Laterally dynamic - likely to recover sinuosity after straightening

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Lengths (m)	Longitudinal Gradient (s)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width	Stream power comments
36	US	0.50	0.50	-	2	5.20	0.912	1.10	2.50	2.74	0.75	8.06	6.04	Cascade	54026	Laterally dynamic - likely to recover sinuosity after straightening
37	US	0.50	0.50	4.28	1	10.28	0.040	25.00	1.50	1.91	0.50	1.63	0.82	Step-pool	320	Laterally dynamic - likely to recover sinuosity after straightening
37	DS	0.50	0.50	2.22	3	48.76	0.245	4.08	3.50	3.66	1.00	4.17	4.17	Cascade	10004	Laterally dynamic - likely to recover sinuosity after straightening
38	DS	0.50	0.50	2.32	2	17.30	0.043	23.26	2.50	2.74	0.75	1.75	1.31	Step-pool	553	Laterally dynamic - likely to recover sinuosity after straightening
38	US	0.50	0.50	2.66	2	9.04	0.240	4.17	2.50	2.74	0.75	4.13	3.10	Cascade	7293	Laterally dynamic - likely to recover sinuosity after straightening
39	DS	0.50	0.50	3.00	2	43.19	0.046	21.74	2.50	2.74	0.75	1.81	1.36	Step-pool	612	Laterally dynamic - likely to recover sinuosity after straightening
39	US	0.50	0.50	2.84	2	8.12	0.656	1.52	2.50	2.74	0.75	6.84	5.13	Cascade	32958	Laterally dynamic - likely to recover sinuosity after straightening
40	DS	0.50	0.50	0.59	2	13.30	0.220	4.55	2.50	2.74	0.75	3.96	2.97	Cascade	6401	Laterally dynamic - likely to recover sinuosity after straightening
40	US	0.50	0.50	5.45	2	8.15	0.400	2.50	2.50	2.74	0.75	5.34	4.00	Cascade	15693	Laterally dynamic - likely to recover sinuosity after straightening
42	DS	0.50	0.50	1.12	2	5.72	0.265	3.77	2.50	2.74	0.75	4.34	3.26	Cascade	8462	Laterally dynamic - likely to recover sinuosity after straightening
43	DS	1.50	0.70	1.63	2	18.90	0.021	47.62	4.30	4.63	2.03	1.67	3.40	Step-pool	699	Laterally dynamic - likely to recover sinuosity after straightening
44	US	0.50	0.50	-	2	8.83	0.610	1.64	2.50	2.74	0.75	6.59	4.94	Cascade	29553	Laterally dynamic - likely to recover sinuosity after straightening
44	DS	0.75	0.70	3.80	2	39.28	0.001	714.29	3.55	3.88	1.51	0.40	0.60	Plane- riffle	8	Low energy- likely to experience sedimentation
45	US	0.50	0.50	4.11	2	15.70	0.623	1.61	2.50	2.74	0.75	6.66	5.00	Cascade	30503	Laterally dynamic - likely to recover sinuosity after straightening
45	DS	0.60	0.60	3.87	2	25.18	0.010	100.00	3.00	3.28	1.08	0.95	1.03	Step-pool/Plane bed	101	Laterally dynamic - likely to recover sinuosity after straightening
46	US (north)	0.50	0.50	0.80	2	112.18	0.010	100.00	2.50	2.74	0.75	0.84	0.63	Step-pool/Plane bed	62	Laterally dynamic - likely to recover sinuosity after straightening
46	US	0.50	0.50	-	2	4.61	0.952	1.05	2.50	2.74	0.75	8.23	6.18	Cascade	57619	Laterally dynamic - likely to recover sinuosity after straightening
46	US (south)	0.50	0.50	4.15	2	35.44	0.016	62.50	2.50	2.74	0.75	1.07	0.80	Step-pool/Plane bed	126	Laterally dynamic - likely to recover sinuosity after straightening
46	DS	0.50	0.50	4.61	2	13.88	0.041	24.39	2.50	2.74	0.75	1.71	1.28	Step-pool	515	Laterally dynamic - likely to recover sinuosity after straightening
47	DS	0.50	0.50	4.59	2	14.13	0.051	19.61	2.50	2.74	0.75	1.91	1.43	Step-pool	714	Laterally dynamic - likely to recover sinuosity after straightening
47	US	0.50	0.50	4.52	3	38.45	0.100	10.00	3.50	3.66	1.00	2.66	2.66	Cascade	2609	Laterally dynamic - likely to recover sinuosity after straightening
49	DS	0.50	0.50	4.26	2	25.21	0.010	100.00	2.50	2.74	0.75	0.84	0.63	Step-pool/Plane bed	62	Laterally dynamic - likely to recover sinuosity after straightening
49	DS (Access Track)	0.50	0.50	1.61	2	5.06	0.018	55.56	2.50	2.74	0.75	1.13	0.85	Step-pool/Plane bed	150	Laterally dynamic - likely to recover sinuosity after straightening
49	US	0.50	0.50	-	2	4.77	1.110	0.90	2.50	2.74	0.75	8.89	6.67	Cascade	72542	Laterally dynamic - likely to recover sinuosity after straightening

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Lengths (m)	Longitudinal Gradient (s)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width	Stream power comments
50	DS	0.50	0.50	2.30	2	33.32	0.042	23.81	2.50	2.74	0.75	1.73	1.30	Step-pool	534	Laterally dynamic - likely to recover sinuosity after straightening
50	US	0.50	0.50	-	2	6.57	0.510	1.96	2.50	2.74	0.75	6.03	4.52	Cascade	22592	Laterally dynamic - likely to recover sinuosity after straightening
51	DS	0.50	0.50	7.24	2	58.85	0.031	32.26	2.50	2.74	0.75	1.49	1.11	Step-pool	339	Laterally dynamic - likely to recover sinuosity after straightening
51	US	0.50	0.50	4.07	2	19.86	0.086	11.63	2.50	2.74	0.75	2.47	1.86	Step-pool/cascade	1564	Laterally dynamic - likely to recover sinuosity after straightening
52	DS	-	-	-	-	-	-	-	-	-	-	-	-	No design info	No design info	No design info
52	US	-	-	-	-	-	-	-	-	-	-	-	-	No design info	No design info	No design info
54	DS	0.25	0.25	0.72	2	58.65	0.251	3.98	1.25	1.37	0.19	2.66	0.50	Cascade	1228	Laterally dynamic - likely to recover sinuosity after straightening
55	US	0.50	0.50	3.35	2	18.84	0.016	62.50	2.50	2.74	0.75	1.07	0.80	Step-pool/Plane bed	126	Laterally dynamic - likely to recover sinuosity after straightening
55	DS	0.50	0.50	2.52	2	22.14	0.120	8.33	2.50	2.74	0.75	2.92	2.19	Cascade	2579	Laterally dynamic - likely to recover sinuosity after straightening
56	US	0.50	0.50	2.52	2	62.85	0.025	40.00	2.50	2.74	0.75	1.33	1.00	Step-pool/Plane bed	245	Laterally dynamic - likely to recover sinuosity after straightening
56	US (Access Track)	0.50	0.50	-	2	6.03	0.367	2.72	2.50	2.74	0.75	5.11	3.83	Cascade	13791	Laterally dynamic - likely to recover sinuosity after straightening
56	DS	0.50	0.50	1.15	2	15.34	0.070	14.29	2.50	2.74	0.75	2.23	1.67	Step-pool	1149	Laterally dynamic - likely to recover sinuosity after straightening
57	US	0.75	0.70	2.05	2	21.49	0.081	12.35	3.55	3.88	1.51	3.03	4.56	Step-pool/cascade	3616	Laterally dynamic - likely to recover sinuosity after straightening
57	DS	1.25	0.70	1.58	2	52.18	0.011	90.91	4.05	4.38	1.86	1.18	2.19	Step-pool/Plane bed	237	Laterally dynamic - likely to recover sinuosity after straightening
58	US	0.50	0.50	1.66	2	32.73	0.036	27.78	2.50	2.74	0.75	1.60	1.20	Step-pool	424	Laterally dynamic - likely to recover sinuosity after straightening
58	DS	0.50	0.50	0.61	2	30.94	0.054	18.52	2.50	2.74	0.75	1.96	1.47	Step-pool	778	Laterally dynamic - likely to recover sinuosity after straightening
59	DS	-	-	-	-	-	-	-	-	-	-	-	-	No design info	No design info	No design info
59	US	-	-	-	-	-	-	-	-	-	-	-	-	No design info	No design info	No design info
60	DS	0.50	0.50	1.07	2	33.52	0.100	10.00	2.50	2.74	0.75	2.67	2.00	Cascade	1962	Laterally dynamic - likely to recover sinuosity after straightening
60	US	0.25	0.25	1.53	2	56.59	0.184	5.43	1.25	1.37	0.19	2.28	0.43	Cascade	771	Laterally dynamic - likely to recover sinuosity after straightening
61	DS	0.50	0.60	0.89	2	33.52	0.083	12.05	2.90	3.18	1.02	2.70	2.75	Step-pool/cascade	2238	Laterally dynamic - likely to recover sinuosity after straightening
61	US	0.75	0.70	1.98	2	56.33	0.013	76.92	3.55	3.88	1.51	1.21	1.83	Step-pool/Plane bed	233	Laterally dynamic - likely to recover sinuosity after straightening
62	US	0.50	0.50	1.86	2	31.07	0.026	38.46	2.50	2.74	0.75	1.36	1.02	Step-pool/Plane bed	260	Laterally dynamic - likely to recover sinuosity after straightening
64	DS	-	-	-	-	-	-	-	-	-	-	-	-	No design info	No design info	No design info
64	US	-	-	-	-	-	-	-	-	-	-	-	-	No design info	No design info	No design info
17-21	US	0.75	0.50	13.17	2	321.38	0.032	31.25	2.25	2.55	0.75	1.58	1.19	Step-pool	372	Laterally dynamic - likely to recover sinuosity after straightening

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Lengths (m)	Longitudinal Gradient (s)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width	Stream power comments
35a	US	0.50	0.50	-	3	10.31	0.530	1.89	3.50	3.66	1.00	6.13	6.13	Cascade	31830	Laterally dynamic - likely to recover sinuosity after straightening
41a	DS	0.50	0.50	0.69	1	15.44	0.193	5.18	1.50	1.91	0.50	3.59	1.80	Cascade	3395	Laterally dynamic - likely to recover sinuosity after straightening
41a	US	0.50	0.50	2.64	1	13.16	0.407	2.46	1.50	1.91	0.50	5.21	2.61	Cascade	10398	Laterally dynamic - likely to recover sinuosity after straightening
41b	DS	0.50	0.50	0.72	2	5.51	0.228	4.39	2.50	2.74	0.75	4.03	3.02	Cascade	6753	Laterally dynamic - likely to recover sinuosity after straightening
41b	US	0.50	0.50	1.11	2	13.32	0.352	2.84	2.50	2.74	0.75	5.01	3.76	Cascade	12955	Laterally dynamic - likely to recover sinuosity after straightening
42-43 Channel 1	US	0.60	1.00	7.14	1	156.17	0.064	15.63	2.60	3.43	1.60	3.04	4.87	Step-pool/cascade	3055	Laterally dynamic - likely to recover sinuosity after straightening
42-43 Channel 2	US	1.00	0.70	9.94	1	564.21	0.027	37.04	2.40	2.98	1.19	1.78	2.12	Step-pool-High V	561	Laterally dynamic - likely to recover sinuosity after straightening

Note:

Mannings, n = 0.05 for Natural Stream, Stony for all diversion channels

Mannings equation was used to calculate the velocity and capacity of each diversion channel.

11.4.3.3. Assessment Design Information (7th iteration) for Channel Realignments- see drawings 5.1 to 5.7

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Length (m)	Longitudinal Gradient (m/m)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	1:200 year Design Flow (m^3/s)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width (1:200)	Stream power comments
-1	DS	0.50	0.50	0.76	2	19.05	0.195	5.13	2.50	2.74	0.75	0.14	3.73	2.80	Cascade	5341	Laterally dynamic - likely to recover sinuosity after straightening
1	US_2	0.50	0.50	5.17	2	76.93	0.161	6.21	2.50	2.74	0.75	0.99	3.39	2.54	Cascade	4007	Laterally dynamic - likely to recover sinuosity after straightening
1	US_1	0.50	0.50	1.83	2	41.68	0.240	4.17	2.50	2.74	0.75	0.99	4.13	3.10	Cascade	7293	Laterally dynamic - likely to recover sinuosity after straightening
1	DS	0.50	0.50	2.85	2	70.00	0.247	4.05	2.50	2.74	0.75	0.99	4.19	3.15	Cascade	7615	Laterally dynamic - likely to recover sinuosity after straightening
2	US (South)	0.50	0.50	11.86	2	127.52	0.100	10.00	2.50	2.74	0.75	0.61	2.67	2.00	Cascade	1962	Laterally dynamic - likely to recover sinuosity after straightening
2	US	-	-	-	-	-	-	-	-	-	-		-	-	No design info	No design info	No design info
2	DS	-	-	-	-	-	-	-	-	-	-		-	-	No design info	No design info	No design info
3	DS (Access Track)	0.50	0.50	1.82	2	15.66	0.200	5.00	2.50	2.74	0.75	0.19	3.77	2.83	Cascade	5548	Laterally dynamic - likely to recover sinuosity after straightening
3	DS	0.50	0.50	5.59	2	30.43	0.260	3.85	2.50	2.74	0.75	0.19	4.30	3.23	Cascade	8224	Laterally dynamic - likely to recover sinuosity after straightening
3	US	0.50	0.50	10.10	2	59.09	0.315	3.17	2.50	2.74	0.75	0.19	4.74	3.55	Cascade	10967	Laterally dynamic - likely to recover sinuosity after straightening
4	US_1	0.50	0.50	5.45	2	21.36	0.455	2.20	2.50	2.74	0.75	0.32	5.69	4.27	Cascade	19038	Laterally dynamic - likely to recover sinuosity after straightening
4	US_3	0.50	0.50	1.17	2	80.23	0.107	9.35	2.50	2.74	0.75	0.32	2.76	2.07	Cascade	2171	Laterally dynamic - likely to recover sinuosity after straightening
4	US_2	0.50	0.50	1.15	2	22.14	0.210	4.76	2.50	2.74	0.75	0.32	3.87	2.90	Cascade	5969	Laterally dynamic - likely to recover sinuosity after straightening
4	DS	0.50	0.50	3.37	2	5.35	0.565	1.77	2.50	2.74	0.75	0.32	6.34	4.76	Cascade	26344	Laterally dynamic - likely to recover sinuosity after straightening
4	DS (Access Track)	0.50	0.50	1.05	2	35.90	0.174	5.75	2.50	2.74	0.75	0.32	3.52	2.64	Cascade	4502	Laterally dynamic - likely to recover sinuosity after straightening
5	US	0.50	0.50	2.19	2	99.93	0.158	6.33	2.50	2.74	0.75	0.70	3.35	2.52	Cascade	3896	Laterally dynamic - likely to recover sinuosity after straightening
5	DS_2	0.50	0.50	1.23	2	39.09	0.270	3.70	2.50	2.74	0.75	0.70	4.39	3.29	Cascade	8703	Laterally dynamic - likely to recover sinuosity after straightening
5	DS_1	0.50	0.50	1.15	2	18.63	0.410	2.44	2.50	2.74	0.75	0.70	5.40	4.05	Cascade	16285	Laterally dynamic - likely to recover sinuosity after straightening
6	DS_2	0.50	0.50	2.68	2	35.22	0.311	3.22	2.50	2.74	0.75	0.25	4.71	3.53	Cascade	10758	Laterally dynamic - likely to recover sinuosity after straightening
6	DS_1	0.50	0.50	1.64	2	17.21	0.566	1.77	2.50	2.74	0.75	0.25	6.35	4.76	Cascade	26414	Laterally dynamic - likely to recover sinuosity after straightening
6	US	0.50	0.50	7.76	2	24.66	0.500	2.00	2.50	2.74	0.75	0.25	5.97	4.48	Cascade	21931	Laterally dynamic - likely to recover sinuosity after straightening
7	DS	0.50	0.50	0.99	2	43.42	0.378	2.65	2.50	2.74	0.75	0.73	5.19	3.89	Cascade	14416	Laterally dynamic - likely to recover sinuosity after straightening
7	US_2 (Verge)	0.50	0.50	2.94	1	50.89	0.064	15.63	1.50	1.91	0.50	0.73	2.07	1.03	Step-pool	648	Laterally dynamic - likely to recover sinuosity after straightening
7	US_2	0.50	0.50	1.06	2	24.20	0.315	3.17	2.50	2.74	0.75	0.73	4.74	3.55	Cascade	10967	Laterally dynamic - likely to recover sinuosity after straightening

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Length (m)	Longitudinal Gradient (m/m)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	1:200 year Design Flow (m^3/s)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width (1:200)	Stream power comments
7	US_3	0.50	0.50	0.52	2	19.89	0.379	2.64	2.50	2.74	0.75	0.73	5.20	3.90	Cascade	14473	Laterally dynamic - likely to recover sinuosity after straightening
7	US_1	0.50	0.50	8.31	2	27.70	0.474	2.11	2.50	2.74	0.75	0.73	5.81	4.36	Cascade	20243	Laterally dynamic - likely to recover sinuosity after straightening
7	US_3 (Verge)	0.50	0.50	2.58	1	65.32	0.040	25.00	1.50	1.91	0.50	0.73	1.63	0.82	Step-pool	320	Laterally dynamic - likely to recover sinuosity after straightening
8	DS	0.50	0.50	4.62	2	40.30	0.295	3.39	2.50	2.74	0.75	1.54	4.58	3.44	Cascade	9939	Laterally dynamic - likely to recover sinuosity after straightening
8	US_2	0.50	0.50	5.40	2	17.55	0.114	8.77	2.50	2.74	0.75	1.54	2.85	2.14	Cascade	2388	Laterally dynamic - likely to recover sinuosity after straightening
8	US_1	0.50	0.50	4.22	2	74.37	0.362	2.76	2.50	2.74	0.75	1.54	5.08	3.81	Cascade	13510	Laterally dynamic - likely to recover sinuosity after straightening
10	DS	0.50	0.50	4.30	2	41.23	0.053	18.87	2.50	2.74	0.75	0.63	1.94	1.46	Step-pool	757	Laterally dynamic - likely to recover sinuosity after straightening
10	US	0.50	0.50	3.28	2	47.06	0.327	3.06	2.50	2.74	0.75	0.63	4.83	3.62	Cascade	11599	Laterally dynamic - likely to recover sinuosity after straightening
10	US_Verge	1.00	0.75	1.43	2	119.26	0.010	100.00	4.00	4.35	1.88	0.63	1.14	2.14	Plane- riffle/Plane bed	210	Laterally dynamic - likely to recover sinuosity after straightening
12	US_1	0.50	0.50	6.23	2	28.29	0.399	2.51	2.50	2.74	0.75	0.83	5.33	4.00	Cascade	15634	Laterally dynamic - likely to recover sinuosity after straightening
12	US_2	0.50	0.50	5.09	2	50.00	0.182	5.49	2.50	2.74	0.75	0.83	3.60	2.70	Cascade	4816	Laterally dynamic - likely to recover sinuosity after straightening
12	DS	0.50	0.50	7.46	2	28.00	0.350	2.86	2.50	2.74	0.75	0.83	4.99	3.74	Cascade	12844	Laterally dynamic - likely to recover sinuosity after straightening
13	US	1.50	0.70	11.57	2	18.60	0.070	14.29	4.30	4.63	2.03	3.66	3.05	6.20	Step-pool	4253	Laterally dynamic - likely to recover sinuosity after straightening
13	DS_2	0.75	0.60	2.99	2	12.00	0.106	9.43	3.15	3.43	1.17	3.66	3.18	3.72	Cascade	3861	Laterally dynamic - likely to recover sinuosity after straightening
13	DS (Access Track)	0.50	0.50	10.15	2	10.84	0.561	1.78	2.50	2.74	0.75	3.66	6.32	4.74	Cascade	26065	Laterally dynamic - likely to recover sinuosity after straightening
13	DS_1	0.50	0.50	1.43	2	17.88	0.499	2.00	2.50	2.74	0.75	3.66	5.96	4.47	Cascade	21865	Laterally dynamic - likely to recover sinuosity after straightening
14	US_1	0.50	0.50	2.74	2	23.75	0.194	5.15	2.50	2.74	0.75	0.38	3.72	2.79	Cascade	5300	Laterally dynamic - likely to recover sinuosity after straightening
14	US_2	0.50	0.50	3.18	2	23.92	0.350	2.86	2.50	2.74	0.75	0.38	4.99	3.74	Cascade	12844	Laterally dynamic - likely to recover sinuosity after straightening
14	DS (Access Track)	0.50	0.50	2.64	2	15.40	0.545	1.83	2.50	2.74	0.75	0.38	6.23	4.67	Cascade	24958	Laterally dynamic - likely to recover sinuosity after straightening
14	DS	0.50	0.50	2.22	2	23.42	0.423	2.36	2.50	2.74	0.75	0.38	5.49	4.12	Cascade	17065	Laterally dynamic - likely to recover sinuosity after straightening
15	US_2	0.50	0.50	2.30	2	25.05	0.135	7.41	2.50	2.74	0.75	0.57	3.10	2.33	Cascade	3077	Laterally dynamic - likely to recover sinuosity after straightening
15	DS	0.50	0.50	4.70	2	8.39	0.410	2.44	2.50	2.74	0.75	0.57	5.40	4.05	Cascade	16285	Laterally dynamic - likely to recover sinuosity after straightening
15	US_1	0.50	0.50	6.98	2	29.10	0.338	2.96	2.50	2.74	0.75	0.57	4.91	3.68	Cascade	12189	Laterally dynamic - likely to recover sinuosity after straightening
21	US	0.90	0.90	6.00	1	275.00	0.002	476.19	2.70	3.45	1.62	0.89	0.55	0.90	Plane- riffle	18	High energy - likely to erode constructed features

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Length (m)	Longitudinal Gradient (m/m)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	1:200 year Design Flow (m^3/s)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width (1:200)	Stream power comments
21	DS	0.75	0.50	3.89	2	227.21	0.022	45.45	2.75	2.99	0.88	0.89	1.31	1.15	Plane- riffle/Plane bed	247	Laterally dynamic - likely to recover sinuosity after straightening
22	US_1	0.50	0.50	4.13	2	25.92	0.428	2.34	2.50	2.74	0.75	0.49	5.52	4.14	Cascade	17369	Laterally dynamic - likely to recover sinuosity after straightening
22	US_2	0.50	0.50	3.15	2	37.20	0.079	12.66	2.50	2.74	0.75	0.49	2.37	1.78	Step-pool	1377	Laterally dynamic - likely to recover sinuosity after straightening
22	DS	0.50	0.50	1.46	2	8.40	0.320	3.13	2.50	2.74	0.75	0.49	4.77	3.58	Cascade	11229	Laterally dynamic - likely to recover sinuosity after straightening
25	US	0.50	0.50	3.37	2.00	24.00	0.36	2.75	2.50	2.74	0.75	0.43	5.09	3.82	Cascade	13623	Laterally dynamic - likely to recover sinuosity after straightening
25	DS_1	0.50	0.50	1.60	2.00	12.32	0.22	4.61	2.50	2.74	0.75	0.43	3.93	2.95	Cascade	6270	Laterally dynamic - likely to recover sinuosity after straightening
25	DS_2	0.50	0.50	2.12	3.00	8.20	0.23	4.41	3.50	3.66	1.00	0.43	4.01	4.01	Cascade	8922	Laterally dynamic - likely to recover sinuosity after straightening
25	DS (Access Track)	0.50	0.50	1.82	3.00	39.85	0.07	14.08	3.50	3.66	1.00	0.43	2.24	2.24	Step-pool	1561	Laterally dynamic - likely to recover sinuosity after straightening
27	DS	0.50	0.50	1.32	2	7.05	0.300	3.33	2.50	2.74	0.75	0.80	4.62	3.47	Cascade	10193	Laterally dynamic - likely to recover sinuosity after straightening
27	DS (Access Track)	0.50	0.50	1.24	2	16.25	0.016	62.50	2.50	2.74	0.75	0.80	1.07	0.80	Plane- riffle/Plane bed	126	Laterally dynamic - likely to recover sinuosity after straightening
27	US_2	0.50	0.50	3.48	3	89.17	0.026	38.91	3.50	3.66	1.00	0.80	1.35	1.35	Plane- riffle/Plane bed	340	Laterally dynamic - likely to recover sinuosity after straightening
27	US_1	0.50	0.50	1.76	2	15.60	0.053	19.01	2.50	2.74	0.75	0.80	1.94	1.45	Step-pool	748	Laterally dynamic - likely to recover sinuosity after straightening
28	DS (Access Track)	0.50	0.50	0.94	3	23.01	0.023	43.48	3.50	3.66	1.00	1.10	1.28	1.28	Plane- riffle/Plane bed	288	Laterally dynamic - likely to recover sinuosity after straightening
28	US_2	0.50	0.50	3.80	2	16.82	0.110	9.09	2.50	2.74	0.75	1.10	2.80	2.10	Cascade	2263	Laterally dynamic - likely to recover sinuosity after straightening
28	DS	0.50	0.50	2.87	2	14.02	0.359	2.79	2.50	2.74	0.75	1.10	5.06	3.79	Cascade	13343	Laterally dynamic - likely to recover sinuosity after straightening
28	US_1	0.50	0.50	5.38	2	50.66	0.136	7.35	2.50	2.74	0.75	1.10	3.11	2.33	Cascade	3111	Laterally dynamic - likely to recover sinuosity after straightening
30	DS	0.50	0.50	3.11	2	18.07	0.141	7.09	2.50	2.74	0.75	0.14	3.17	2.38	Cascade	3284	Laterally dynamic - likely to recover sinuosity after straightening
30	DS (Access Track)	0.50	0.50	1.64	2	50.60	0.005	200.00	2.50	2.74	0.75	0.14	0.60	0.45	Plane- riffle	22	High energy - likely to erode constructed features
30	US	0.50	0.50	4.98	2	77.81	0.121	8.26	2.50	2.74	0.75	0.14	2.94	2.20	Cascade	2611	Laterally dynamic - likely to recover sinuosity after straightening
31	DS	1.30	0.80	3.76	3	86.30	0.019	52.63	6.10	6.36	2.96	4.80	1.66	4.90	Plane- riffle/Plane bed	913	Laterally dynamic - likely to recover sinuosity after straightening
31	US	0.50	0.50	6.30	2	20.28	0.288	3.47	2.50	2.74	0.75	4.80	4.53	3.40	Cascade	9587	Laterally dynamic - likely to recover sinuosity after straightening
33	US	0.50	0.50	4.91	2	20.28	0.280	3.57	2.50	2.74	0.75	0.18	4.47	3.35	Cascade	9191	Laterally dynamic - likely to recover sinuosity after straightening
33	DS (Access Track)	2.00	1.00	1.29	3	115.08	0.005	200.00	8.00	8.32	5.00	4.98	1.01	5.03	Plane- riffle	247	Laterally dynamic - likely to recover sinuosity after straightening
33	DS	1.35	0.80	2.65	3	42.13	0.023	43.48	6.15	6.41	3.00	4.98	1.83	5.49	Plane- riffle/Plane bed	1236	Laterally dynamic - likely to recover sinuosity after straightening

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Length (m)	Longitudinal Gradient (m/m)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	1:200 year Design Flow (m^3/s)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width (1:200)	Stream power comments
34	US	0.50	0.50	5.90	2	24	0.362	2.76	2.50	2.74	0.75	1.18	5.08	3.81	Cascade	13510	Laterally dynamic - likely to recover sinuosity after straightening
34	DS	0.60	0.60	2.60	2	35.10	0.019	52.63	3.00	3.28	1.08	1.18	1.31	1.42	Plane- riffle/Plane bed	264	Laterally dynamic - likely to recover sinuosity after straightening
35	US	0.50	0.50	2.71	2	22.57	0.125	8.00	2.50	2.74	0.75	0.56	2.98	2.24	Cascade	2741	Laterally dynamic - likely to recover sinuosity after straightening
35	DS (Access Track)	1.00	1.00	1.05	3	64.42	0.003	333.33	7.00	7.32	4.00	0.56	0.73	2.93	Plane- riffle	86	Laterally dynamic - likely to recover sinuosity after straightening
35	DS_2	0.50	0.50	1.45	2	10.21	0.058	17.24	2.50	2.74	0.75	0.56	2.03	1.52	Step-pool	866	Laterally dynamic - likely to recover sinuosity after straightening
35	DS_1	0.50	0.50	1.34	2	13.80	0.139	7.19	2.50	2.74	0.75	0.56	3.15	2.36	Cascade	3215	Laterally dynamic - likely to recover sinuosity after straightening
36	DS	0.50	0.50	1.59	2	114.87	0.021	47.62	2.50	2.74	0.75	0.81	1.22	0.92	Plane- riffle/Plane bed	189	Laterally dynamic - likely to recover sinuosity after straightening
36	US_1	0.50	0.50	4.30	2	9.03	0.523	1.91	2.50	2.74	0.75	0.81	6.10	4.58	Cascade	23462	Laterally dynamic - likely to recover sinuosity after straightening
36	US_2	0.60	0.50	4.96	2	64.48	0.015	66.67	2.60	2.84	0.80	0.81	1.05	0.84	Plane- riffle/Plane bed	124	Laterally dynamic - likely to recover sinuosity after straightening
37	DS	0.50	0.50	2.15	3	48.92	0.039	25.64	3.50	3.66	1.00	0.19	1.66	1.66	Step-pool	635	Laterally dynamic - likely to recover sinuosity after straightening
37	US_1	0.50	0.50	0.55	2	10.36	0.233	4.29	2.50	2.74	0.75	0.19	4.07	3.06	Cascade	6977	Laterally dynamic - likely to recover sinuosity after straightening
37	US_2	0.50	0.50	1.97	2	12.27	0.226	4.42	2.50	2.74	0.75	0.19	4.01	3.01	Cascade	6665	Laterally dynamic - likely to recover sinuosity after straightening
38	DS	0.50	0.50	1.76	2	21.10	0.025	40.00	2.50	2.74	0.75	0.27	1.33	1.00	Plane- riffle/Plane bed	245	Laterally dynamic - likely to recover sinuosity after straightening
38	US_2	0.50	0.50	1.30	2	13.29	0.134	7.46	2.50	2.74	0.75	0.27	3.09	2.32	Cascade	3043	Laterally dynamic - likely to recover sinuosity after straightening
38	US_1	0.50	0.50	2.43	2	8.63	0.221	4.52	2.50	2.74	0.75	0.27	3.97	2.98	Cascade	6445	Laterally dynamic - likely to recover sinuosity after straightening
39	DS	0.50	0.50	1.71	2	43.08	0.025	40.00	2.50	2.74	0.75	0.22	1.33	1.00	Plane- riffle/Plane bed	245	Laterally dynamic - likely to recover sinuosity after straightening
39	US	0.50	0.50	4.91	2	22.80	0.434	2.30	2.50	2.74	0.75	0.22	5.56	4.17	Cascade	17735	Laterally dynamic - likely to recover sinuosity after straightening
40	DS	0.50	0.50	0.81	2	14.57	0.061	16.39	2.50	2.74	0.75	0.20	2.08	1.56	Step-pool	935	Laterally dynamic - likely to recover sinuosity after straightening
40	US	0.50	0.50	5.41	2	7.76	0.390	2.56	2.50	2.74	0.75	0.20	5.27	3.95	Cascade	15108	Laterally dynamic - likely to recover sinuosity after straightening
42	DS	0.50	0.50	2.29	2	10.19	0.250	4.00	2.50	2.74	0.75	0.50	4.22	3.16	Cascade	7754	Laterally dynamic - likely to recover sinuosity after straightening
42	US	0.50	0.50	5.36	2	15.94	0.736	1.36	2.50	2.74	0.75	0.50	7.24	5.43	Cascade	39167	Laterally dynamic - likely to recover sinuosity after straightening
43	DS	1.50	0.70	0.79	2	19.81	0.029	34.48	4.30	4.63	2.03	2.25	1.97	3.99	Plane- riffle/Plane bed	1134	Laterally dynamic - likely to recover sinuosity after straightening
44	US	0.50	0.50	3.46	2	26.74	0.200	5.00	2.50	2.74	0.75	0.43	3.77	2.83	Cascade	5548	Laterally dynamic - likely to recover sinuosity after straightening
44	DS	0.70	0.70	2.05	2	35.26	0.005	200.00	3.50	3.83	1.47	0.43	0.75	1.10	Plane- riffle	54	Stable

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Length (m)	Longitudinal Gradient (m/m)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	1:200 year Design Flow (m^3/s)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width (1:200)	Stream power comments
45	US_1	0.50	0.50	3.64	2	24.30	0.215	4.65	2.50	2.74	0.75	0.77	3.91	2.93	Cascade	6184	Laterally dynamic - likely to recover sinuosity after straightening
45	US_2	0.50	0.50	1.21	2	42.99	0.027	37.04	2.50	2.74	0.75	0.77	1.39	1.04	Plane- riffle/Plane bed	275	Laterally dynamic - likely to recover sinuosity after straightening
45	US_3	0.50	0.50	1.39	2	39.10	0.048	20.83	2.50	2.74	0.75	0.77	1.85	1.39	Step-pool	652	Laterally dynamic - likely to recover sinuosity after straightening
45	DS	0.60	0.60	3.76	2	21.40	0.010	100.00	3.00	3.28	1.08	0.77	0.95	1.03	Plane- riffle/Plane bed	101	Laterally dynamic - likely to recover sinuosity after straightening
46	US_2	0.50	0.50	2.31	2	65.41	0.066	15.15	2.50	2.74	0.75	0.20	2.17	1.63	Step-pool	1052	Laterally dynamic - likely to recover sinuosity after straightening
46	US_1	0.50	0.50	3.26	2	23.97	0.204	4.90	2.50	2.74	0.75	0.20	3.81	2.86	Cascade	5715	Laterally dynamic - likely to recover sinuosity after straightening
46	US_3	0.50	0.50	2.53	2	59.56	0.045	22.22	2.50	2.74	0.75	0.20	1.79	1.34	Step-pool	592	Laterally dynamic - likely to recover sinuosity after straightening
46	DS	0.50	0.50	3.04	2	11.00	0.055	18.18	2.50	2.74	0.75	0.20	1.98	1.48	Step-pool	800	Laterally dynamic - likely to recover sinuosity after straightening
47	US_2	0.50	0.50	2.68	2	44.70	0.057	17.54	2.50	2.74	0.75	0.17	2.01	1.51	Step-pool	844	Laterally dynamic - likely to recover sinuosity after straightening
47	DS	0.50	0.50	2.05	2	12.39	0.058	17.24	2.50	2.74	0.75	0.17	2.03	1.52	Step-pool	866	Laterally dynamic - likely to recover sinuosity after straightening
47	US_1	0.50	0.50	3.37	2	24.08	0.241	4.15	2.50	2.74	0.75	0.17	4.14	3.11	Cascade	7339	Laterally dynamic - likely to recover sinuosity after straightening
49	DS	0.50	0.50	1.43	2	8.04	0.238	4.20	2.50	2.74	0.75	0.08	4.12	3.09	Cascade	7202	Laterally dynamic - likely to recover sinuosity after straightening
49	US_2	0.50	0.50	1.41	2	11.07	0.127	7.87	2.50	2.74	0.75	0.08	3.01	2.26	Cascade	2807	Laterally dynamic - likely to recover sinuosity after straightening
49	DS (Access Track)	0.50	0.50	2.68	1	19.28	0.006	166.67	1.50	1.91	0.50	0.08	0.63	0.32	Plane- riffle/Plane bed	19	High energy - likely to erode constructed features
49	US_1	0.50	0.50	3.09	2	11.01	0.500	2.00	2.50	2.74	0.75	0.08	5.97	4.48	Cascade	21931	Laterally dynamic - likely to recover sinuosity after straightening
50	DS	0.50	0.50	3.06	2	10.00	0.459	2.18	2.50	2.74	0.75	0.02	5.72	4.29	Cascade	19290	Laterally dynamic - likely to recover sinuosity after straightening
50	US	0.50	0.50	2.07	2	23.45	0.007	142.86	2.50	2.74	0.75	0.08	0.71	0.53	Plane- riffle/Plane bed	36	Stable
51	DS	0.50	0.50	2.68	2	80	0.071	14.08	2.50	2.74	0.75	0.53	2.25	1.69	Step-pool	1174	Laterally dynamic - likely to recover sinuosity after straightening
51	US	0.50	0.50	1.90	2	25.55	0.042	25.55	2.50	2.74	0.75	0.02	1.73	1.30	Step-pool	534	Laterally dynamic - likely to recover sinuosity after straightening
52	DS	0.50	0.50	2.99	2	67.42	0.055	18.18	2.50	2.74	0.75	0.53	1.98	1.48	Step-pool	800	Laterally dynamic - likely to recover sinuosity after straightening
52	US	-	-	-	-	-	-	-	-	-	-		-	-	No design info		
54	DS	0.25	0.25	0.65	2	58.65	0.251	3.98	1.25	1.37	0.19	0.03	2.66	0.50	Cascade	1228	Laterally dynamic - likely to recover sinuosity after straightening
55	US_1	0.50	0.50	0.55	2	13.50	0.020	50.00	2.50	2.74	0.75	0.21	1.19	0.90	Plane- riffle/Plane bed	175	Laterally dynamic - likely to recover sinuosity after straightening
55	US_2	0.50	0.50	0.64	2	10.73	0.201	4.98	2.50	2.74	0.75	0.21	3.78	2.84	Cascade	5590	Laterally dynamic - likely to recover sinuosity after straightening
55	DS	0.50	0.50	0.69	2	13.82	0.058	17.24	2.50	2.74	0.75	0.21	2.03	1.52	Step-pool	866	Laterally dynamic - likely to recover sinuosity after straightening

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Length (m)	Longitudinal Gradient (m/m)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	1:200 year Design Flow (m^3/s)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width (1:200)	Stream power comments
56	US	0.50	0.50	1.19	2	62.81	0.025	40.00	2.50	2.74	0.75	0.23	1.33	1.00	Plane- riffle/Plane bed	245	Laterally dynamic - likely to recover sinuosity after straightening
56	DS (Access Track)	0.50	0.50	2.06	2	47.34	0.012	83.33	2.50	2.74	0.75	0.23	0.92	0.69	Plane- riffle/Plane bed	82	Stable
56	DS	0.50	0.50	5.09	2	10.05	0.446	2.24	2.50	2.74	0.75	0.23	5.64	4.23	Cascade	18476	Laterally dynamic - likely to recover sinuosity after straightening
57	US	0.60	0.60	1.93	2	8.22	0.188	5.32	3.00	3.28	1.08	3.64	4.13	4.46	Cascade	8222	Laterally dynamic - likely to recover sinuosity after straightening
57	DS	0.75	0.75	1.25	2	33.11	0.038	26.32	3.75	4.10	1.69	3.64	2.16	3.64	Step-pool	1355	Laterally dynamic - likely to recover sinuosity after straightening
58	US	0.50	0.50	1.48	2	32.73	0.036	27.78	2.50	2.74	0.75	0.59	1.60	1.20	Step-pool	424	Laterally dynamic - likely to recover sinuosity after straightening
58	DS	0.50	0.50	0.52	2	31.29	0.054	18.52	2.50	2.74	0.75	0.59	1.96	1.47	Step-pool	778	Laterally dynamic - likely to recover sinuosity after straightening
59	DS	-	-	-	-	-	-	-	-	-	-		-	-	No design info	No design info	No design info
59	US	-	-	-	-	-	-	-	-	-	-		-	-	No design info	No design info	No design info
60	DS	0.50	0.50	0.92	2	33.52	0.100	10.00	2.50	2.74	0.75	0.13	2.67	2.00	Cascade	1962	Laterally dynamic - likely to recover sinuosity after straightening
60	US	0.25	0.25	1.37	2	56.59	0.184	5.43	1.25	1.37	0.19	0.13	2.28	0.43	Cascade	771	Laterally dynamic - likely to recover sinuosity after straightening
61	DS	0.50	0.60	0.67	2	33.52	0.083	12.05	2.90	3.18	1.02	1.04	2.70	2.75	Step-pool	2238	Laterally dynamic - likely to recover sinuosity after straightening
61	US_2	0.50	0.50	0.50	2	35.96	0.040	25.00	2.50	2.74	0.75	1.04	1.69	1.27	Step-pool	496	Laterally dynamic - likely to recover sinuosity after straightening
61	US_1	0.50	0.50	0.50	2	50.09	0.031	32.26	2.50	2.74	0.75	1.04	1.49	1.11	Step-pool	339	Laterally dynamic - likely to recover sinuosity after straightening
62	DS	0.50	0.50	2.63	2	10.00	0.160	6.25	2.50	2.74	0.75	0.16	3.38	2.53	Cascade	3970	Laterally dynamic - likely to recover sinuosity after straightening
62	US	0.50	0.50	1.33	2	29.59	0.026	38.46	2.50	2.74	0.75	0.16	1.36	1.02	Plane- riffle/Plane bed	260	Laterally dynamic - likely to recover sinuosity after straightening
63	US	1.00	1.00	4.70	2	63.36	0.029	34.48	5.00	5.47	3.00	5.37	2.28	6.84	Plane- riffle/Plane bed	1945	Laterally dynamic - likely to recover sinuosity after straightening
64	DS	-	-	-	-	-	-	-	-	-	-		-	-	No design info	No design info	No design info
64	US	-	-	-	-	-	-	-	-	-	-		-	-	No design info	No design info	No design info
35a	DS	0.50	0.50	2.66	2	21.06	0.029	34.48	2.50	2.74	0.75	0.56	1.44	1.08	Plane- riffle/Plane bed	306	Laterally dynamic - likely to recover sinuosity after straightening
35a	US	0.50	0.50	2.96	2	8.40	0.381	2.62	2.50	2.74	0.75	0.56	5.21	3.91	Cascade	14588	Laterally dynamic - likely to recover sinuosity after straightening
41a	DS	0.50	0.50	1.28	2	16.44	0.144	6.94	2.50	2.74	0.75	0.17	3.20	2.40	Cascade	3390	Laterally dynamic - likely to recover sinuosity after straightening
41a	US	0.50	0.50	4.17	2	28.92	0.481	2.08	2.50	2.74	0.75	0.17	5.85	4.39	Cascade	20693	Laterally dynamic - likely to recover sinuosity after straightening
41b	US_2	0.50	0.50	1.11	2	26.47	0.188	5.32	2.50	2.74	0.75	0.25	3.66	2.74	Cascade	5056	Laterally dynamic - likely to recover sinuosity after straightening
41b	DS	0.50	0.50	0.59	2	7.40	0.204	4.90	2.50	2.74	0.75	0.25	3.81	2.86	Cascade	5715	Laterally dynamic - likely to recover sinuosity after straightening

ID	Location (i.e upstream or downstream of the A9)	Channel Base Width b (m)	Minimum Channel Depth d (m)	Maximum Channel Depth (m)	Channel Side Slopes (1:x)	Diversion Length (m)	Longitudinal Gradient (m/m)	Slope (1:x)	Top Width T (m)	Wetted Perimeter p (m)	Flow Area A (m^2)	1:200 year Design Flow (m^3/s)	Velocity (1:200 year) v (m/s)	Channel Capacity (1:200 year) Q (m^3/s)	Preferred River Type (based on slope and low sinuosity planform and energy info)	Stream Power/unit width (1:200)	Stream power comments
41b	US_1	0.50	0.50	3.76	2	27.77	0.446	2.24	2.50	2.74	0.75	0.25	5.64	4.23	Cascade	18476	Laterally dynamic - likely to recover sinuosity after straightening
42-43 Channel 1	US	1.00	0.70	1.54	1	150.00	0.010	100.00	2.40	2.98	1.19	0.72	1.08	1.29	Plane- riffle/Plane bed	126	Laterally dynamic - likely to recover sinuosity after straightening
42-43 Channel 2	US	1.20	0.70	5.32	1	700.00	0.025	40.00	2.60	3.18	1.33	2.25	1.77	2.35	Plane- riffle/Plane bed	576	Laterally dynamic - likely to recover sinuosity after straightening

11.4.3.4. Assessment Design Information (7th iteration) for Channel Crossings - see Drawings 5.1 to 5.7

Chainage	HYDRO ID	Bed Material to be included in culvert	Size Estimate to include for bed material	Upstream watercourse bed invert level (m AOD)	Downstream watercourse bed invert level (m AOD)	Culvert Length (m)	Gradient (m/m)
0+220	1	Y	1500 x 1500	440.201	439.475	67.05	0.011
0+400	2	Y		-	-	-	-
0+610	3	N	900	444.846	444.561	29.81	0.010
0+790	4	Y	1500	444.942	444.536	37.42	0.011
0+960	5	Y	1500	447.966	447.476	48.95	0.010
1+145	6	Y	1500 x 1250	448.581	448.271	30.03	0.010
1+245	7	Y	1500	449.022	448.715	30.74	0.010
1+500	8	Y	2000 x 1500	450.867	450.495	37.13	0.010
1+675	10	Y	1500	452.664	452.241	32.54	0.013
1+875	12	Y	1500	453.974	453.663	31.12	0.010
2+020	13	Y	2400 x 1800	453.169	451.728	37.59	0.038
2+075	14	Y	1500	453.713	452.458	28.84	0.044
2+180	15	Y	1500	455.068	454.320	41.12	0.018
2+520	18						
2+700	20						
2+775	21	Y	1500 x 1250	458.247	457.864	38.34	0.010
2+860	22	Y	1500	458.503	458.125	37.75	0.010
3+000	23	-	-	-	-	-	-
3+180	25	N	1200	458.070	456.124	51.08	0.038
3+340	27	Y	1500x1250	457.307	456.168	56.46	0.020
3+445	28	Y	1500	457.621	456.164	33.94	0.043
3+625	30	Y	1200	455.346	454.938	40.84	0.010
3+775	31	Y	2700x2100	452.778	452.402	37.28	0.010
3+860	33	Y	1200	452.380	451.927	45.46	0.010
3+950	34	Y	1800	451.061	450.628	64	0.010
4+030	35	Y	1500	451.064	450.635	41.89	0.010
4+120	35a	Y	1200	451.330	450.932	39.82	0.010
4+255	36	Y	1500	451.746	451.031	36.48	0.020
4+400	37	Y	1200	452.578	452.216	36.22	0.010
4+495	38	Y	1200	452.145	451.795	35.00	0.010
4+550	39	Y	1200	450.960	450.646	31.49	0.010
4+690	40	Y	1200	450.253	447.999	33.43	0.067
(4+775)	(41a)	Y	1200	448.679	447.188	37.28	0.040
(4+855)	(41b)	Y	1200	448.103	446.424	41.98	0.040
4+960	42	Y	1500	446.676	446.171	39.05	0.013
~~5+380~~	~~42a~~	-	-	-	-	-	-
6+145	43	Y	2400 x 1800	426.559	426.095	38.14	0.012
6+275	44		1500	425.101	424.746	35.55	0.010
6+460	45		1500	423.488	423.123	36.44	0.010

Chainage	HYDRO ID	Bed Material to be included in culvert	Size Estimate to include for bed	Upstream watercourse bed invert level	Downstream watercourse bed invert	Culvert Length (m)	Gradient (m/m)
6+610	46	Y	1200	422.789	422.408	38.10	0.010
6+700	47	Y	1200	422.821	422.425	39.60	0.010
6+810	49	Y	1200	422.797	422.425	34.43	0.011
6+860	50	Y	1200	422.652	422.167	48.45	0.010
6+980	51	Y	1500x1250	423.706	421.650	45.01	0.046
7+200	52	-	-	-	-	-	-
7+265	54	N	900	423.081	421.722	47.11	0.029
7+425	55	N	900	422.033	420.325	59.66	0.029
7+625	56	Y	1200	421.308	419.930	34.43	0.040
7+900	57	Y	2400 x 1800	418.239	417.826	41.31	0.010
8+200	58	Y	1500	417.576	417.123	45.36	0.010
8+400	59	-	-	-	-	-	-
8+550	60	N	900	415.486	415.022	46.42	0.010
8+700	61	Y	1500x1250	412.480	411.087	40.39	0.034
9+105	62	N	900	403.825	403.454	37.13	0.010
9+275	63	Y	3000 x 1800	-	-	-	-
9+275	64						

(orange)	denotes crossings to be bridge structures.
(light blue)	denotes crossings to be downsized due to assessment of flood risk. Size TBC.
(green)	denotes crossings identified as earthworks drain crossings only and not natural watercourses.

11.4.3.5. Assessment Design Information (7th iteration) for structures and erosion protection - see Drawings 5.1 to 5.7

ID	Risk Assessment ID	Type	Length (m)
2	S1	Bridge	23 extension
23	S3	Bridge	33.6
52	S4	Bridge	30.8
59	S6	Bridge	33.6
64	S7	Bridge	27.9
2	AB1	Bridge	
52	AB2	Bridge	
64	MS9	Bridge	
2	N/A	Bank protection (total length both banks but some is replacement)	235
23	N/A	Bank protection (total length both banks)	Replacement so no change
52	N/A	Bank protection (total length both banks)	100
59	N/A	Bank protection (total length both banks)	100
64	N/A	Bank protection (total length both banks)	100
Truim	8	Embankment toe protection- approx 5m from channel	265
Truim	14	Embankment toe protection- approx 3m from channel	45
Truim	15	Embankment toe protection- approx 7m from channel	57
Truim	19	Embankment toe protection- approx 5m from channel	40
Truim	23	Embankment toe protection- approx 7m from channel	142