Appendix 11.4

Hydromorphology Assessment Part 4

Annex 11.4.4-Hydromorphological Catchment Assessment-159

Catchment No.	159
Catchment Name	-

Channel Nature	Nature of water course	Natural
	Size of water course	Minor

Quantitative Spatial Elements	Catchment Area (km^2)	0.3
	Average slope in catchment (°)	5
	% Catchment over 750m (for snow melt risk)	0

WFD classification	Water, flows and levels	Good
	Physical condition	Good
	Overall ecological status	Good

Geology	Majority Bedrock (see Drawing 11.4.4.1 a and b Catchment 159)	Loch Laggan Psammite formation-Psammite, Micaeous	resistant to weathering, impermeable
	Is an alluvial fan present at or near the crossing?	No	

Environmental designations (see Drawing 11.4.4.1 c, Catchment 159)	Ramsar	No	
	SAC	No	
	SPA	No	
	SSSI	No	

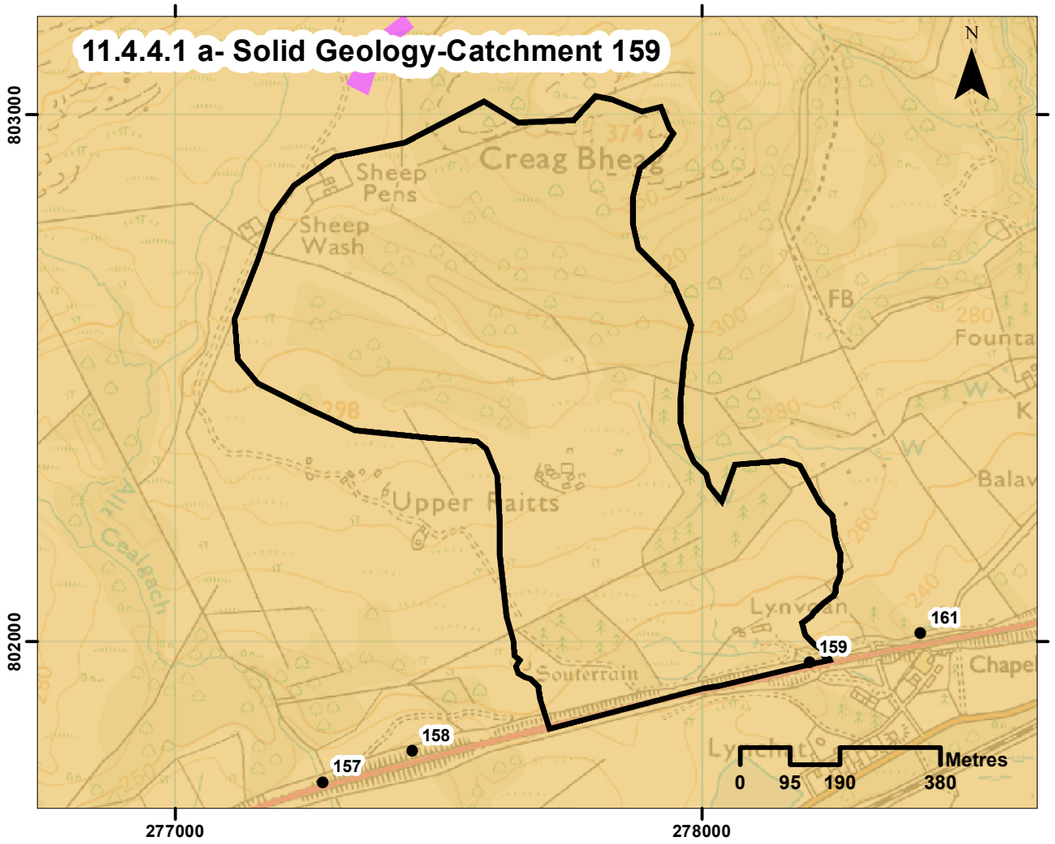
Sediment source and supply - Catchment Scale	Changes in slope and channel confinement	See Drawing 11.4.4.2, Catchment 159	
	Is peat present in the catchment?	Yes	In former glacial metlwater channel
	Is there a bog burst risk?	Yes	
	Current valley side or terrace erosion	No	
	Potential valley side or terrace erosion	No	
	Hill slope failures (including peat slides and debris flows and slides)	No	
	Hill slope failures coupled to channel	No	
	Vertical incision present in catchment	No	
	Bank erosion/lateral migration	Yes	Channel seems to wander across midcatchment slope in Google and ArcGIS imagery
	Unvegetated bars	No	
	Wooded/forested areas in catchment	Yes	Some scrub woodland and deciduous woodaland
	Infrastructure type (see Drawing 11.4.4.1 d, Catchment 159)	Yes	Ruins of Upper Raitts settlement. No impact on channel
	Comment on sediment source potential in catchment	Limited. Potential for bog burst but unlikely to reach crossing	
	Comment on sediment supply potential to crossing	Limited. Potential for bog burst but unlikely to reach crossing	

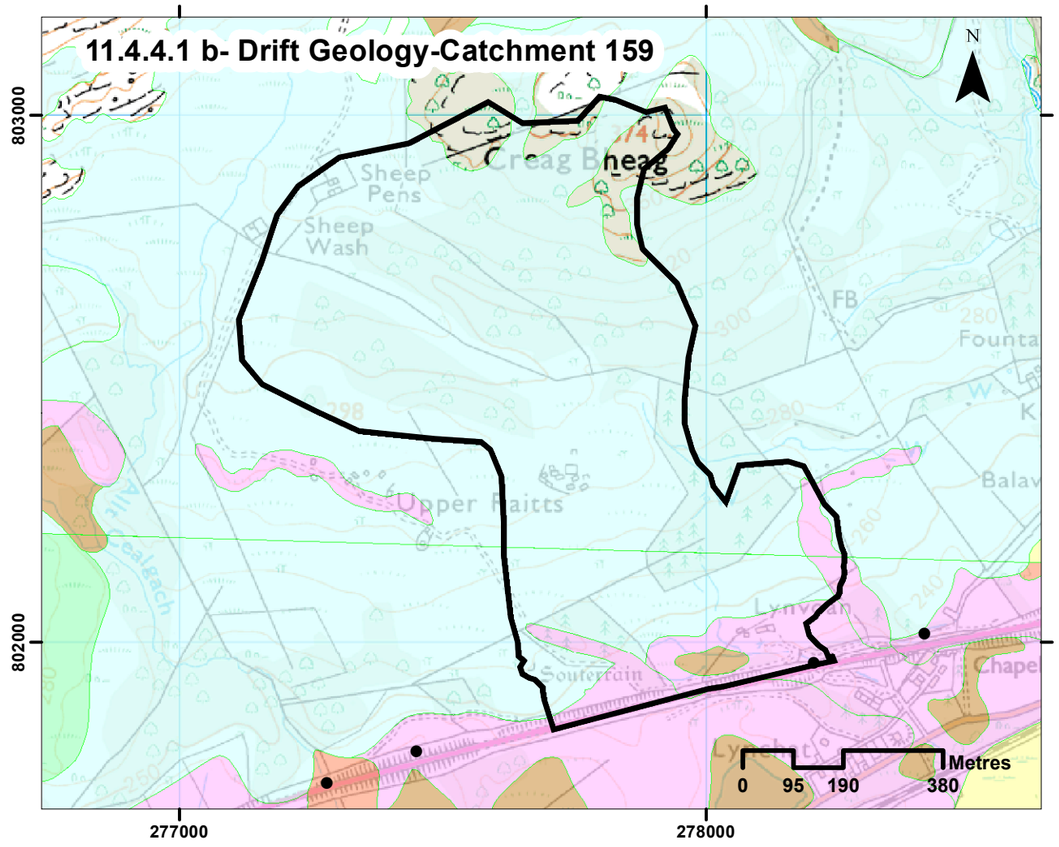
Morphology and Process-Reach upstream of crossing	Channel morphology		Not visible
	Predominant sediment size		Not visible
	Unvegetated bars		Not visible
	Vertical incision		Not visible
	Deposition		Not visible
	Lateral migration/bank erosion		Not visible
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 159		Not visible
	Impact of infrastructure		Not visible
	Channel realignment	Yes	Small body of standing water shown c.80m u/s of crossing in 1903 mapping no longer exists

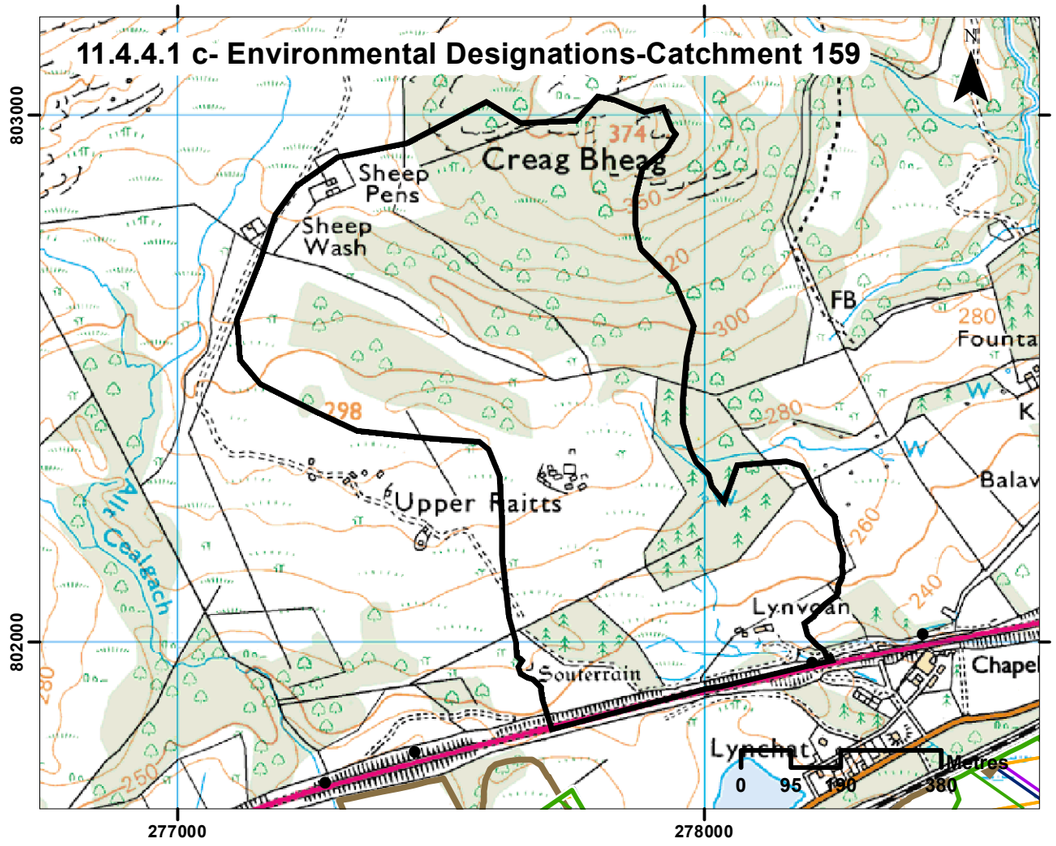
Morphology and Process-At crossing	Channel morphology	Engineered	
	Predominant sediment size	-	None visible
	Unvegetated bars	No	
	Vertical incision	None	
	Deposition	None	
	Lateral migration/bank erosion	None	
	Damaged/unstable drains or armouring	No	

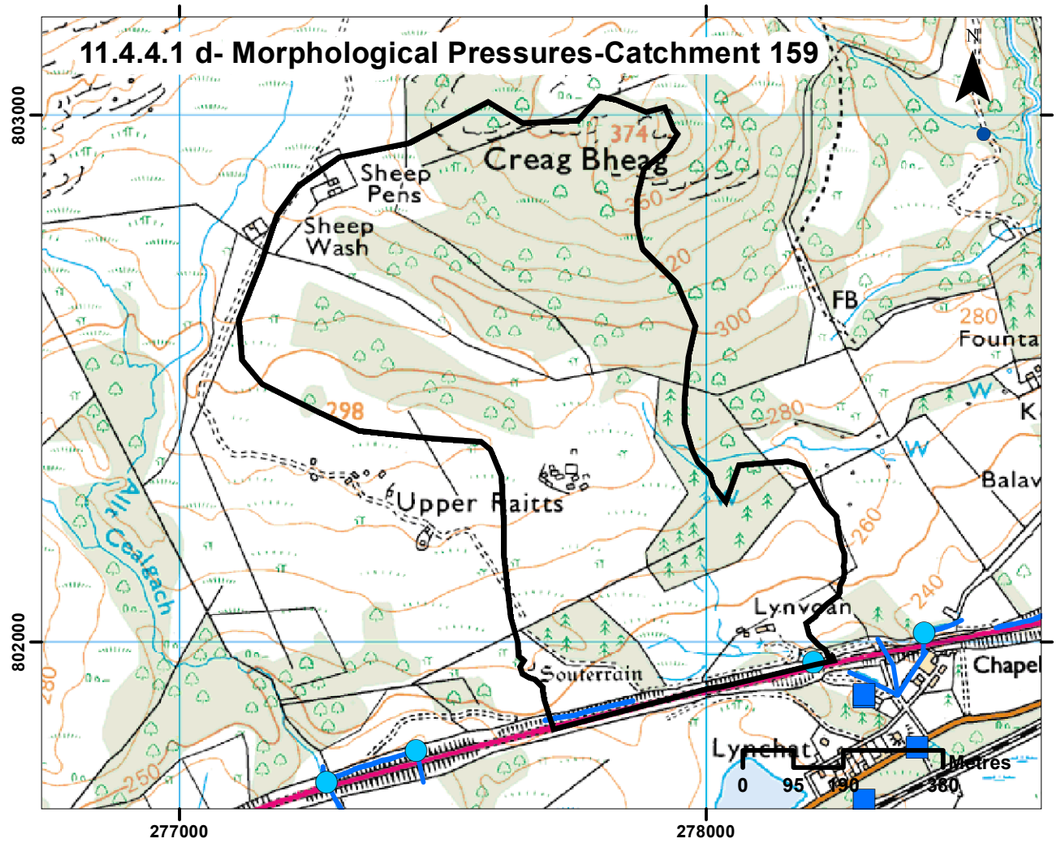
Morphology and Process-Reach downstream of crossing	Channel morphology	Engineered	Appears to re-enter culvert immediately under farmyard and track until emerging into meandering channel c.180m d/s of crossing on d/s side of B9152
	Predominant sediment size		Not visible
	Unvegetated bars	No	
	Vertical incision		Assumed not, not visible though
	Deposition		Assumed not, not visible though
	Lateral migration/bank erosion		Assumed not, not visible though
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 159	Yes	Channel culverted under farmyard and minor road for c.180m
	Impact of infrastructure	Yes	Channel confined in culvert for substantial distance. Significant disruption required for any improvement d/s of crossing
	Channel realignment	Yes	See comments on enclosure in culvert above.

Summary behaviour	Limited activity in this catchment. Limited realignment u/s of crossing. Seems stable and vegetated. D/s of crossing realigned, probably during railway construction to take flow from this and other channels through just one point along the railway embankment.









Legend

General
- Crossing location

Solid Geology
- Loch Laggan Psammite Formation - Psammite, Micaceous

Drift Geology
- Peat
- Glaciofluvial Ice Contact Deposits
- Gaick Plateau Moraine Formation
- Hummocky Glacial Deposits
- Ardverikie Till Formation - Diamicton
- Glaciofluvial Sheet Deposits
- Alluvium
- River Terrace Deposits
- Alluvial Fan Deposits
- Head
- Talus - Rock Fragments
- Talus Cone

Environmental Designations
- Ramsar
- Special Site of Scientific Interest
- Special Area of Conservation
- Special Protection Area
- National Nature Reserve

Morphological Pressures
- Culvert
- Ford
- Discharge Location
- Drainage Ditch

REV	SUIT	DATE	DESCRIPTION	BY	APP

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TRANSPORT SCOTLAND
A9 DUALLING PERTH TO INVERNESS Crubenmore to Kincraig

9 CRUBENMORE TO KINCRAIG EIA

Drawing 11.4.4.1 Catchment 159 Catchment Overview

DESIGN:	DRAWN:	CHK:	APP:
EL	EV	EL	EL

DATE: 20/12/2017

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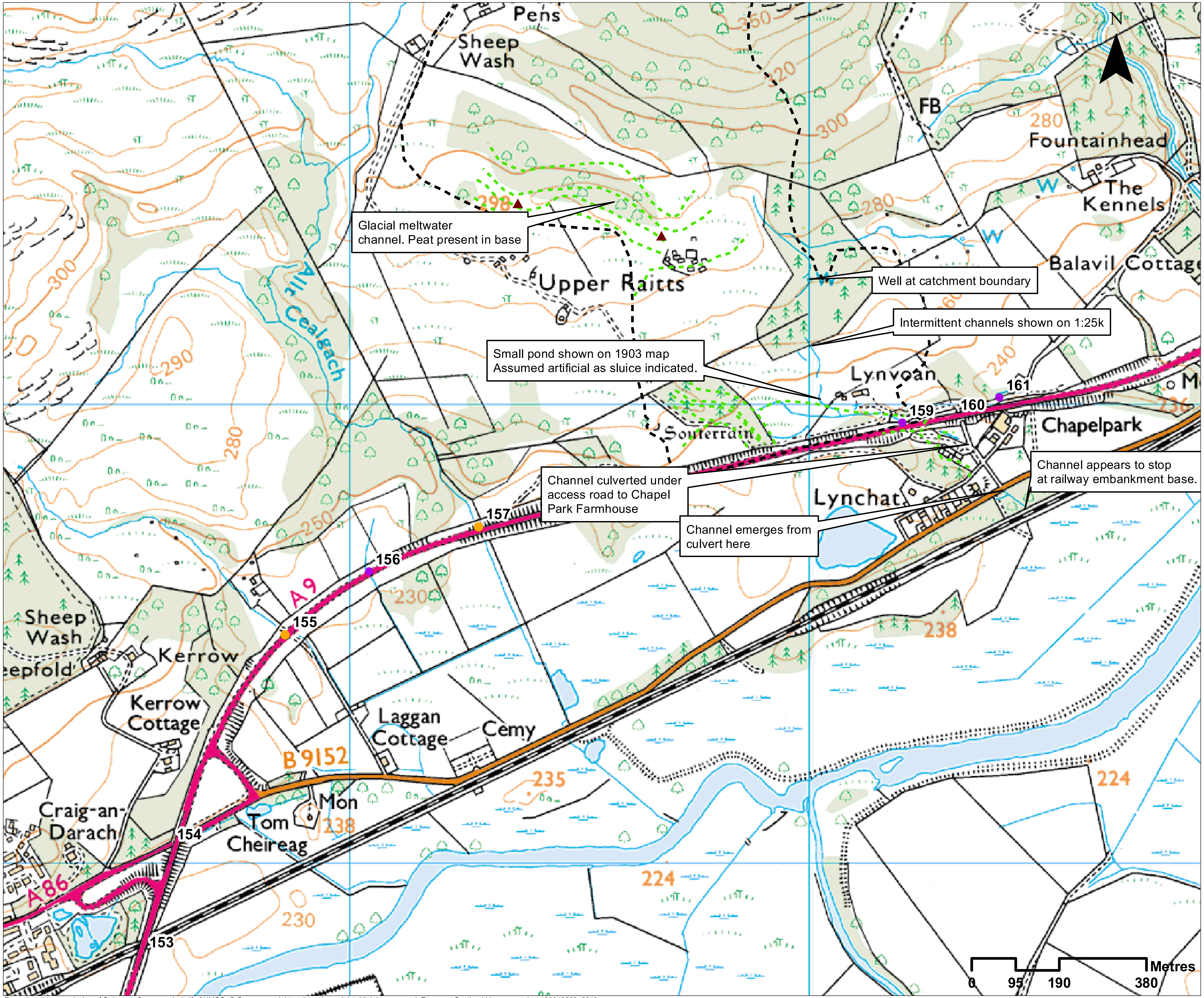

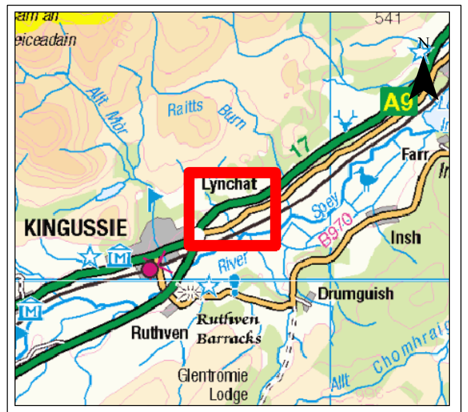

Legend

- Major crossing
- Minor crossing
- Other crossing
- Peat
- Break in slope
- Crossing catchment

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DRAWING 11.4.4.2.
Catchment 159 Baseline Assessment

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Annex 11.4.4-Hydromorphological Catchment Assessment-161

Catchment No.	161
Catchment Name	-

Channel Nature	Nature of water course	Drain
	Size of water course	Minor

Quantitative Spatial Elements	Catchment Area (km^2)	0.7
	Average slope in catchment (°)	6.3
	% Catchment over 750m (for snow melt risk)	0

WFD classification	Water, flows and levels	Good
	Physical condition	Good
	Overall ecological status	Good

Geology	Majority Bedrock (see Drawing 11.4.4.1 a and b Catchment 161)	Loch Laggan Psammite formation-Psammite, Micaeous	resistant to weathering, impermeable
	Is an alluvial fan present at or near the crossing?	No	

Environmental designations (see Drawing 11.4.4.1 c, Catchment 161)	Ramsar	No	
	SAC	No	
	SPA	No	
	SSSI	No	

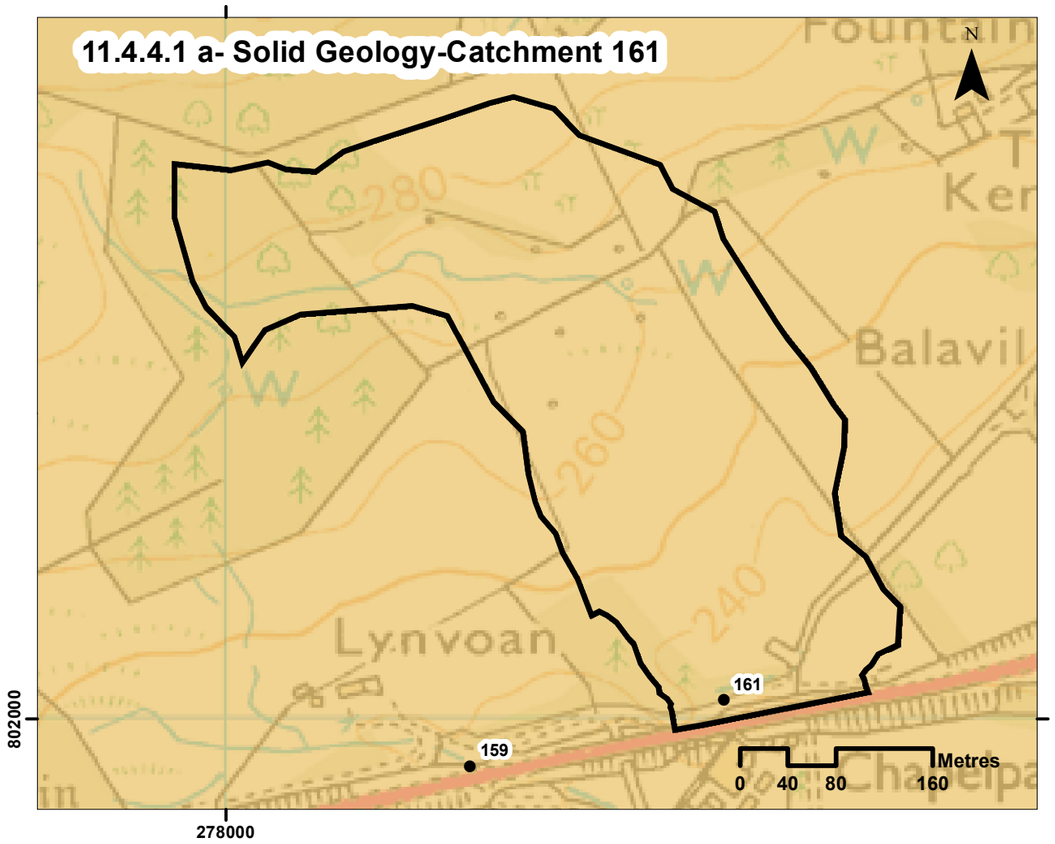
Sediment source and supply - Catchment Scale	Changes in slope and channel confinement	See Drawing 11.4.4.2, Catchment 161	
	Is peat present in the catchment?	Yes	Lower catchment only
	Is there a bog burst risk?	No	
	Current valley side or terrace erosion	No	
	Potential valley side or terrace erosion	No	
	Hill slope failures (including peat slides and debris flows and slides)	No	
	Hill slope failures coupled to channel	No	
	Vertical incision present in catchment	No	
	Bank erosion/lateral migration	No	
	Unvegetated bars	No	
	Wooded/forested areas in catchment	Yes	Scrubwoodland and planations in mid and lower catchment
	Infrastructure type (see Drawing 11.4.4.1 d, Catchment 161)	No	
	Comment on sediment source potential in catchment	Very limited	
	Comment on sediment supply potential to crossing	Very limited, little channelisation. Channels of intermittent continuity as upper channel disappears into sink, probaly to become subsurface flow (note the flush)	

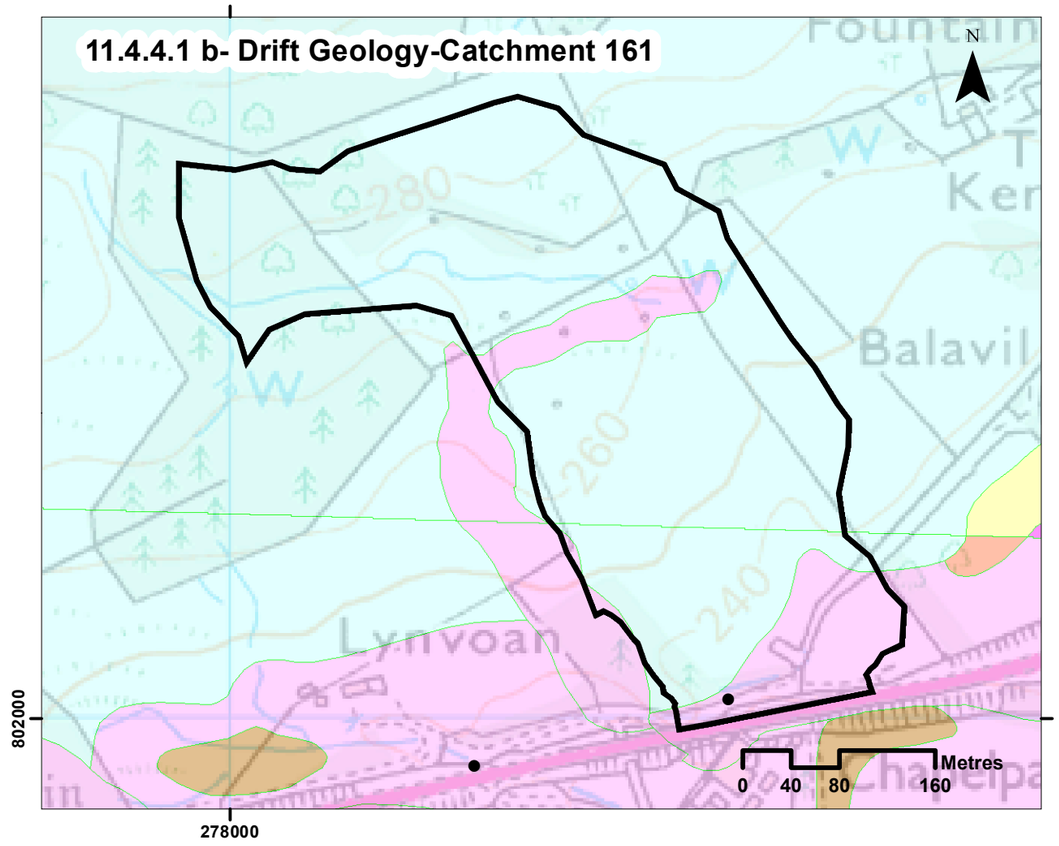
Morphology and Process-Reach upstream of crossing	Channel morphology	Engineered	Drain
	Predominant sediment size	-	
	Unvegetated bars	No	
	Vertical incision	None	
	Deposition	None	
	Lateral migration/bank erosion	None	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 161	None	
	Impact of infrastructure	None	
	Channel realignment	Yes	Road parallel drain

Morphology and Process-At crossing	Channel morphology	Engineered	Pipe culvert in concrete structure
	Predominant sediment size	-	
	Unvegetated bars	No	
	Vertical incision	None	
	Deposition	Low	
	Lateral migration/bank erosion	None	
	Damaged/unstable drains or armouring	No	

Morphology and Process-Reach downstream of crossing	Channel morphology		No photos
	Predominant sediment size		No photos
	Unvegetated bars		No photos
	Vertical incision		No photos
	Deposition		No photos
	Lateral migration/bank erosion		No photos
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 161	Yes	Farm buildings and minor road
	Impact of infrastructure	Yes	Channel likely culverted for significant distances
	Channel realignment	Yes	Significant realignment likely to have occurred d/s of road to take channel in culvert. Not confirmed by any photos or the map but suspect this channel has a confluence with 159 somewhere under the road.

Summary behaviour	Limited activity in this catchment. Limited realignment u/s of crossing. Seems stable and vegetated. D/s of crossing realigned, probably during railway construction to take flow from this and other channels through just one point along the railway embankment.





Legend

General

- Crossing location

Solid Geology

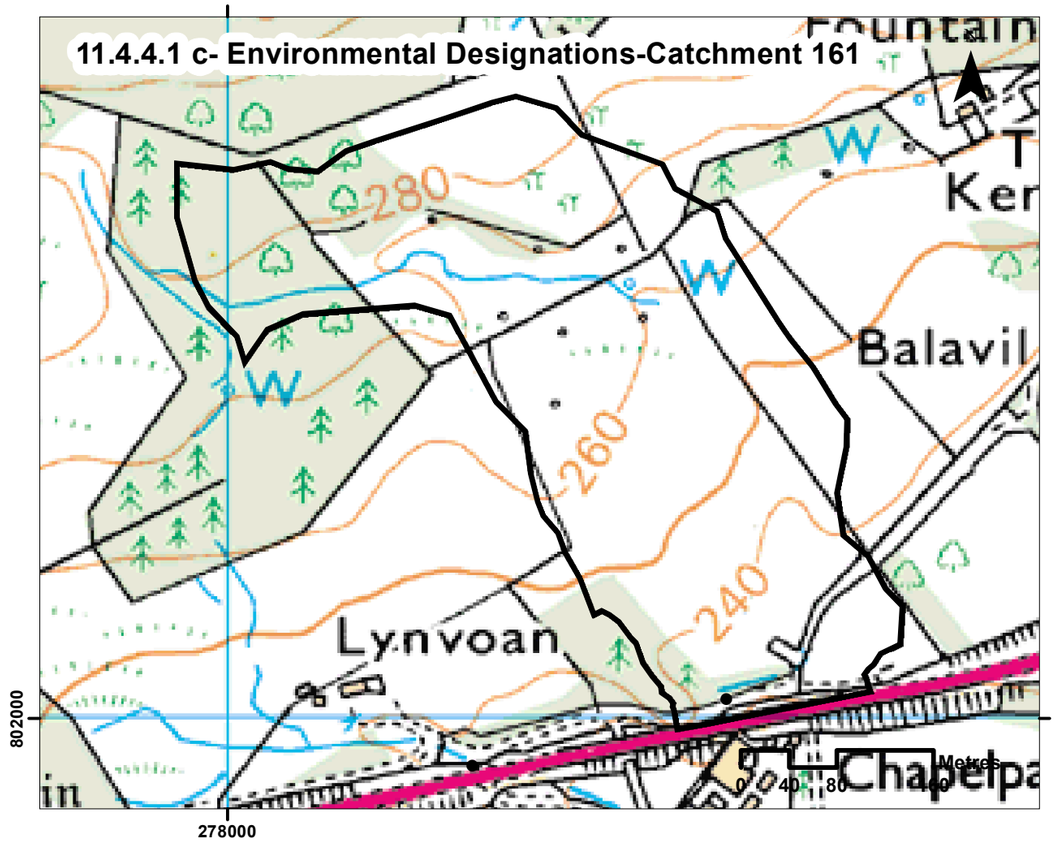
- Loch Laggan Psammite Formation - Psammite, Micaceous

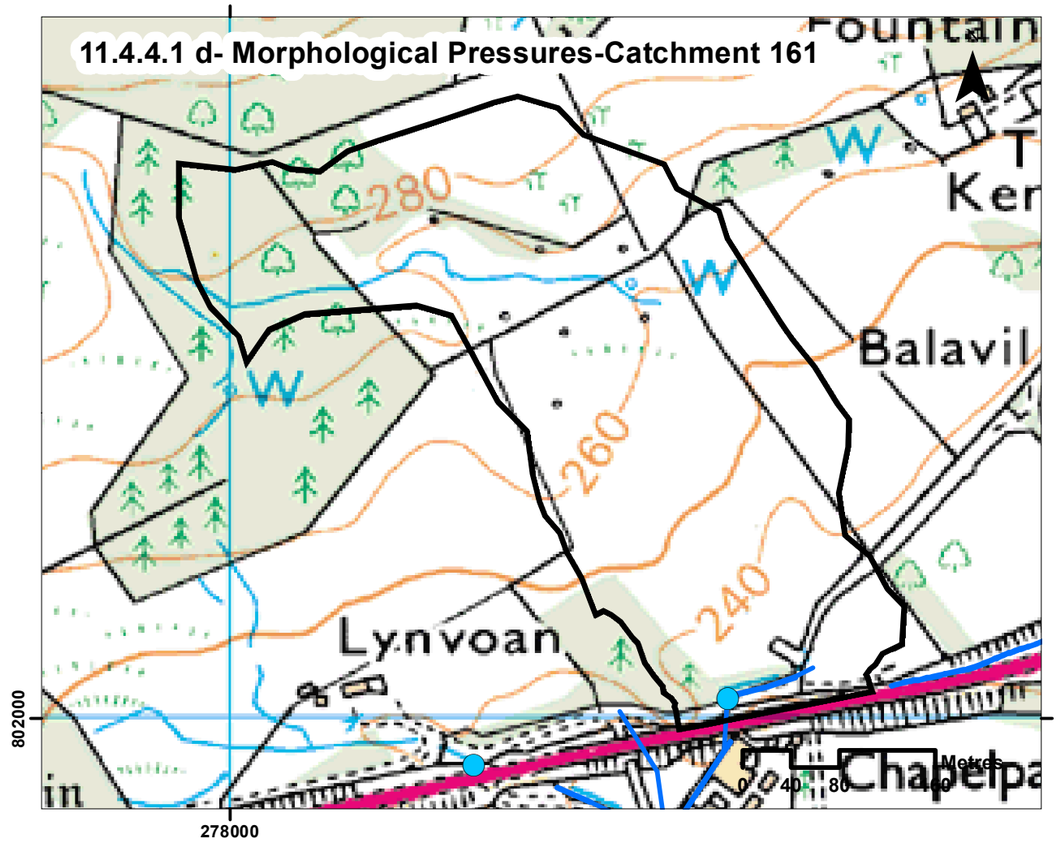
Drift Geology

- Peat
- Glaciofluvial Ice Contact Deposits
- Gaick Plateau Moraine Formation
- Hummocky Glacial Deposits
- Ardverikie Till Formation - Diamicton
- Glaciofluvial Sheet Deposits
- Alluvium
- River Terrace Deposits
- Alluvial Fan Deposits
- Head
- Talus - Rock Fragments
- Talus Cone

Morphological Pressures

- Culvert
- Drainage Ditch





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CONGHDAIL ALBA

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Crubenmore to Kincraig

9 CRUBENMORE TO KINCRAIG EIA

Drawing 11.4.4.1 Catchment 161 Catchment Overview

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DATE: 20/12/2017

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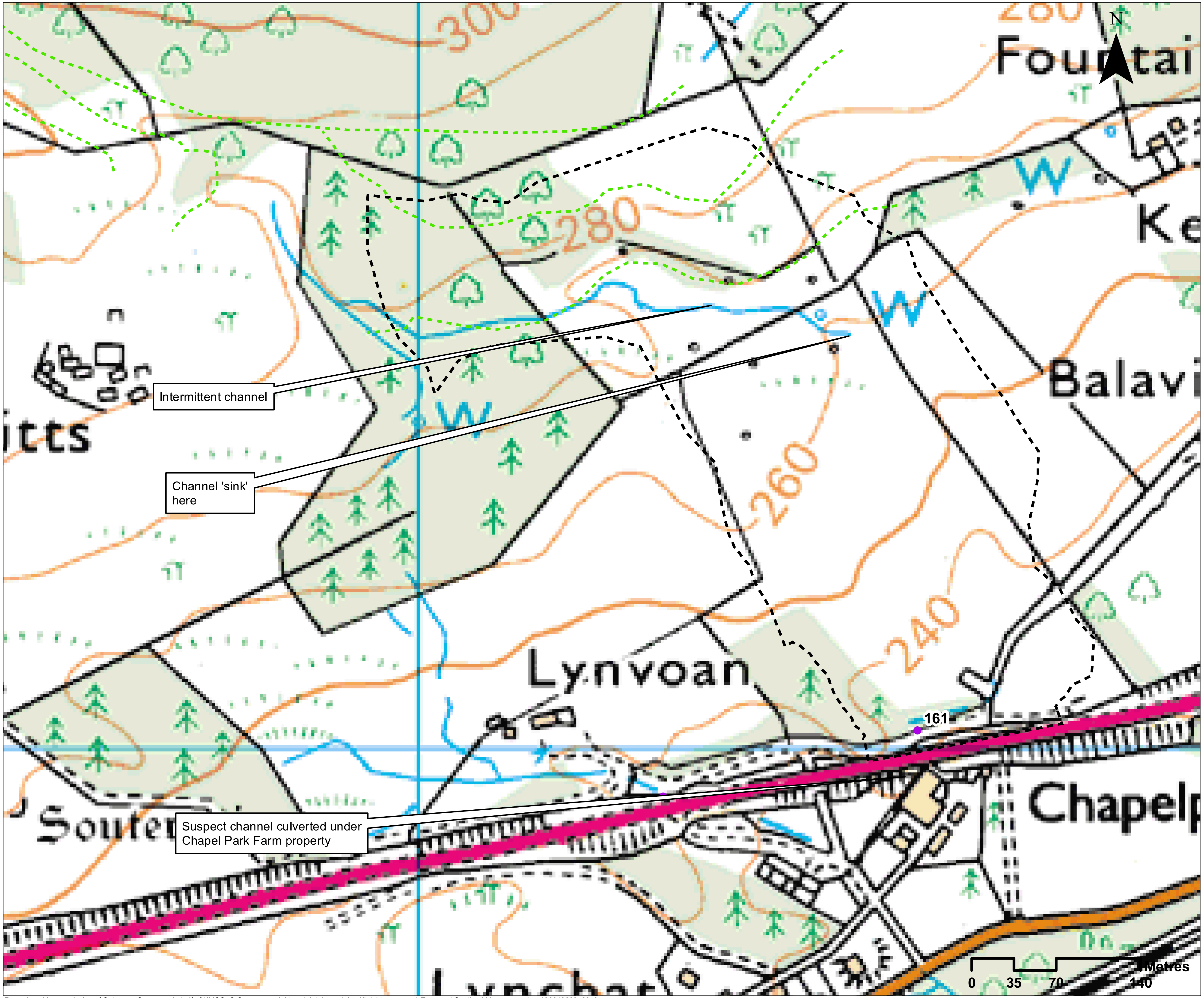

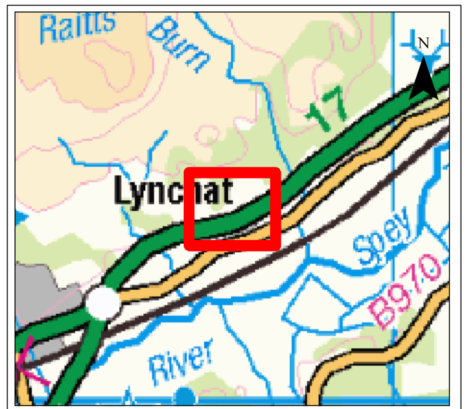

Legend

- Minor crossing
- Break in slope
- Crossing catchment

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PROJECT 9 CRUBENMORE TO KINCRAIG EIA

DRAWING 11.4.4.2.
Catchment 161 Baseline Assessment

DESIGN:	DRAWN:	CHK:	APP:
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Annex 11.4.4-Hydromorphological Catchment Assessment-162

Catchment No.	162
Catchment Name	Raitts Burn

Channel Nature	Nature of water course	Natural
	Size of water course	Major

Quantitative Spatial Elements	Catchment Area (km^2)	12
	Average slope in catchment (°)	7.8
	% Catchment over 750m (for snow melt risk)	2.6

WFD classification	Water, flows and levels	High
	Physical condition	Good
	Overall ecological status	Moderate

Geology	Majority Bedrock (see Drawing 11.4.4.1 a and b Catchment 162)	Loch Laggan Psammite formation-Psammite, Micaeous	resistant to weathering, impermeable
	Is an alluvial fan present at or near the crossing?	Yes	Risk of avulsion

Environmental designations (see Drawing 11.4.4.1 c, Catchment 162)	Ramsar	Yes	**River Spey - Insh Marshes** Breeding birds, wetlands, freshwater habitats, trophic range river/stream,Whooper Swan
	SAC	Yes	**Insh Marshes** Alder woodland on floodplains, clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels, Otter, very we mires often identified by an unstable quaking surface **River Spey** Atlantic salmon, freshwater pearl mussel, otter, sea lamprey
	SPA	Yes	**River Spey - Insh Marshes** Hen Harrier, Osprey breeding, Spotted Crake breeding, Whooper swan, Wigeon breeding, Wood Sandpiper
	SSSI	Yes	**River Spey - Insh Marshes** Arctic charr, breeding bird assemblage, flood plain fen, invertebrate assemblage, mesotrophic loch, Osprey breeding, Otter, vascular plant assemblage, Whooper swan

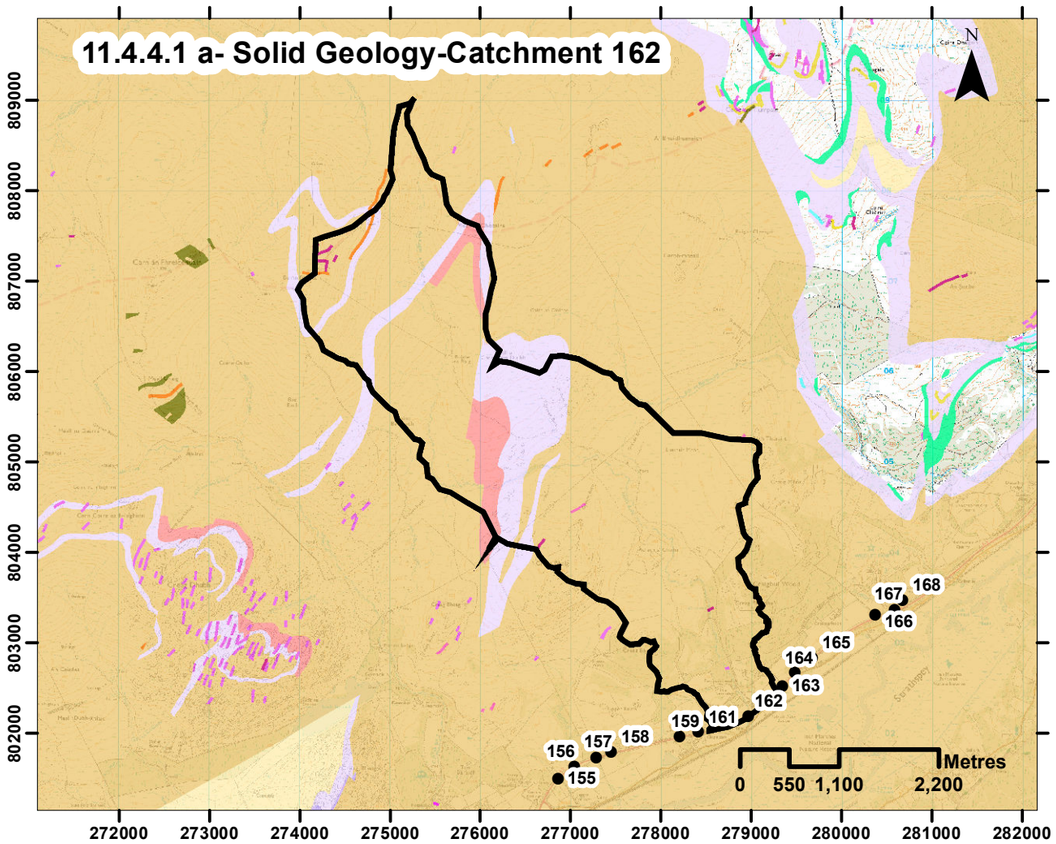
Sediment source and supply - Catchment Scale	Changes in slope and channel confinement	See Drawing 11.4.4.2, Catchment 162	
	Is peat present in the catchment?	Yes	Visible in GoogleEarth in upper catchment and in BGS 1:50k superficials mapping
	Is there a bog burst risk?	Yes	Some valley and watershed mire deposits which look potentially deep. Evidence of peat hagging. Extensive blanket bog deposits which may fail as peat slides, but scars small and limited to upper catchment. Possibly slope angles limit likelihood of failures
	Current valley side or terrace erosion	Yes	>7km
	Potential valley side or terrace erosion	Yes	c.7km of unconfined channel
	Hill slope failures (including peat slides and debris flows and slides)	Yes	Limited scars in upper
	Hill slope failures coupled to channel	No	Not visible other than terrace/valleyside erosion
	Vertical incision present in catchment	Yes	Presumably but difficult to see on GoogleEarth and no photos sufficiently far upstream
	Bank erosion/lateral migration	Yes	Lengthy sections of unconfined channel where floodplain has developed in valley bottom and wandering channel has developed
	Unvegetated bars	Yes	Principally in the flatter mid-section of the catchment
	Wooded/forested areas in catchment	Yes	Lower catchment wooded, including immediately adjacent to river.
	Infrastructure type (see Drawing 11.4.4.1 d, Catchment 162)	Yes	Access track to upper catchment
	Comment on sediment source potential in catchment	Sediment source potential is VERY HIGH. Very obvious eroding valley sides/terrace bluffs in mid catchment, mobile bars and channel is likely incising in the c. 1-2km u/s of the channel - according to BGS 1:50k mapping, there are extensive deposits of loose rock fragments (scree) moved downslope from freeze-thaw processes.	
	Comment on sediment supply potential to crossing	Evidence from site photos indicates that large volumes of coarse sediment are supplied to the crossing. This is unsurprising given the sources of sediment present. It is unlikely that coarse sediment will travel all the way from the upper catchment to the lower catchment in all but the most extreme events, but coarse sediment deposited in the flood plain in earlier flood events and terrace and scree deposits in the mid to lower catchment would probably to reach the crossing in moderately large events.	

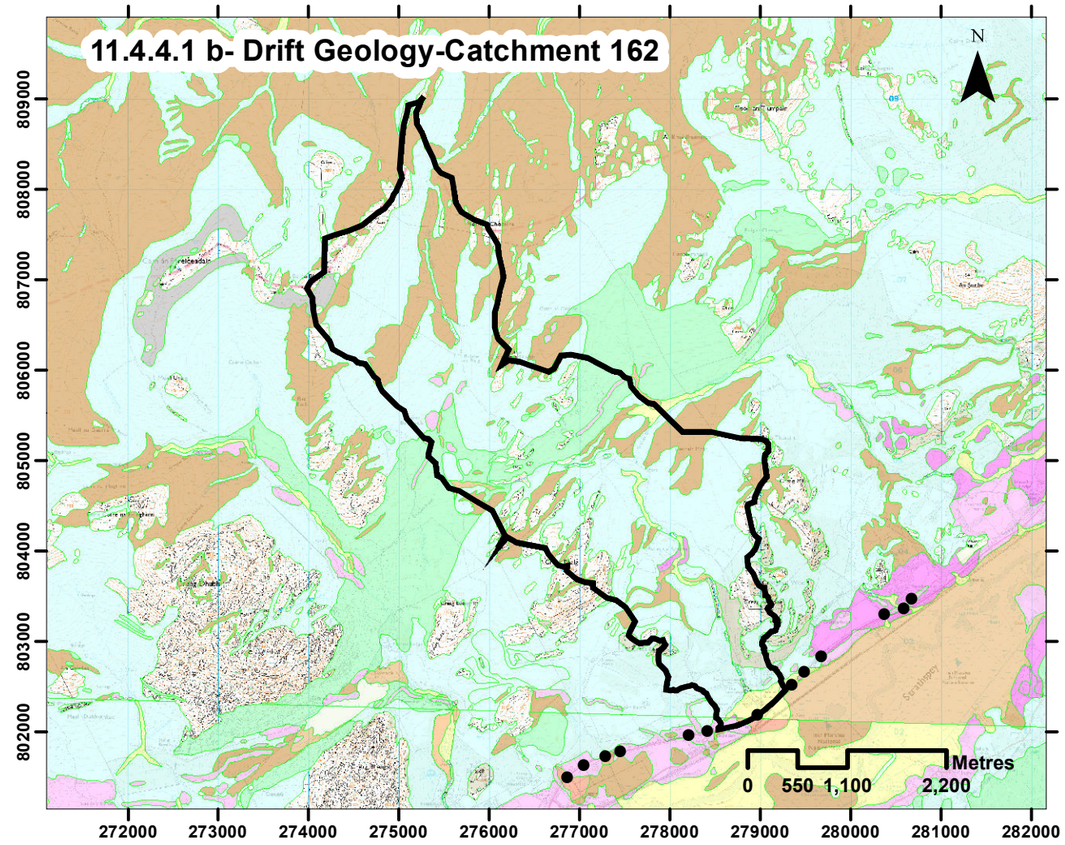
Morphology and Process-Reach upstream of crossing	Channel morphology	Plane bed	
	Predominant sediment size	Gravel and Cobbles	
	Unvegetated bars	No	
	Vertical incision	Low	
	Deposition	Low	
	Lateral migration/bank erosion	Medium	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 162	Yes	Mains of Ballavil Bridge 150m u/s of crossing
	Impact of infrastructure	Possibly	
	Channel realignment	No	Channel follows course shown in 1899 OS map

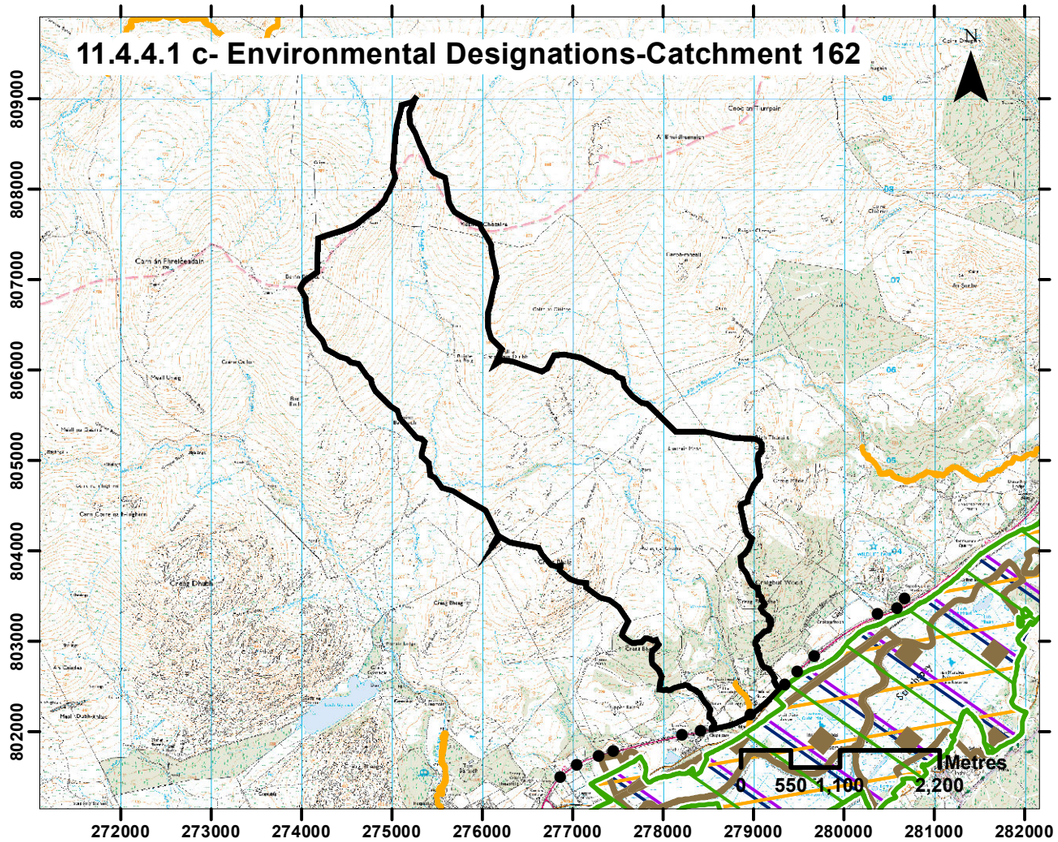
Morphology and Process-At crossing	Channel morphology	Plane bed	Mobile bed - bridge crossing, no culvert
	Predominant sediment size	Gravel-cobble	
	Unvegetated bars	Yes	Small unvegetated bar d/s of crossing on right bank
	Vertical incision	Low	
	Deposition	Medium	
	Lateral migration/bank erosion	Low	
	Damaged/unstable drains or armouring	No	Structures at crossing seem intact

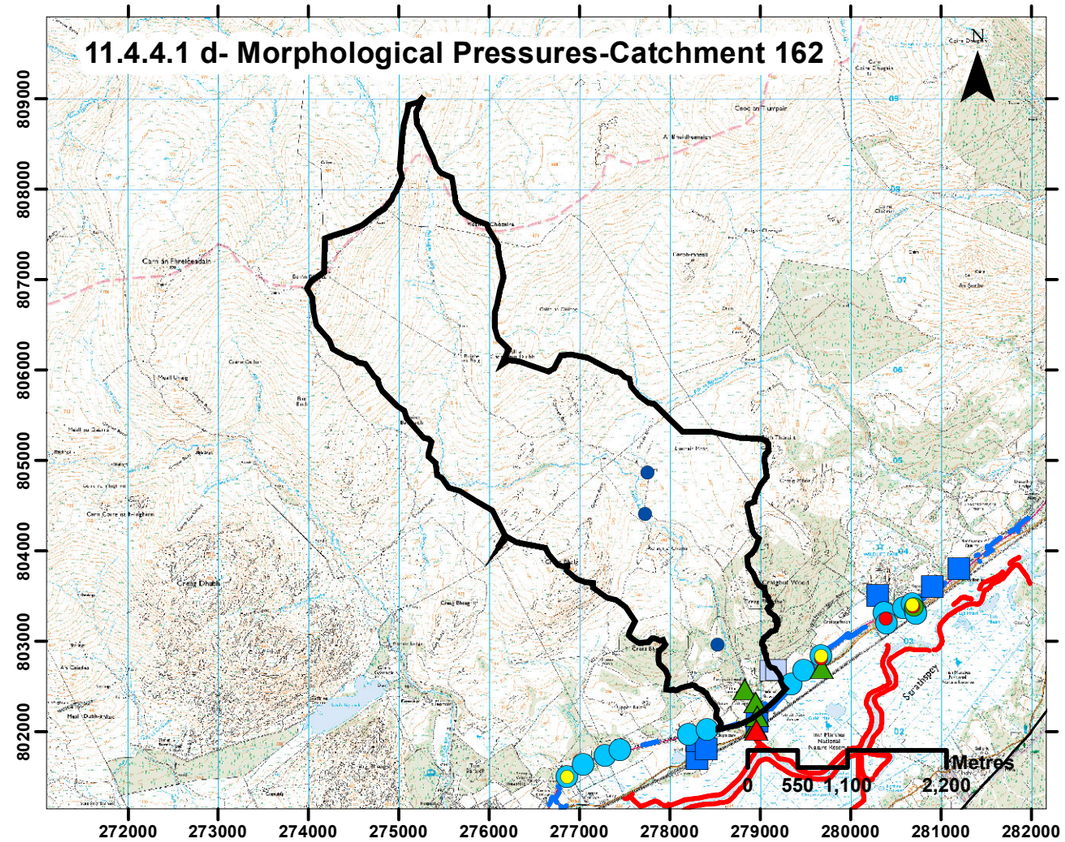
Morphology and Process-Reach downstream of crossing	Channel morphology	Plane bed	
	Predominant sediment size	Gravel-cobble	
	Unvegetated bars	Yes	Large in-channel gravel-cobble bar deposited
	Vertical incision	None	
	Deposition	High	
	Lateral migration/bank erosion	None	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 162	Yes	B9152 road bridge, Railway Bridge, Levees d/s of railway bridge
	Impact of infrastructure	Yes	Road and railway crossing heavily restricts passage of sediment, water and woody debris, leading to deposition of
	Channel realignment	No	OS mapping, but levees have been constructed d/s of railway and dredging appears to have occurred.

Summary behaviour	Limited activity in this catchment. Limited realignment u/s of crossing. Seems stable and vegetated. D/s of crossing realigned, probably during railway construction to take flow from this and other channels through just one point along the railway embankment.









Legend

General

- Crossing location

Solid Geology

- Gaick Psammite Formation - Psammite
- Loch Laggan Psammite Formation - Psammite, Micaceous
- North Britain Siluro-Devonian Calc-Alkaline Dyke Suite - Microdiorite
- Pitmain Semipelite Member - Semipelite And Calcsilicate-Rock
- Pitmain Semipelite Member - Semipelite, Gneissose
- Scottish Highland Ordovician Minor Intrusion Suite - Leucogranite
- Scottish Highland Siluro-Devonian Calc-Alkaline Minor Intrusion Suite- (Other Than Dykes) - Microdiorite

Drift Geology

- Peat
- Glaciofluvial Ice Contact Deposits
- Gaick Plateau Moraine Formation
- Hummocky Glacial Deposits
- Ardverikie Till Formation - Diamicton
- Glaciofluvial Sheet Deposits
- Alluvium
- River Terrace Deposits
- Alluvial Fan Deposits
- Head
- Talus - Rock Fragments
- Talus Cone

Environmental Designations

- Ramsar
- Special Site of Scientific Interest
- Special Area of Conservation
- Special Protection Area
- National Nature Reserve

Morphological Pressures

- Railway Bridge
- Road Bridge
- Culvert
- Cascade
- Step in Bed
- Catchpit
- Ford
- Discharge Location
- Abstraction Location
- Drainage Ditch
- Flood Embankment
- Power Lines

REV	SUIT	DATE	DESCRIPTION	BY	APP

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Drawing 11.4.4.1 Catchment 162 Catchment Overview

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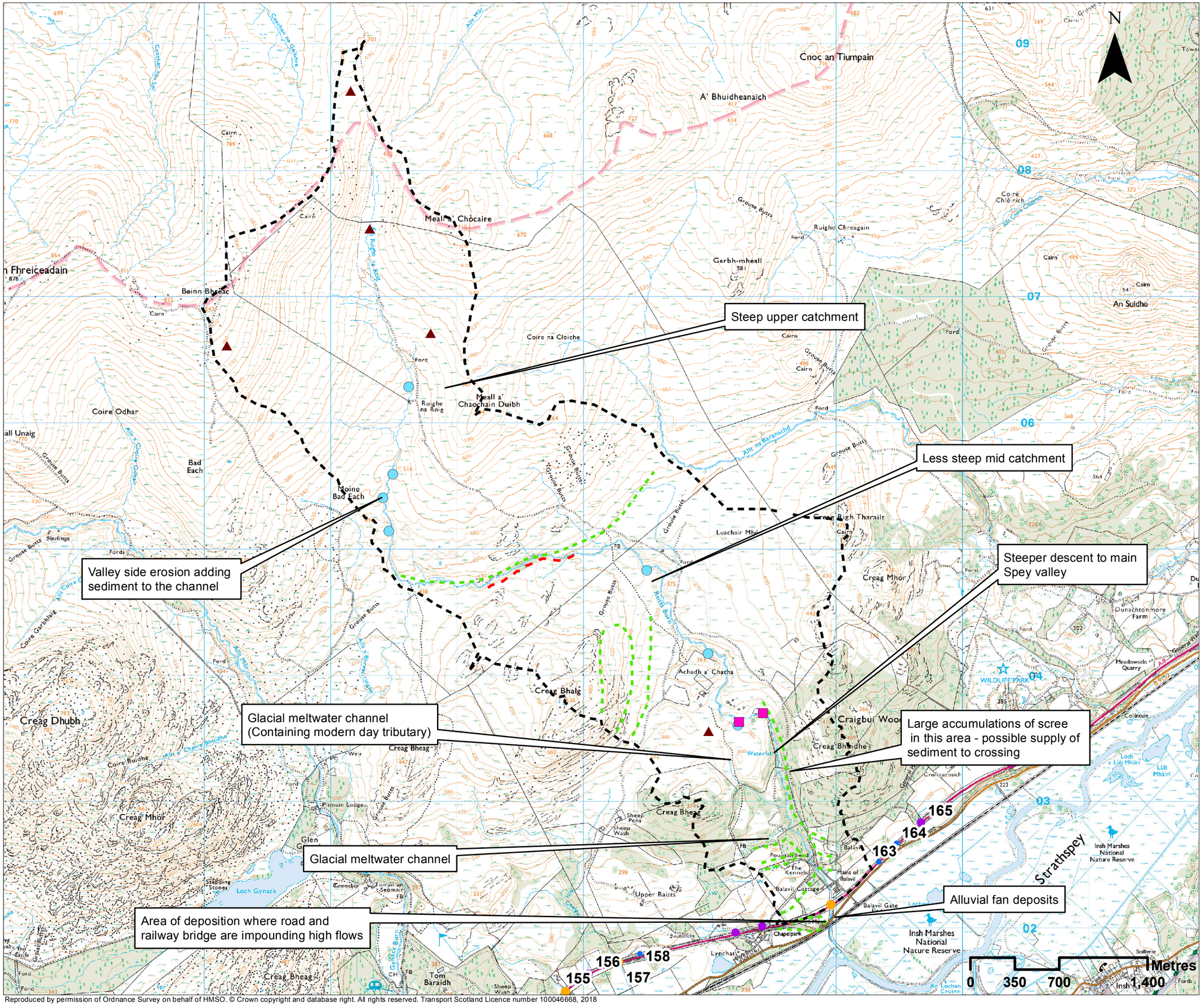

Legend

- Major crossing
- Minor crossing
- Other crossing
- Peat
- Valley side erosion
- Unvegetated bar
- Break in slope
- Terrace
- Crossing catchment

REV	SUIT	DATE	DESCRIPTION	BY	APP

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PROJECT 9 CRUBENMORE TO KINCRAIG EIA

DRAWING 11.4.4.2.
Catchment 162 Baseline Assessment

DESIGN:	DRAWN:	CHK:	APP:
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DATE: 19/12/2017

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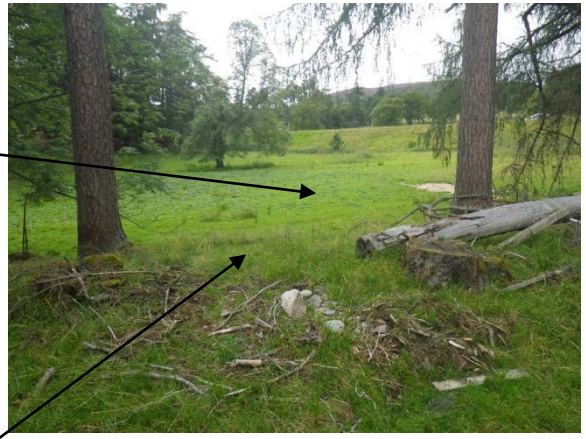
Photograph 11.4.4.54- Downstream

Photograph 11.4.4.55- Upstream

Photograph 11.4.4.56- Upstream



Photograph 11.4.4.57

Photograph 11.4.4.58

Photograph 11.4.4.59- Downstream

Photograph 11.4.4.60

Photograph 11.4.4.61

Photograph 11.4.4.62- Upstream

Photograph 11.4.4.63

Photograph 11.4.4.64

Photograph 11.4.4.65- Downstream

Photograph 11.4.4.66

Photograph 11.4.4.67

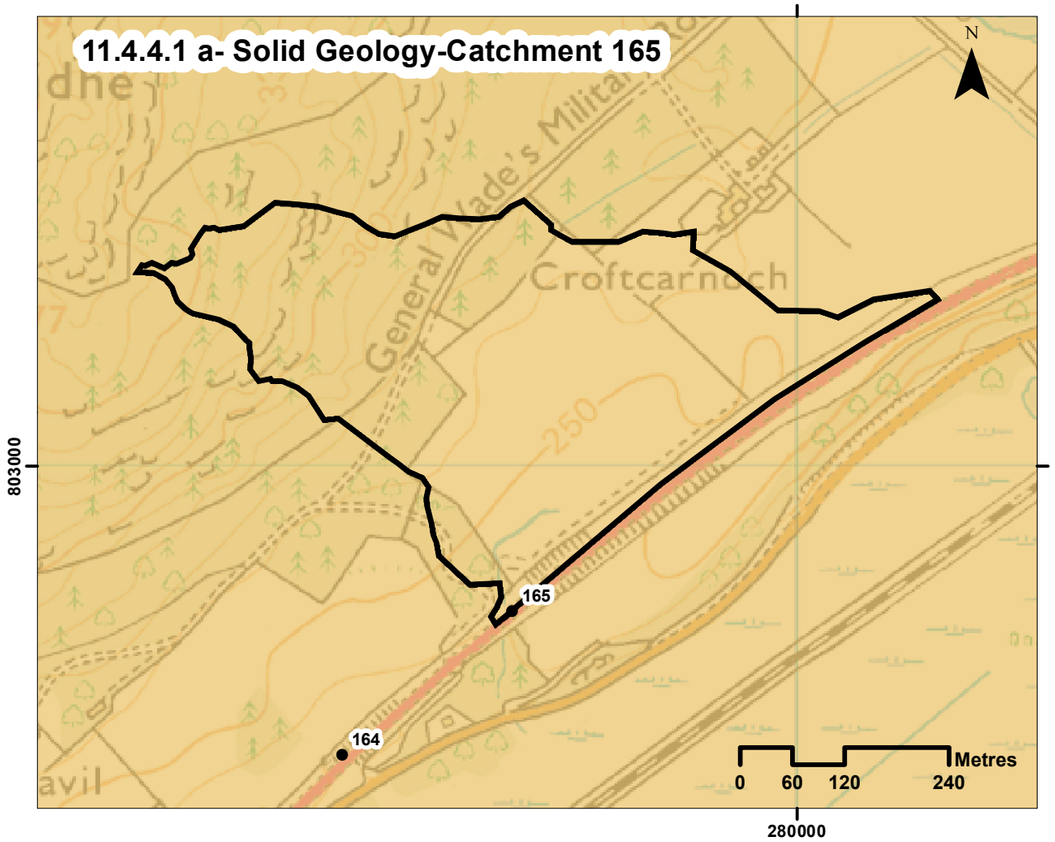
Annex 11.4.4-Hydromorphological Catchment Assessment-165

Catchment No.	165
Catchment Name	-

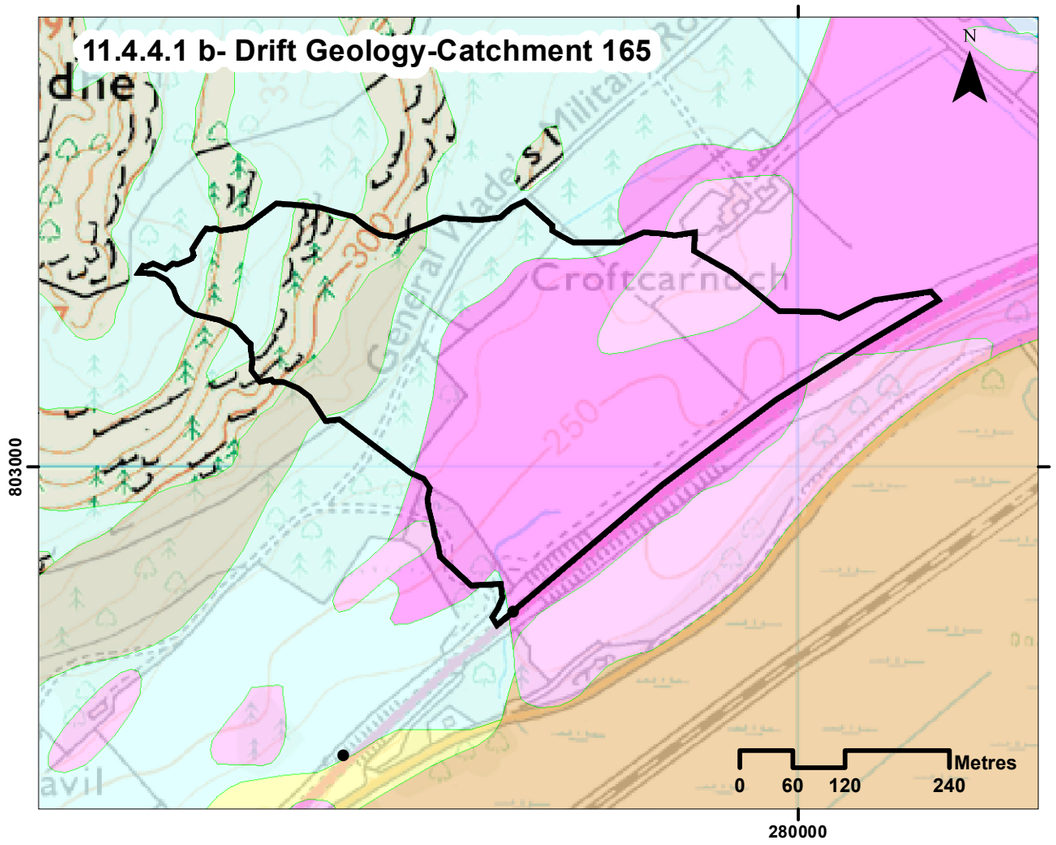
Channel Nature	Nature of water course	Drain	
	Size of water course	Minor	
Quantitative Spatial Elements	Catchment Area (km^2)	0.2	
	Average slope in catchment (°)	7.5	
	% Catchment over 750m (for snow melt risk)	0	
WFD classification	Water, flows and levels	Good	
	Physical condition	Good	
	Overall ecological status	Good	
Geology	Majority Bedrock (see Drawing 11.4.4.1 a and b Catchment 165)	Loch Laggan Psammite formation-Psammite, Micaeous	resistant to weathering, impermeable
	Is an alluvial fan present at or near the crossing?	No	
Environmental designations (see Drawing 11.4.4.1 c, Catchment 165)	Ramsar	Yes	**River Spey - Insh Marshes** Breeding birds, wetlands, freshwater habitats, trophic range river/stream, Whooper Swan
	SAC	Yes	**Insh Marshes** Alder woodland on floodplains, clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels, Otter, very we mires often identified by an unstable quaking surface **River Spey** Atlantic salmon, freshwater pearl mussel, otter, sea lamprey
	SPA	Yes	Hen Harrier, Osprey breeding, Spotted
	SSSI	Yes	**River Spey - Insh Marshes** Arctic charr, breeding bird assemblage, flood plain fen, invertebrate assemblage, mesotrophic loch, Osprey breeding, Otter, vascular plant assemblage, Whooper swan
Sediment source and supply - Catchment Scale	Changes in slope and channel confinement	See Drawing 11.4.4.2, Catchment 165	
	Is peat present in the catchment?	Yes	Floodplain mire deposits d/s/ of road on spey floodplain.
	Is there a bog burst risk?	No	D/s of road on flat ground.
	Current valley side or terrace erosion	No	
	Potential valley side or terrace erosion	No	
	Hill slope failures (including peat slides and debris flows and slides)	No	
	Hill slope failures coupled to channel	No	
	Vertical incision present in catchment	No	
	Bank erosion/lateral migration	No	
	Unvegetated bars	No	
	Wooded/forested areas in catchment	Yes	Extensive woodland in upper catchment
	Infrastructure type (see Drawing 11.4.4.1 d, Catchment 165)	Yes	B9152 and Railway d/s of A9
	Comment on sediment source potential in catchment	Limited. Talus deposits present as are glacio fluvial sands and gravels, but these are not exposed and a flowing channel in upper catchment is very limited therefore transport of sediment to crossing unlikely	
	Comment on sediment supply potential to crossing	See above	
Morphology and Process-Reach upstream of crossing	Channel morphology	Plane bed	
	Predominant sediment size	Fines	difficult to see as channel completely vegetated
	Unvegetated bars	No	
	Vertical incision	None	
	Deposition	Low	probably deposition of fines in vegetated channel
	Lateral migration/bank erosion	None	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 165	Yes	OS Mapping shows track u/s of road, probably crosses channel at a ford.
	Impact of infrastructure	None evident	
	Channel realignment	No	Channel not shown u/s of road on 1899 map
Morphology and Process-At crossing	Channel morphology	Engineered	Pipe culvert
	Predominant sediment size	Fines	
	Unvegetated bars	No	
	Vertical incision	None	
	Deposition	Low	
	Lateral migration/bank erosion	None	
	Damaged/unstable drains or armouring	No	
Morphology and Process-Reach downstream of crossing	Channel morphology		Not known, photos only show culvert exit
	Predominant sediment size		Not known, photos only show culvert exit
	Unvegetated bars		Not known, photos only show culvert exit
	Vertical incision		Not known, photos only show culvert exit
	Deposition		Not known, photos only show culvert exit
	Lateral migration/bank erosion		Not known, photos only show culvert exit
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 165		Not known, photos only show culvert exit
	Impact of infrastructure		Not known, photos only show culvert exit
	Channel realignment		Not known, photos only show culvert exit

Summary behaviour	Limited activity in this catchment. Limited realignment u/s of crossing. Seems stable and vegetated. D/s of crossing realigned, probably during railway construction to take flow from this and other channels through just one point along the railway embankment.

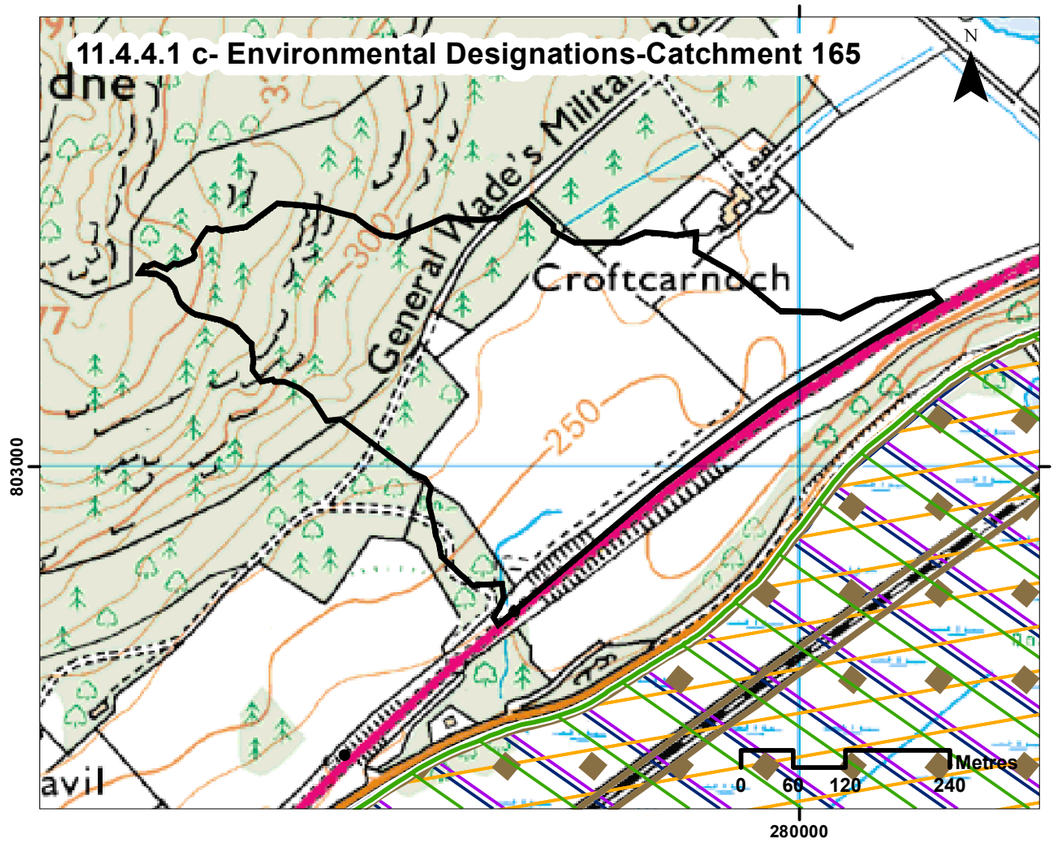
11.4.4.1 a- Solid Geology-Catchment 165



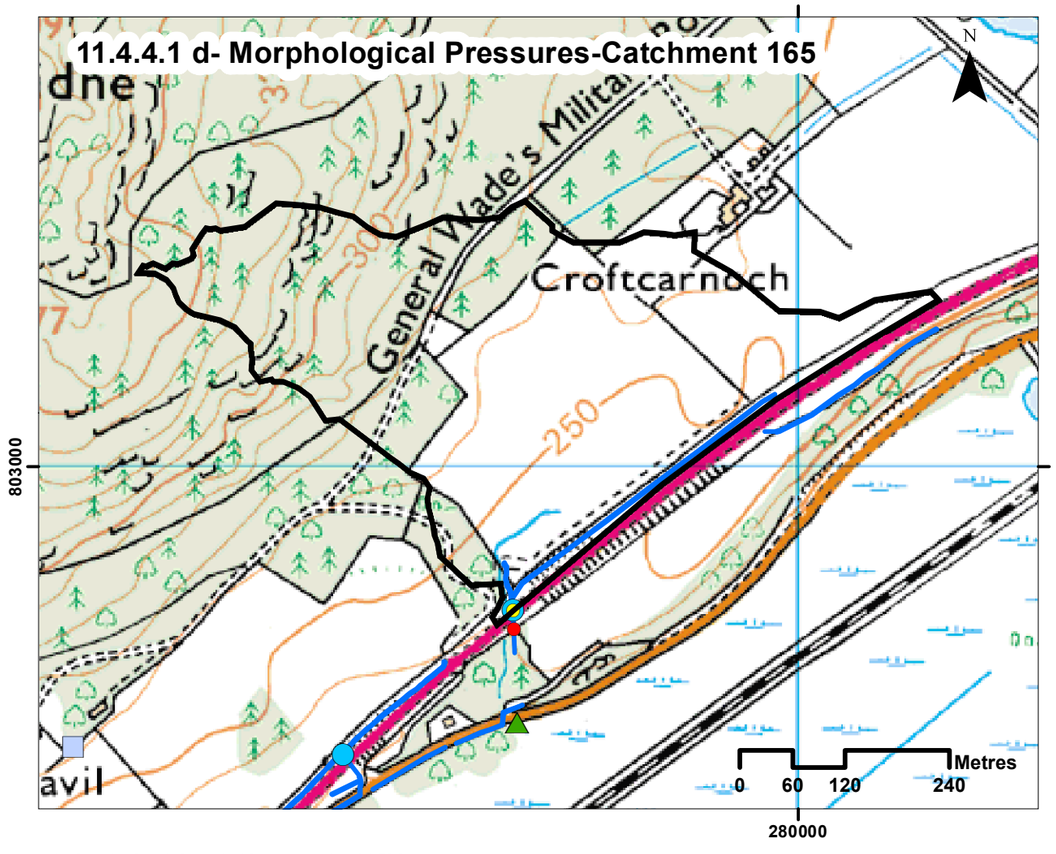
11.4.4.1 b- Drift Geology-Catchment 165



11.4.4.1 c- Environmental Designations-Catchment 165



11.4.4.1 d- Morphological Pressures-Catchment 165



Legend

General
- Crossing location

Solid Geology
- Loch Laggan Psammite Formation - Psammite, Micaceous

Drift Geology
- Peat
- Glaciofluvial Ice Contact Deposits
- Gaick Plateau Moraine Formation
- Hummocky Glacial Deposits
- Ardverikie Till Formation - Diamicton
- Glaciofluvial Sheet Deposits
- Alluvium
- River Terrace Deposits
- Alluvial Fan Deposits
- Head
- Talus - Rock Fragments
- Talus Cone

Environmental Designations
- Ramsar
- Special Site of Scientific Interest
- Special Area of Conservation
- Special Protection Area
- National Nature Reserve

Morphological Pressures
- Road Bridge
- Culvert
- Step in Bed
- Catchpit
- Abstraction Location
- Drainage Ditch

REV	SUIT	DATE	DESCRIPTION	BY	APP

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TRANSPORT SCOTLAND

A9 DUALLING PERTH TO INVERNESS Crubenmore to Kincraig

9 CRUBENMORE TO KINCRAIG EIA

Drawing 11.4.4.1 Catchment 165 Catchment Overview

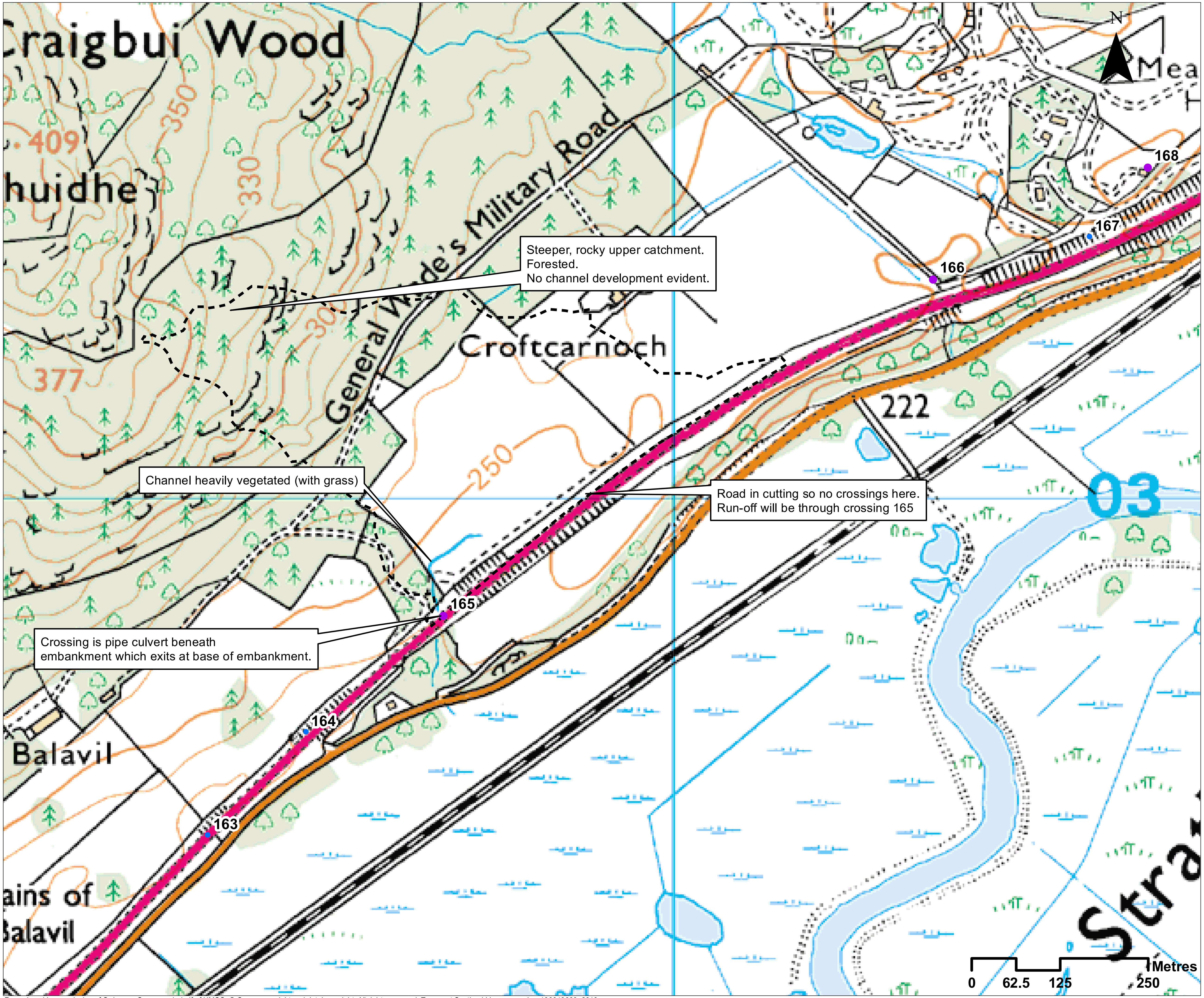
DESIGN:	DRAWN:	CHK:	APP:
EL	EV	EL	EL

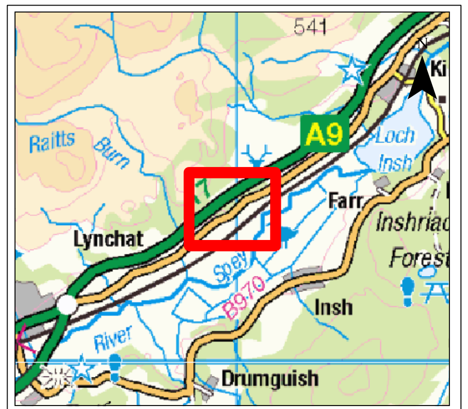
DATE: 20/12/2017

PROJ: 495298

DWG: A9P09-CFJ-EWE-Z_ZZZZZ_ZZ-DR-EN-0009

SHEET:	REVISION:	SUITABILITY:
1 of 1	C01	A3





Legend

- Minor crossing
- Other crossing
- Crossing catchment

REV	SUIT	DATE	DESCRIPTION	BY	APP

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TRANSPORT SCOTLAND
A9 DUALLING PERTH TO INVERNESS

PROJECT 9 CRUBENMORE TO KINCRAIG EIA

DRAWING 11.4.4.2.
Catchment 165 Baseline Assessment

DESIGN:	DRAWN:	CHK:	APP:
EL	AB	EL	EL

DATE: 19/12/2017
PROJ: 495298
DWG: A9P09-CFJ-EWE-Z_ZZZZZ_ZZ-DR-EN-0010

SHEET:	REVISION:	SUITABILITY:
1 OF 1	C01	A3

Annex 11.4.4-Hydromorphological Catchment Assessment-166

Catchment No.	166
Catchment Name	-

Channel Nature	Nature of water course	Drain
	Size of water course	Minor

Quantitative Spatial Elements	Catchment Area (km^2)	0.4
	Average slope in catchment (°)	7
	% Catchment over 750m (for snow melt risk)	0

WFD classification	Water, flows and levels	Good
	Physical condition	Good
	Overall ecological status	Good

Geology	Majority Bedrock (see Drawing 11.4.4.1 a and b Catchment 166)	Loch Laggan Psammite formation-Psammite, Micaeous	resistant to weathering, impermeable
	Is an alluvial fan present at or near the crossing?	No	

Environmental designations (see Drawing 11.4.4.1 c, Catchment 166)	Ramsar	Yes	**River Spey - Insh Marshes** Breeding birds, wetlands, freshwater habitats, trophic range river/stream,Whooper Swan
	SAC	Yes	**Insh Marshes** Alder woodland on floodplains, clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels, Otter, very we mires often identified by an unstable quaking surface **River Spey** Atlantic salmon, freshwater pearl mussel, otter, sea lamprey
	SPA	Yes	**River Spey - Insh Marshes** Hen Harrier, Osprey breeding, Spotted Crake breeding, Whooper swan, Wigeon breeding, Wood Sandpiper
	SSSI	Yes	**River Spey - Insh Marshes** Arctic charr, breeding bird assemblage, flood plain fen, invertebrate assemblage, mesotrophic loch, Osprey breeding, Otter, vascular plant assemblage, Whooper swan

Sediment source and supply - Catchment Scale	Changes in slope and channel confinement	See Drawing 11.4.4.2, Catchment 166	
	Is peat present in the catchment?	Yes	Floodplain mire in very lowest extent of catchment
	Is there a bog burst risk?	No	Floodplain mire in very lowest extent of catchment - d/s of road
	Current valley side or terrace erosion	No	
	Potential valley side or terrace erosion	No	
	Hill slope failures (including peat slides and debris flows and slides)	No	
	Hill slope failures coupled to channel	No	
	Vertical incision present in catchment	No	
	Bank erosion/lateral migration	No	
	Unvegetated bars	No	
	Wooded/forested areas in catchment	No	
	Infrastructure type (see Drawing 11.4.4.1 d, Catchment 166)	Yes	Croftcarnoch farm - distant from watercourse
	Comment on sediment source potential in catchment	Limited. Well vegetated catchment.	
	Comment on sediment supply potential to crossing	Low gradient area between steep upper catchment and crossing, and little channel development means limited opportunity for sediment supply to crossing.	

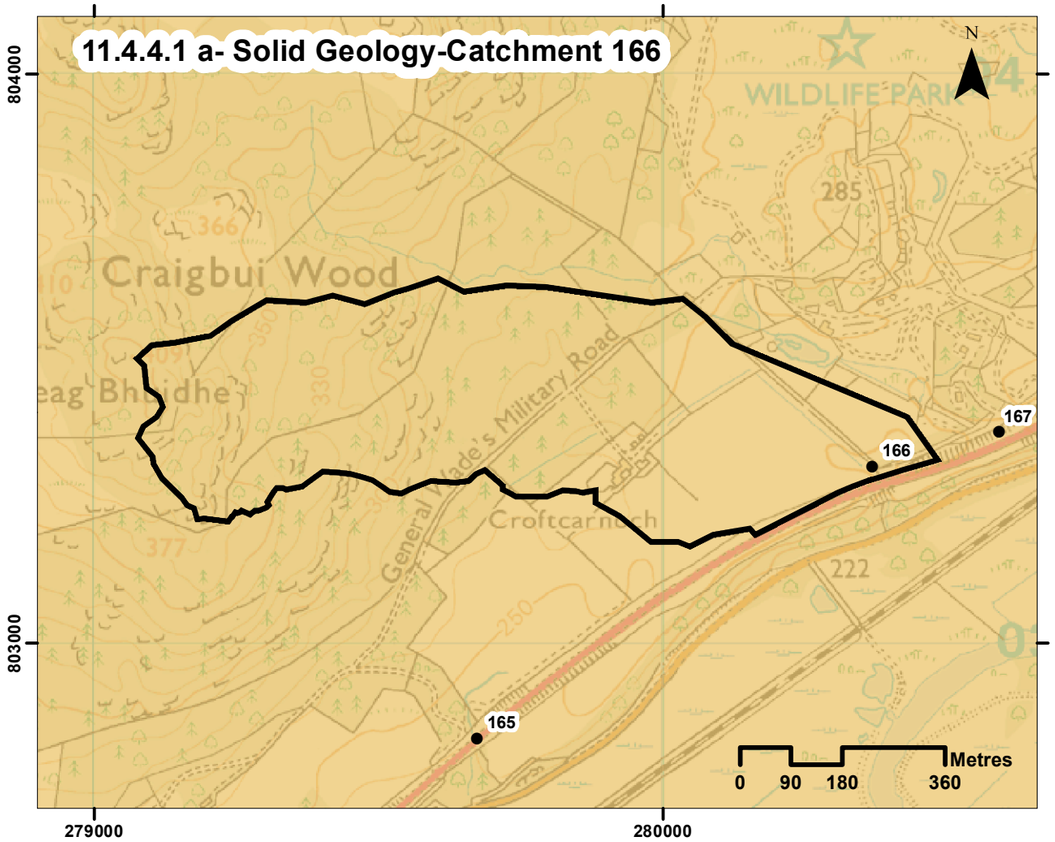
Morphology and Process-Reach upstream of crossing	Channel morphology	Engineered	No Photos (notes say photos are u/s but flow of water is out of culvert towards camera) but OS indicates channel u/s of slope is a cut drain.
	Predominant sediment size	No data	No Photos (notes say photos are u/s but flow of water is out of culvert towards camera)
	Unvegetated bars	No data	No Photos (notes say photos are u/s but flow of water is out of culvert towards camera)
	Vertical incision	No data	No Photos (notes say photos are u/s but flow of water is out of culvert towards camera)
	Deposition	No data	No Photos (notes say photos are u/s but flow of water is out of culvert towards camera)
	Lateral migration/bank erosion	No data	No Photos (notes say photos are u/s but flow of water is out of culvert towards camera)
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 166	No data	No Photos (notes say photos are u/s but flow of water is out of culvert towards camera)
	Impact of infrastructure	No data	flow of water is out of culvert towards
	Channel realignment	No data	No Photos (notes say photos are u/s but flow of water is out of culvert towards camera)

Morphology and Process-At crossing	Channel morphology	Engineered	Pipe culvert
	Predominant sediment size	N/a	
	Unvegetated bars	No	
	Vertical incision	Low	
	Deposition	Low	
	Lateral migration/bank erosion	Low	
	Damaged/unstable drains or armouring	No	

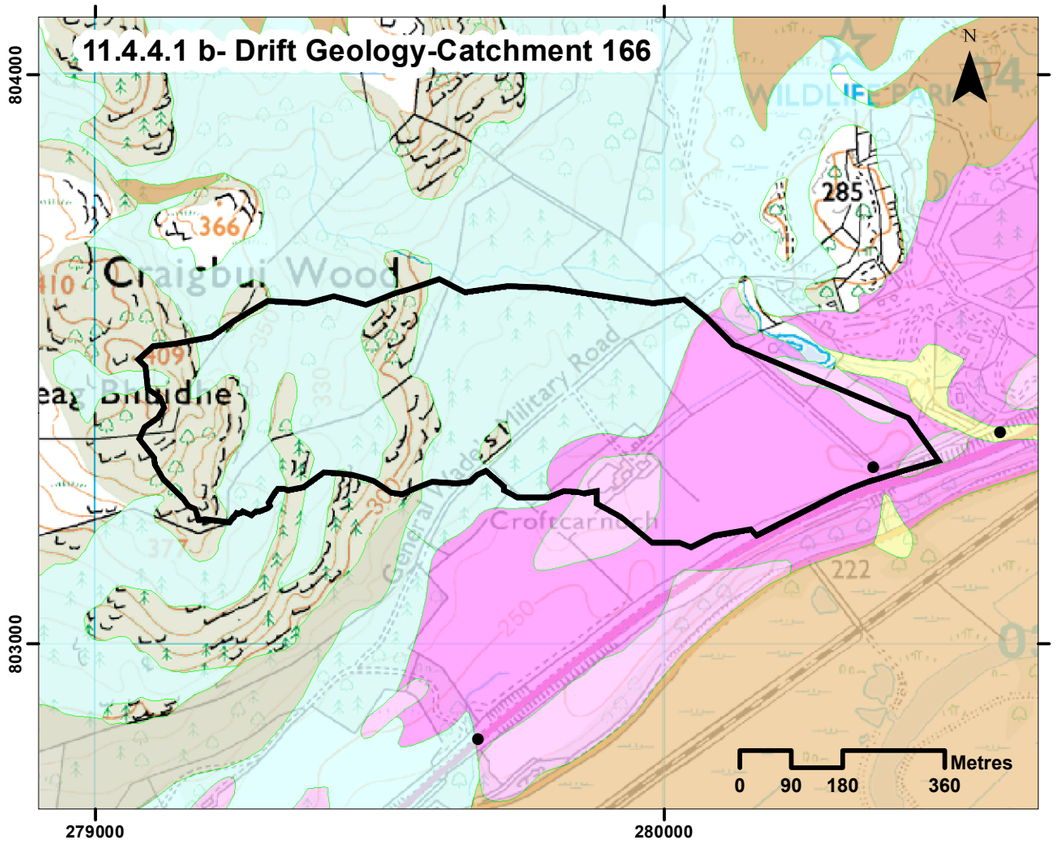
Morphology and Process-Reach downstream of crossing	Channel morphology	Cascade	
	Predominant sediment size	No data	
	Unvegetated bars	No data	
	Vertical incision	No data	
	Deposition	No data	
	Lateral migration/bank erosion	No data	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 166	Yes	Fence across channel, B9152, Railway
	Impact of infrastructure	Yes	Fence will restrict flow and passage of sediment
	Channel realignment	No	Channel straightening u/s of road pre-dates road construction (visible on 1899 OS Map)

Summary behaviour	Limited activity in this catchment. Limited realignment u/s of crossing. Seems stable and vegetated. D/s of crossing realigned, probably during railway construction to take flow from this and other channels through just one point along the railway embankment.

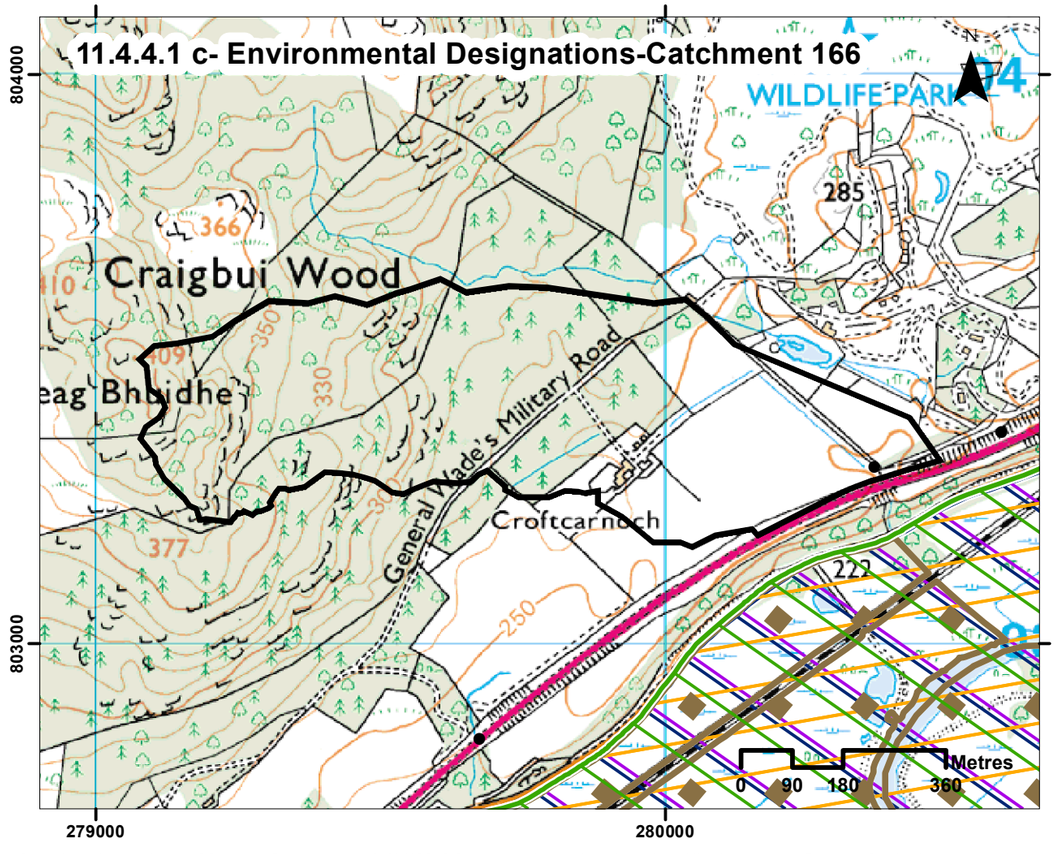
11.4.4.1 a- Solid Geology-Catchment 166



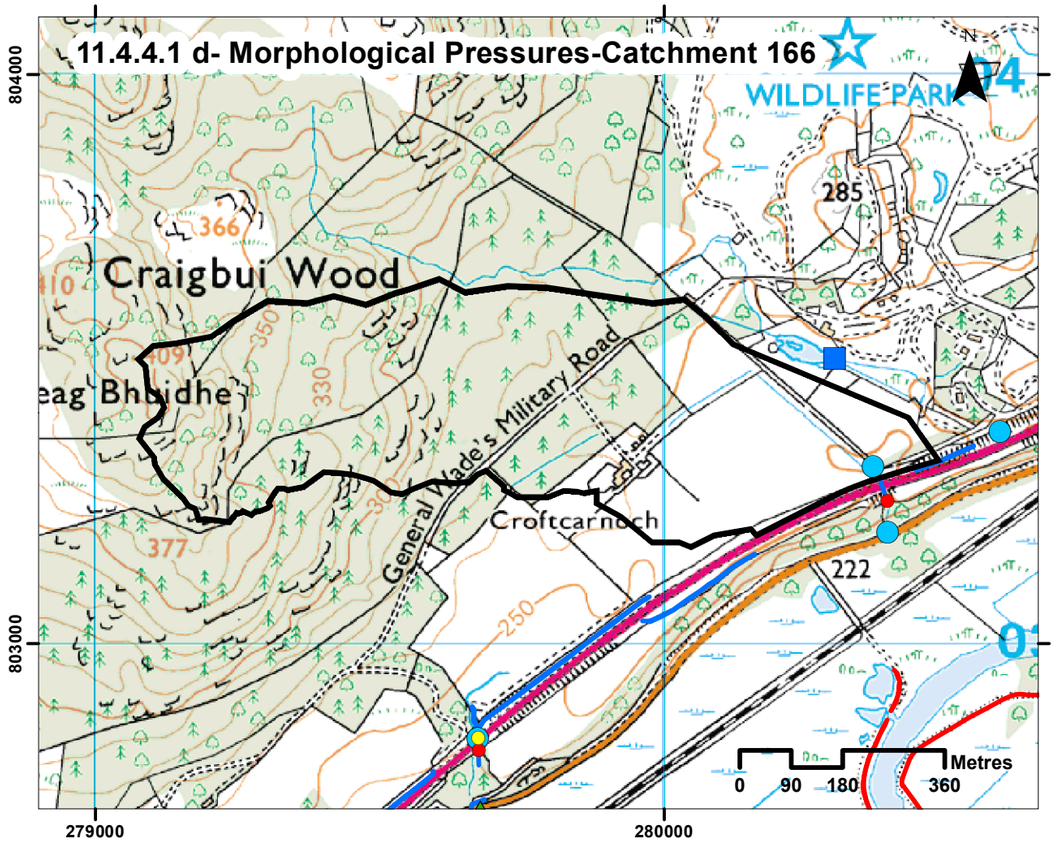
11.4.4.1 b- Drift Geology-Catchment 166



11.4.4.1 c- Environmental Designations-Catchment 166



11.4.4.1 d- Morphological Pressures-Catchment 166



Legend

General
- Crossing location

Solid Geology
- Loch Laggan Psammite Formation - Psammite, Micaceous

Drift Geology
- Peat
- Glaciofluvial Ice Contact Deposits
- Gaick Plateau Moraine Formation
- Hummocky Glacial Deposits
- Ardverikie Till Formation - Diamicton
- Glaciofluvial Sheet Deposits
- Alluvium
- River Terrace Deposits
- Alluvial Fan Deposits
- Head
- Talus - Rock Fragments
- Talus Cone

Environmental Designations
- Ramsar
- Special Site of Scientific Interest
- Special Area of Conservation
- Special Protection Area
- National Nature Reserve

Morphological Pressures
- Road Bridge
- Culvert
- Step in Bed
- Catchpit
- Discharge Location
- Drainage Ditch
- Flood Embankment

REV	SUIT	DATE	DESCRIPTION	BY	APP

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TRANSPORT SCOTLAND CONSULTING ALBA

A9 DUALLING PERTH TO INVERNESS Crubenmore to Kincraig

9 CRUBENMORE TO KINCRAIG EIA

Drawing 11.4.4.1 Catchment 166 Catchment Overview

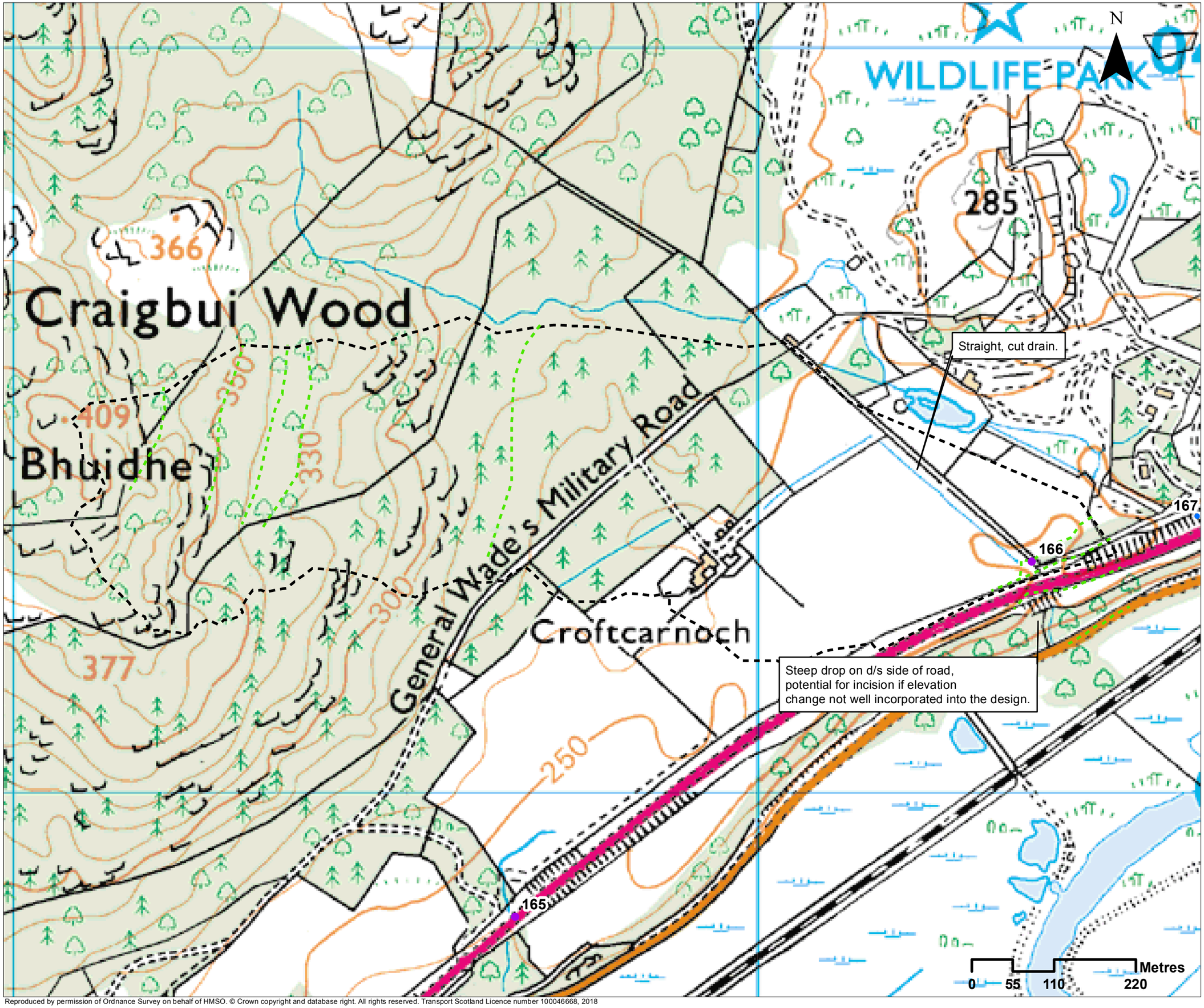
DESIGN:	DRAWN:	CHK:	APP:
EL	EV	EL	EL

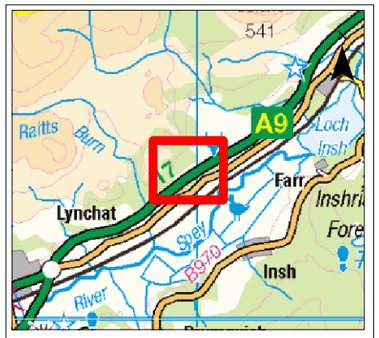
DATE: 20/12/2017

PROJ: 495298

DWG: A9P09-CFJ-EWE-Z_ZZZZZ_ZZ-DR-EN-0009

SHEET:	REVISION:	SUITABILITY:
1 of 1	C01	A3





Legend

- Minor crossing
- Other crossing
- Break in slope
- Crossing catchment

REV	SUIT	DATE	DESCRIPTION	BY	APP

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TRANSPORT SCOTLAND

A9 DUALLING PERTH TO INVERNESS Crubenmore to Kincraig

PROJECT 9 CRUBENMORE TO KINCRAIG EIA

DRAWING 11.4.4.2.
Catchment 166 Baseline Assessment

DESIGN:	DRAWN:	CHK:	APP:
EL	AB	EL	EL

DATE: 19/12/2017

PROJ: 495298

DWG: A9P09-CFJ-EWE-Z_ZZZZZ_ZZ-DR-EN-0010

SHEET:	REVISION:	SUITABILITY:
1 OF 1	C01	A3

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Annex 11.4.4-Hydromorphological Catchment Assessment-168

Catchment No.	168
Catchment Name	-

Channel Nature	Nature of water course	Natural
	Size of water course	Minor

Quantitative Spatial Elements	Catchment Area (km^2)	0.9
	Average slope in catchment (°)	8.2
	% Catchment over 750m (for snow melt risk)	0

WFD classification	Water, flows and levels	Good
	Physical condition	Good
	Overall ecological status	Good

Geology	Majority Bedrock (see Drawing 11.4.4.1 a and b Catchment 168)	Loch Laggan Psammite formation-Psammite, Micaeous	resistant to weathering, impermeable
	Is an alluvial fan present at or near the crossing?	No	

Environmental designations (see Drawing 11.4.4.1 c, Catchment 168)	Ramsar	Yes	**River Spey - Insh Marshes** Breeding birds, wetlands, freshwater habitats, trophic range river/stream,Whooper Swan
	SAC	Yes	**Insh Marshes** Alder woodland on floodplains, clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels, Otter, very we mires often identified by an unstable quaking surface **River Spey** Atlantic salmon, freshwater pearl mussel, otter, sea lamprey
	SPA	Yes	**River Spey - Insh Marshes** Hen Harrier, Osprey breeding, Spotted Crake breeding, Whooper swan, Wigeon breeding, Wood Sandpiper
	SSSI	Yes	**River Spey - Insh Marshes** Arctic charr, breeding bird assemblage, flood plain fen, invertebrate assemblage, mesotrophic loch, Osprey breeding, Otter, vascular plant assemblage, Whooper swan

Sediment source and supply - Catchment Scale	Changes in slope and channel confinement	See Drawing 11.4.4.2, Catchment 168	
	Is peat present in the catchment?	No	
	Is there a bog burst risk?	No	
	Current valley side or terrace erosion	No	
	Potential valley side or terrace erosion	No	
	Hill slope failures (including peat slides and debris flows and slides)	No	
	Hill slope failures coupled to channel	No	
	Vertical incision present in catchment	No	
	Bank erosion/lateral migration	No	
	Unvegetated bars	No	
	Wooded/forested areas in catchment	Yes	Some foresty in middle catchment so somall risk of blockage of culvert
	Infrastructure type (see Drawing 11.4.4.1 d, Catchment 168)	Railway downstream of crossing	
	Comment on sediment source potential in catchment	Little sediment visiable from imagery	
	Comment on sediment supply potential to crossing	Little sediment visiable from imagery	

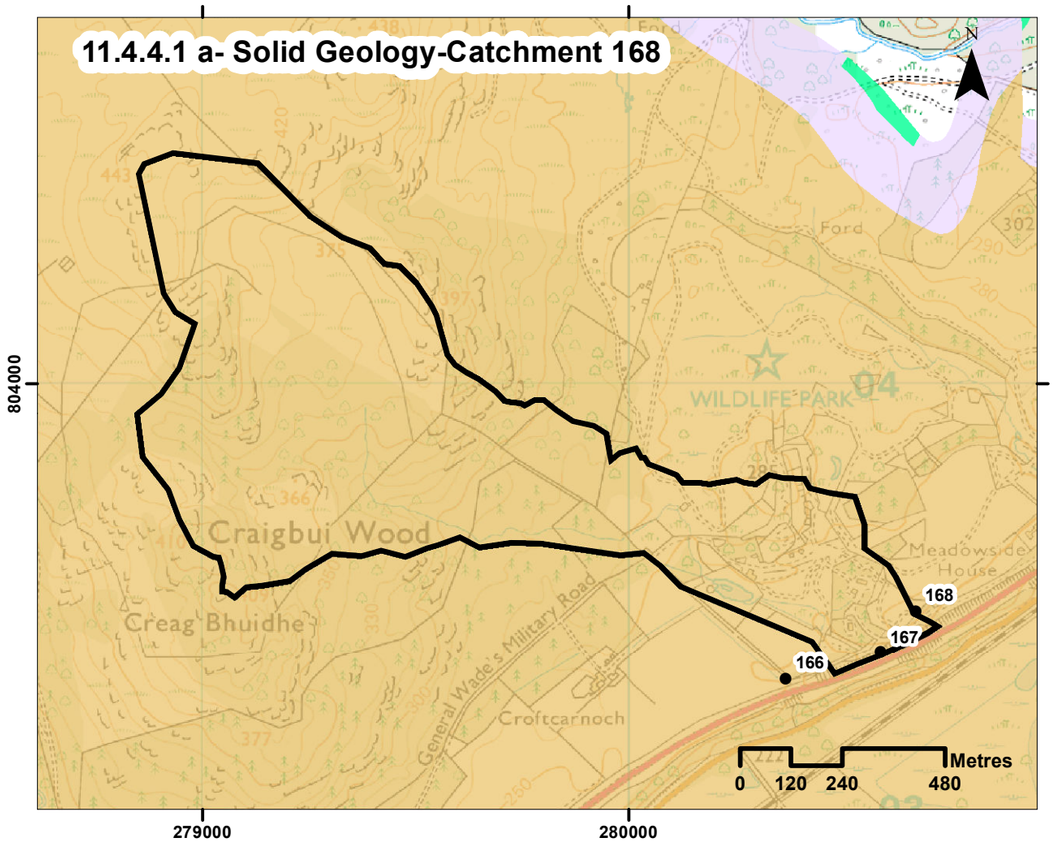
Morphology and Process-Reach upstream of crossing	Channel morphology	Engineered	
	Predominant sediment size	Not visiable in data	
	Unvegetated bars	Not visiable in data	
	Vertical incision	Not visiable in data	
	Deposition	Not visiable in data	
	Lateral migration/bank erosion	Not visiable in data	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 168	Drop chamber upstream end of crossing	
	Impact of infrastructure	Not visiable in data	
	Channel realignment	Not visiable in data	

Morphology and Process-At crossing	Channel morphology	Engineered	
	Predominant sediment size	Not visiable in data	
	Unvegetated bars	None	
	Vertical incision	None	
	Deposition	None	
	Lateral migration/bank erosion	Yes	Now remediated
	Damaged/unstable drains or armouring	Landslide has occured on embankment and has been remediated with granular fill and large boulders (see photographs)	

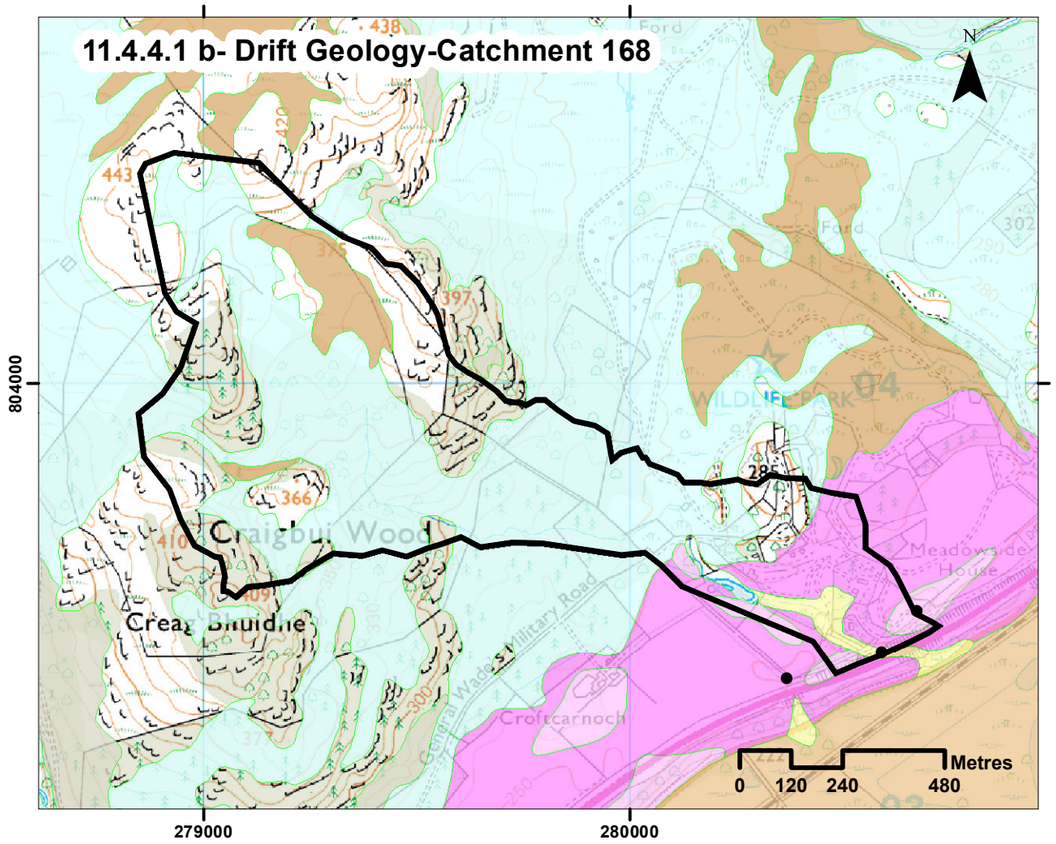
Morphology and Process-Reach downstream of crossing	Channel morphology	Plane bed	
	Predominant sediment size	Gravel	
	Unvegetated bars	None	
	Vertical incision	None	
	Deposition	None	
	Lateral migration/bank erosion	None	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 168	Broad crossing (2 pipe culverts) and Railway bridge downstream	
	Impact of infrastructure	Will reduce downstream flood flows	
	Channel realignment	Yes	

Summary behaviour	Catchment appears relatively stable, but a landslide on the embankment has occurred and the crossing and section directly downstream has been replaced with granular fill, and a boulder lined channel.

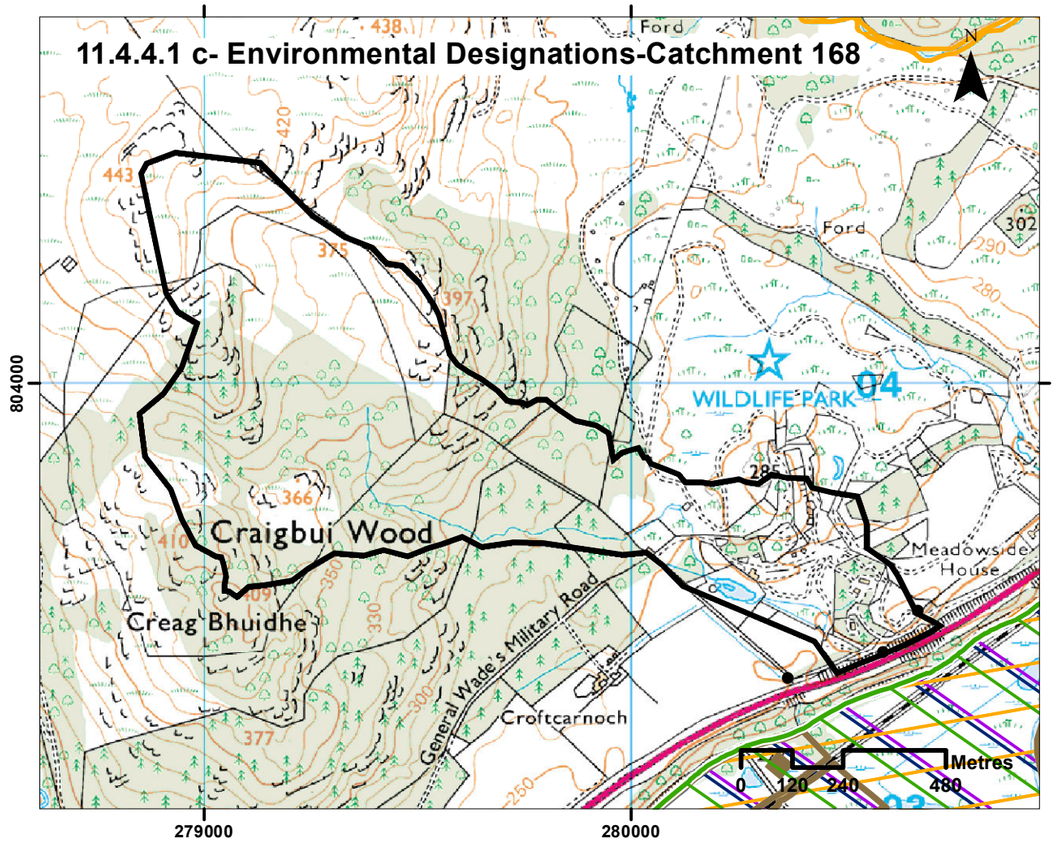
11.4.4.1 a- Solid Geology-Catchment 168



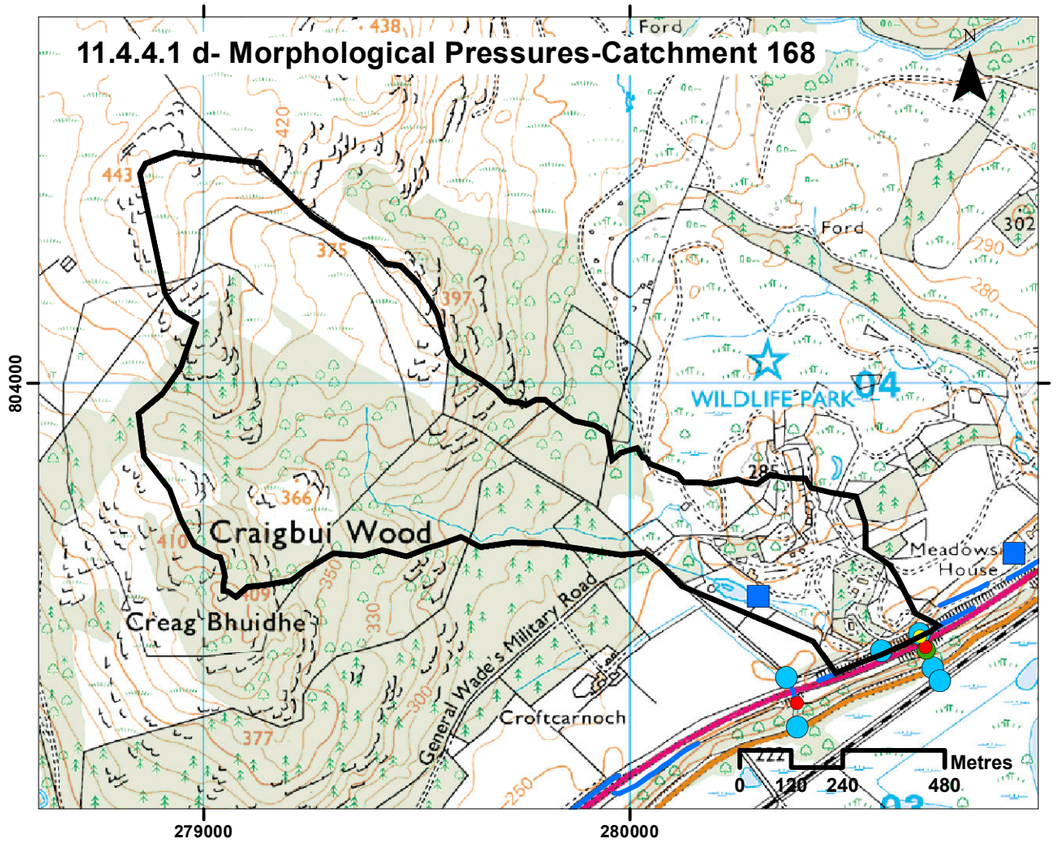
11.4.4.1 b- Drift Geology-Catchment 168



11.4.4.1 c- Environmental Designations-Catchment 168



11.4.4.1 d- Morphological Pressures-Catchment 168



Legend

General
- Crossing location

Solid Geology
- Loch Laggan Psammite Formation - Psammite, Micaceous

Drift Geology
- Peat
- Glaciofluvial Ice Contact Deposits
- Gaick Plateau Moraine Formation
- Hummocky Glacial Deposits
- Ardverikie Till Formation - Diamicton
- Glaciofluvial Sheet Deposits
- Alluvium
- River Terrace Deposits
- Alluvial Fan Deposits
- Head
- Talus - Rock Fragments
- Talus Cone

Environmental Designations
- Ramsar
- Special Site of Scientific Interest
- Special Area of Conservation
- Special Protection Area
- National Nature Reserve

Morphological Pressures
- Culvert
- Cascade
- Step in Bed
- Catchpit
- Discharge Location
- Drainage Ditch

REV	SUIT	DATE	DESCRIPTION	BY	APP

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TRANSPORT SCOTLAND
A9 DUALLING PERTH TO INVERNESS Crubenmore to Kincraig

9 CRUBENMORE TO KINCRAIG EIA

Drawing 11.4.4.1 Catchment 168 Catchment Overview

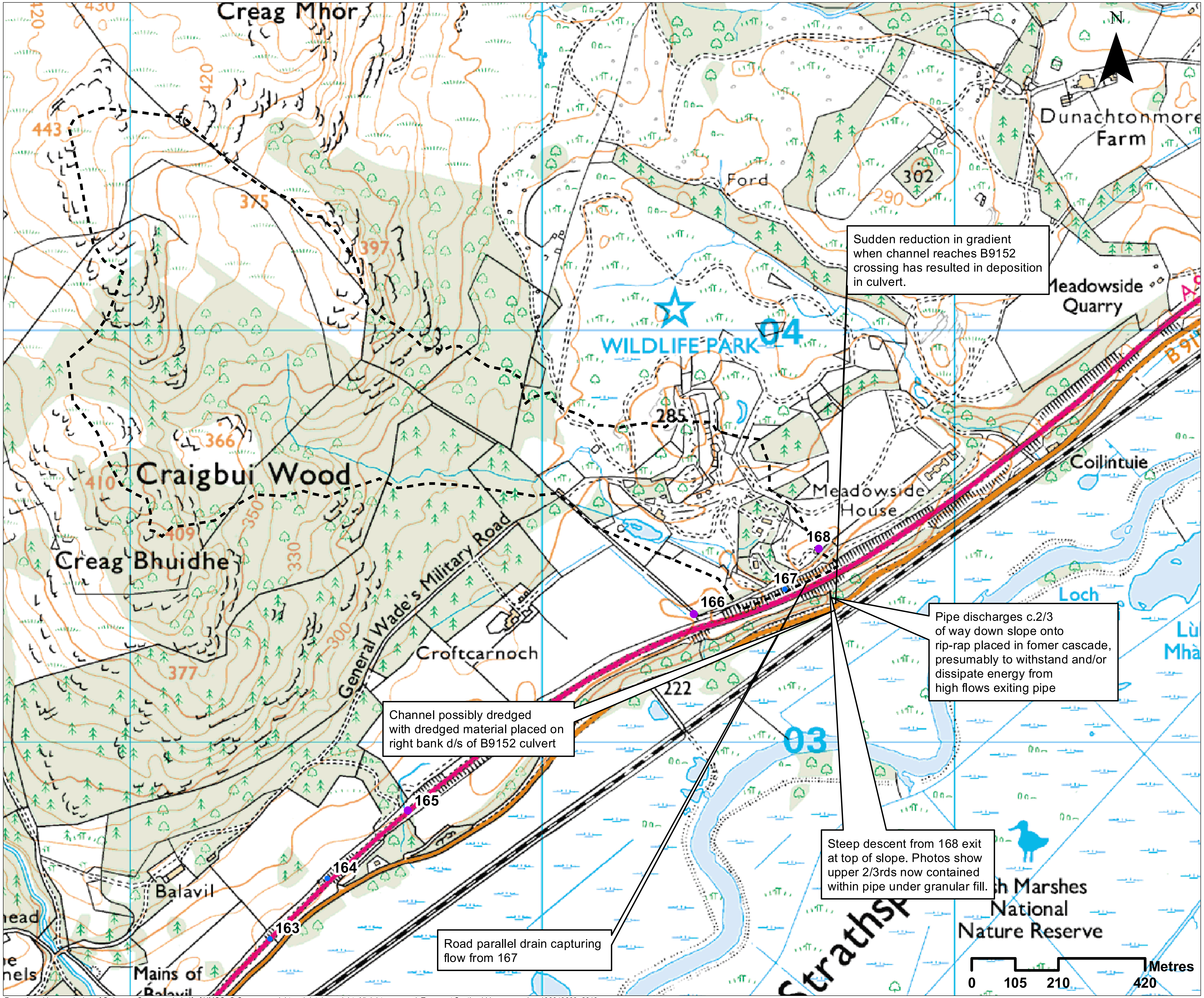
DESIGN:	DRAWN:	CHK:	APP:
EL	EV	EL	EL

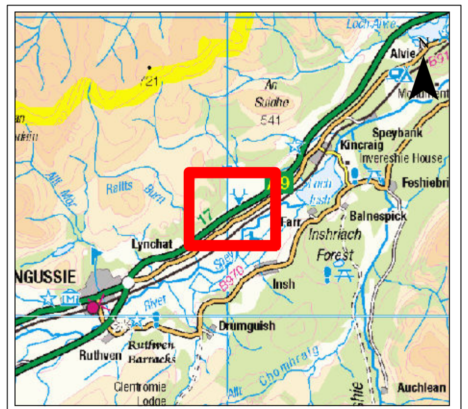
DATE: 20/12/2017

PROJ: 495298

DWG: A9P09-CFJ-EWE-Z_ZZZZZ_ZZ-DR-EN-0009

SHEET:	REVISION:	SUITABILITY:
1 of 1	C01	A3





Legend

- Minor crossing
- Other crossing
- Crossing catchment

REV	SUIT	DATE	DESCRIPTION	BY	APP

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PROJECT 9 CRUBENMORE TO KINCRAIG EIA

DRAWING 11.4.4.2.
Catchment 168 Baseline Assessment

DESIGN:	DRAWN:	CHK:	APP:
EL	AB	EL	EL

DATE: 19/12/2017

PROJ: 495298

DWG: A9P09-CFJ-EWE-Z_ZZZZZ_ZZ-DR-EN-0010

SHEET:	REVISION:	SUITABILITY:
1 OF 1	C01	A3

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Photograph 11.4.4.68

Photograph 11.4.4.69

Photograph 11.4.4.70

Annex 11.4.4-Hydromorphological Catchment Assessment-170

Catchment No.	170
Catchment Name	-

Channel Nature	Nature of water course	Natural
	Size of water course	Minor

Quantitative Spatial Elements	Catchment Area (km^2)	1.4
	Average slope in catchment (°)	6.5
	% Catchment over 750m (for snow melt risk)	0

WFD classification	Water, flows and levels	Good
	Physical condition	Good
	Overall ecological status	Good

Geology	Majority Bedrock (see Drawing 11.4.4.1 a and b Catchment 170)	Loch Laggan Psammite Formation-Psammite, Micaeous	resistant to weathering, impermeable
	Is an alluvial fan present at or near the crossing?	No	

Environmental designations (see Drawing 11.4.4.1 c, Catchment 170)	Ramsar	Yes	**River Spey - Insh Marshes** Breeding birds, wetlands, freshwater habitats, trophic range river/stream,Whooper Swan
	SAC	Yes	**Insh Marshes** Alder woodland on floodplains, clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels, Otter, very we mires often identified by an unstable quaking surface **River Spey** Atlantic salmon, freshwater pearl mussel, otter, sea lamprey
	SPA	Yes	**River Spey - Insh Marshes** Hen Harrier, Osprey breeding, Spotted Crake breeding, Whooper swan, Wigeon breeding, Wood Sandpiper
	SSSI	Yes	**River Spey - Insh Marshes** Arctic charr, breeding bird assemblage, flood plain fen, invertebrate assemblage, mesotrophic loch, Osprey breeding, Otter, vascular plant assemblage, Whooper swan

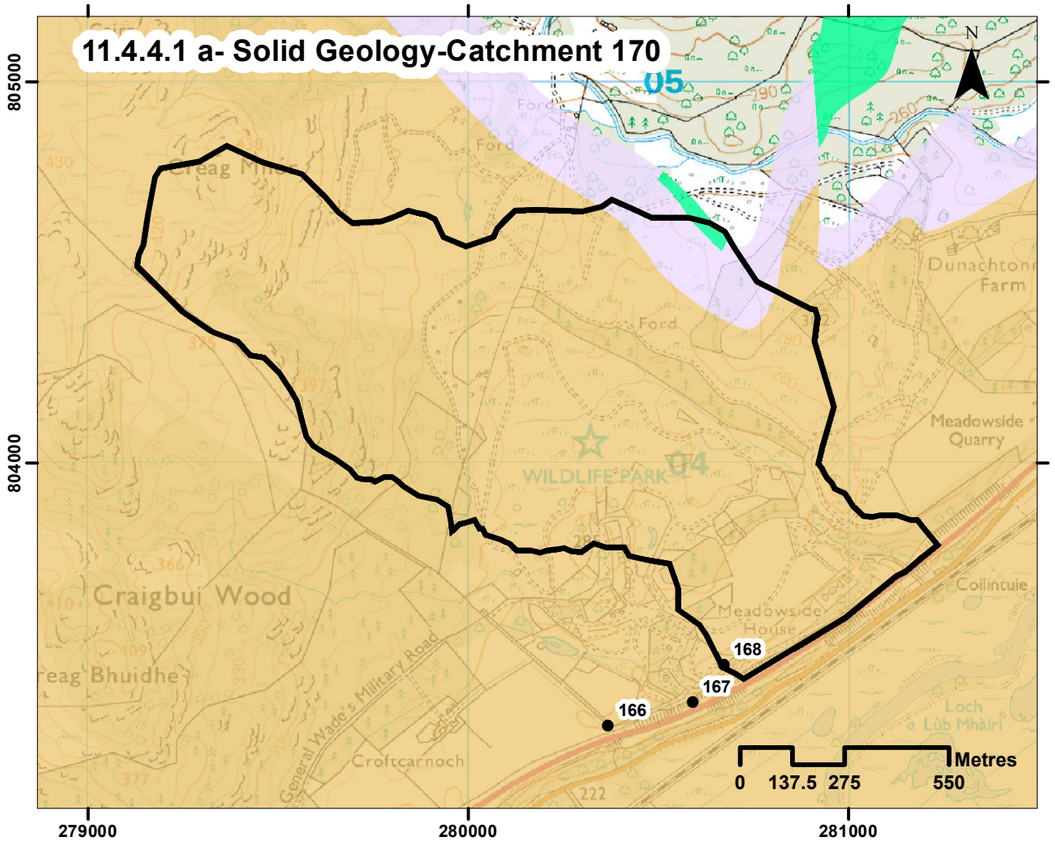
Sediment source and supply - Catchment Scale	Changes in slope and channel confinement	See Drawing 11.4.4.2, Catchment 170	
	Is peat present in the catchment?	Yes	
	Is there a bog burst risk?	No	
	Current valley side or terrace erosion	No	
	Potential valley side or terrace erosion	No	
	Hill slope failures (including peat slides and debris flows and slides)	No	
	Hill slope failures coupled to channel	No	
	Vertical incision present in catchment	No	
	Bank erosion/lateral migration	No	
	Unvegetated bars	No	
	Wooded/forested areas in catchment	No	
	Infrastructure type (see Drawing 11.4.4.1 d, Catchment 170)	No	
	Comment on sediment source potential in catchment	Limited. Well vegetated catchment.	
	Comment on sediment supply potential to crossing	Low gradient area between upper catchment and crossing, limited opportunity for sediment supply to crossing.	

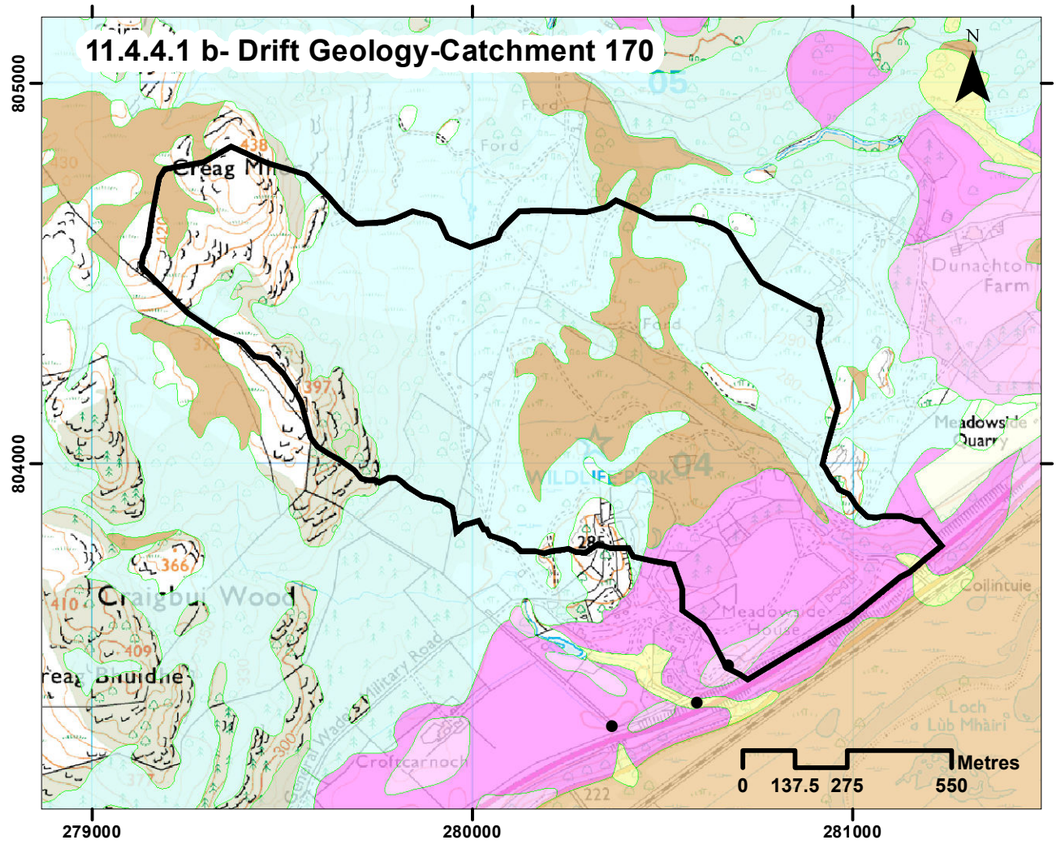
Morphology and Process-Reach upstream of crossing	Channel morphology	Engineered	
	Predominant sediment size	No data	
	Unvegetated bars	No data	
	Vertical incision	No data	
	Deposition	No data	
	Lateral migration/bank erosion	No data	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 170	No data	
	Impact of infrastructure	No data	
	Channel realignment	No data	

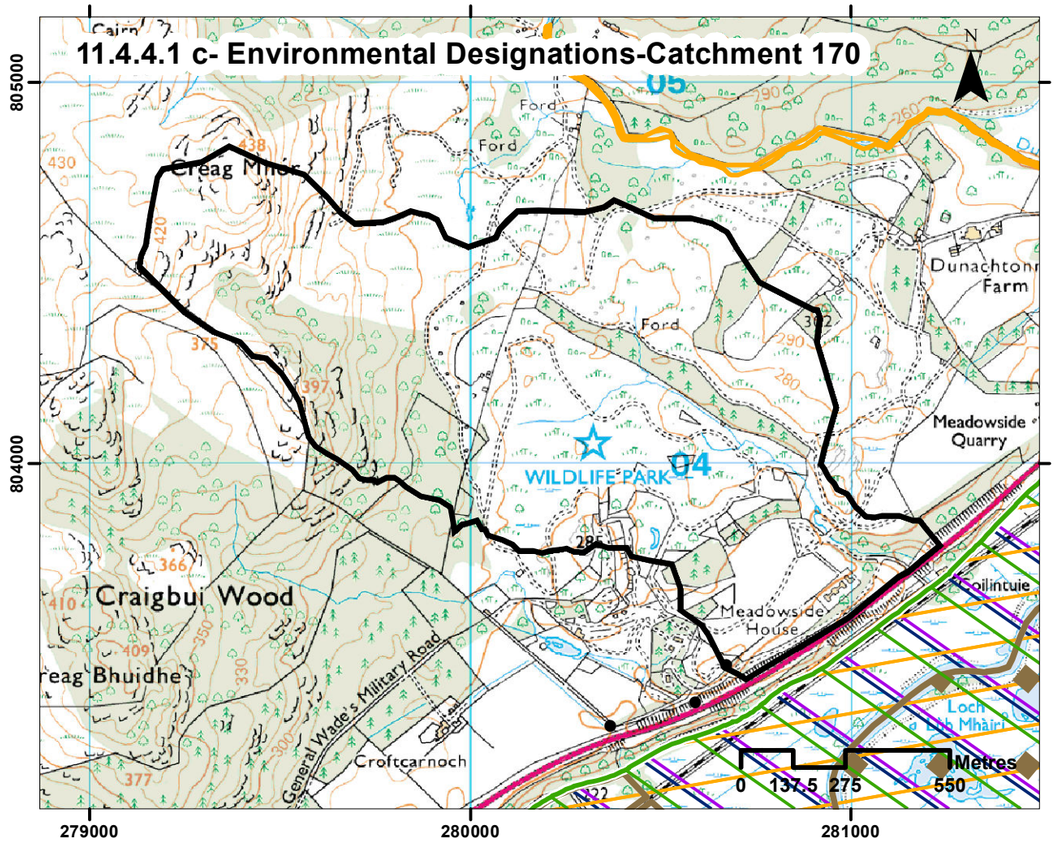
Morphology and Process-At crossing	Channel morphology	Engineered	Pipe culvert
	Predominant sediment size	N/a	
	Unvegetated bars	No	
	Vertical incision	Low	
	Deposition	Low	
	Lateral migration/bank erosion	Low	
	Damaged/unstable drains or armouring	No	

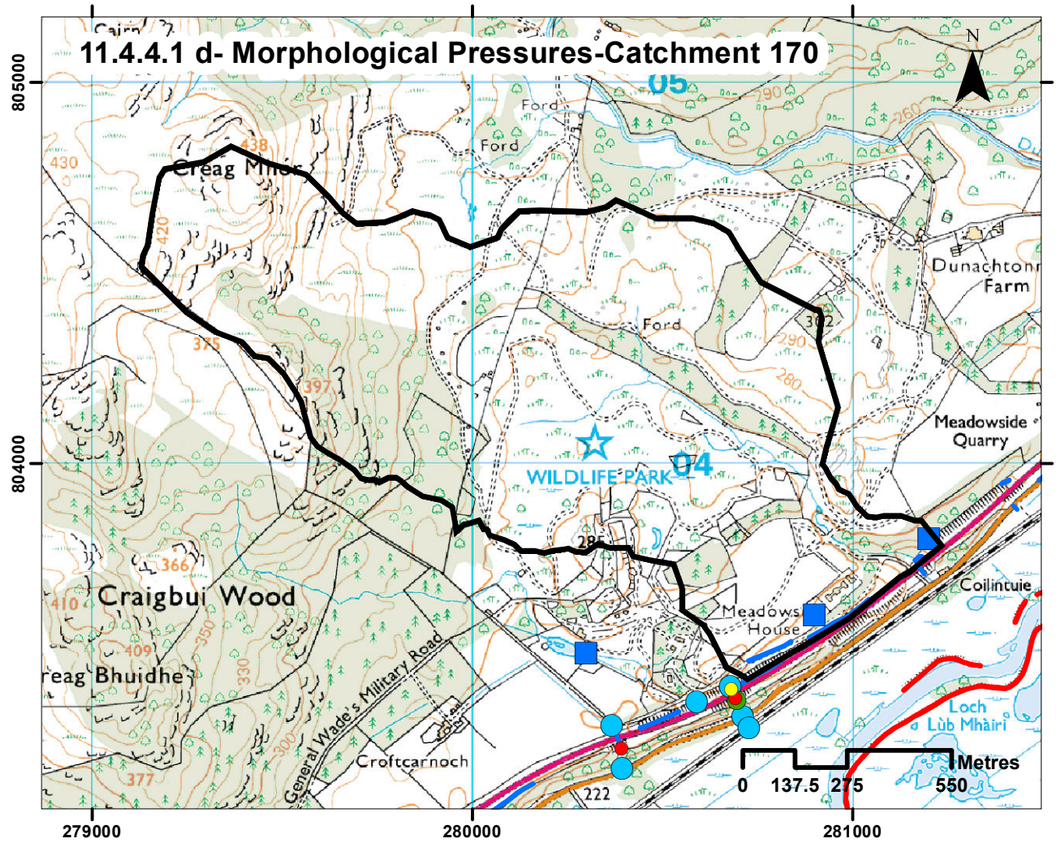
Morphology and Process-Reach downstream of crossing	Channel morphology	No data	
	Predominant sediment size	No data	
	Unvegetated bars	No data	
	Vertical incision	No data	
	Deposition	No data	
	Lateral migration/bank erosion	No data	
	Presence and nature of infrastructure (see Drawing 11.4.4.1 d, Catchment 170	Yes	
	Impact of infrastructure	Yes	
	Channel realignment	No	

Summary behaviour	Limited activity in this catchment. Limited realignment u/s of crossing. Seems stable and vegetated.









Legend

General

- Crossing location

Solid Geology

- Gaick Psammite Formation - Psammite
- Loch Laggan Psammite Formation - Psammite, Micaceous
- North Britain Siluro-Devonian Calc-Alkaline Dyke Suite - Microdiorite
- Pitmain Semipelite Member - Semipelite And Calcsilicate-Rock
- Pitmain Semipelite Member - Semipelite, Gneissose
- Scottish Highland Ordovician Minor Intrusion Suite - Leucogranite
- Scottish Highland Siluro-Devonian Calc-Alkaline Minor Intrusion Suite- (Other Than Dykes) - Microdiorite

Drift Geology

- Peat
- Glaciofluvial Ice Contact Deposits
- Gaick Plateau Moraine Formation
- Hummocky Glacial Deposits
- Ardverikie Till Formation - Diamicton
- Glaciofluvial Sheet Deposits
- Alluvium
- River Terrace Deposits
- Alluvial Fan Deposits
- Head
- Talus - Rock Fragments
- Talus Cone

Environmental Designations

- Ramsar
- Special Site of Scientific Interest
- Special Area of Conservation
- Special Protection Area
- National Nature Reserve

Morphological Pressures

- Culvert
- Cascade
- Step in Bed
- Catchpit
- Discharge Location
- Drainage Ditch
- Flood Embankment

REV	SUIT	DATE	DESCRIPTION	BY	APP

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TRANSPORT SCOTLAND | A9 DUALLING PERTH TO INVERNESS

9 CRUBENMORE TO KINCRAIG EIA

Drawing 11.4.4.1 Catchment 170 Catchment Overview

DESIGN:	DRAWN:	CHK:	APP:
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DATE: 20/12/2017

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DWG: A9P09-CFJ-EWE-Z_ZZZZZ_ZZ-DR-EN-0009

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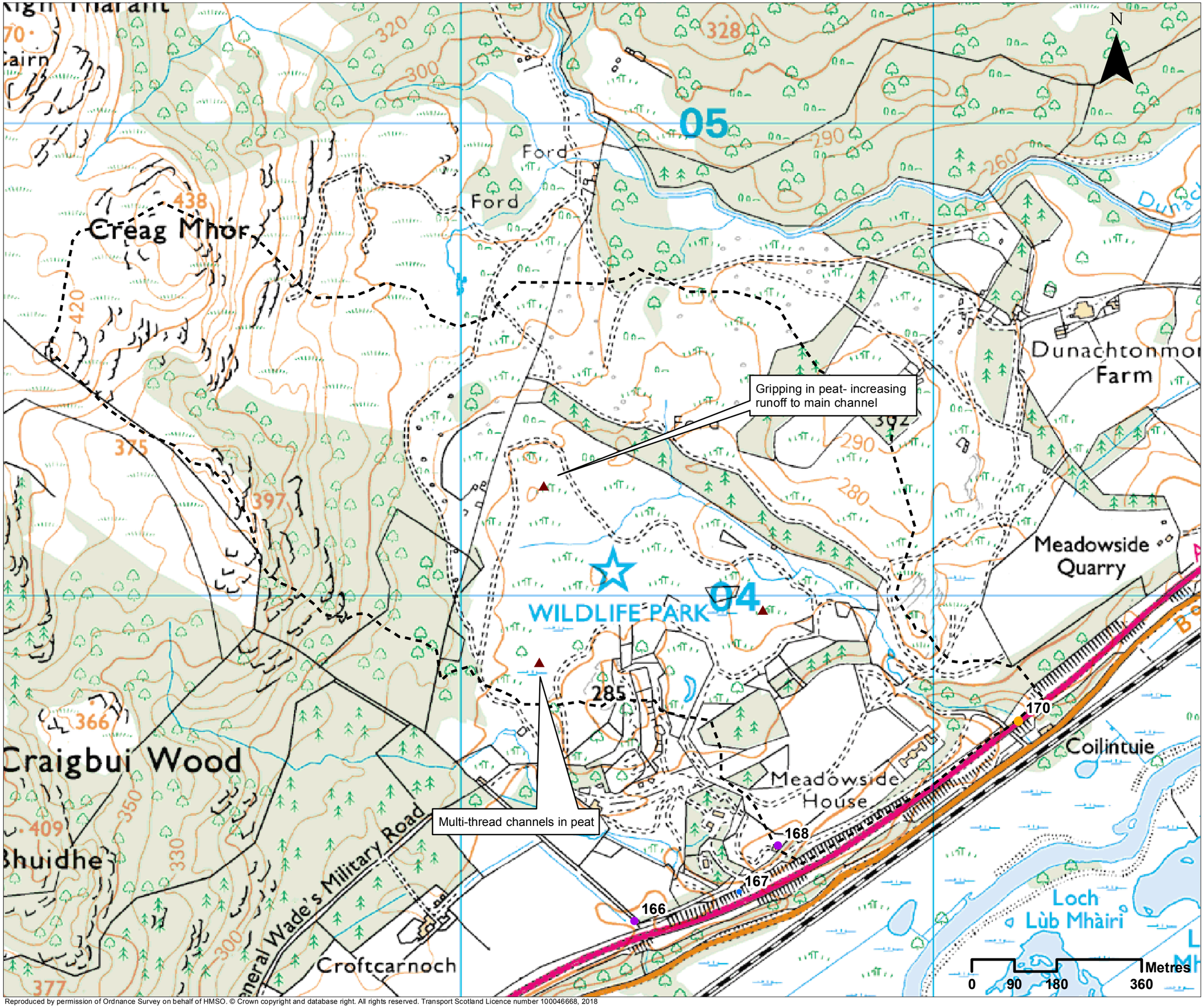
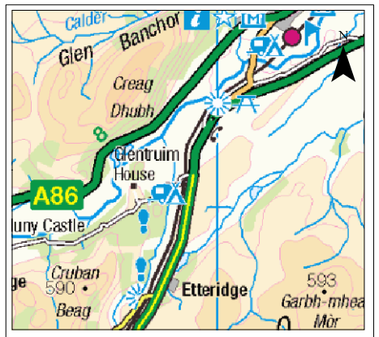
1 of 1	C01	A3





Legend

- Major crossing
- Minor crossing
- Other crossing
- Peak
- Crossing catchment

REV	SUIT	DATE	DESCRIPTION	BY	APP

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PERTH TO INVERNESS
Crubenmore to Kincraig

PROJECT 9 CRUBENMORE TO KINCRAIG EIA

DRAWING 11.4.4.2.
Catchment 170 Baseline Assessment

DESIGN:	DRAWN:	CHK:	APP:
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DATE: 19/12/2017

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DWG: A9P09-CFJ-EWE-Z_ZZZZZ_ZZ-DR-EN-0010

SHEET:	REVISION:	SUITABILITY:
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Annex 11.4.5

EIA Hydromorphological Assessment Tables

Baseline							Design																	Residual significance- After additional mitigation applied				
Hydro ID	Baseline type	Baseline length (m)	Baseline slope (m/m)	Works location	Sensitivity of Receptor	Existing WFD Status	Proposed Works Type	Upstream watercourse bed invert level	Downstream watercourse bed invert level	Total length of works	Proposed Gradient (m/m)	Change in crossing discharge	Is Single Activity limit threshold crossed?	Embedded mitigation	Negative impacts of scheme	Positive impacts of scheme	Worst case degree of change in WFD Status	Spatial extent of Impact	Scale of Impact	Duration of Impact	Magnitude of Impact	Significance	Additional mitigation	Spatial extent of Impact	Scale of Impact	Duration of Impact	Magnitude of Impact	Significance
134	Small natural channel	-	-	US	Low	Overall- Moderate Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	49.55	0.010	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and small change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
134	Pipe	57	0.02	Mainline	Low	Overall- Moderate Water, flows and levels-Good Physical condition- Good	Culvert	280.401	278.210	49.79	0.044	Upsize	No	Upsized culvert to take 1:200 year flow Bed Material added to culvert	Fixed channel position Loss of natural banks	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert and natural bed in crossing	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
134	Small natural channel	-	-	-	Low	Overall- Moderate Water, flows and levels-Good Physical condition- Good	Drain outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
136	Small natural channel	-	-	US	Low	Overall- Moderate Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	81.61	0.017	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and small change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	>0.5	Very Small (length of channel realignment)	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	>0.5	Very Small (length of channel realignment)	Long (More than 6 years)	Minor	Neutral
136	-	-	-	US VERGE	-	Overall- Moderate Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	55.78	0.011	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	<0.5	Very Small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Very Small	Long (More than 6 years)	Minor	Neutral
136	Pipe	109	0.06	Mainline	Low	Overall- Moderate Water, flows and levels-Good Physical condition- Good	Box culvert	-	-	-	-	Upsize	No	Upsized culvert to take 1:200 year flow Reduced length of culvert compared to baseline Pipe to Box culvert Bed Material added to culvert	Fixed channel position	Naturalised flow, due to increased discharge through crossing More natural flow width Improved continuity of sediment transfer due to upsized culvert and addition of bed material	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to new culvert	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
140	-	-	-	-	-	Overall- Moderate Water, flows and levels-Good Physical condition- Good	3 Drain outfalls	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
140	Natural channel	-	-	DS	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	7.40	0.010	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight adverse	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
140	Natural channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	5.23	0.198	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight adverse	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
140	Pipe	60	0.01	Mainline	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Box culvert	254.029	253.287	74.11	0.010	Upsize	No	Upsized culvert to take 1:200 year flow Pipe to Box culvert Bed Material added to culvert	Increased length of fixed channel position Loss of natural banks	Naturalised flow, due to increased discharge through crossing More natural flow width Improved continuity of sediment transfer due to upsized culvert and addition of bed material	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight beneficial due to upsized culvert, change in culvert type and addition of sediment to culvert	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to new culvert	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight beneficial due to upsized culvert, change in culvert type and addition of sediment to culvert
142	Natural channel	-	-	DS	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	11.24	0.124	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
142	Natural channel	-	-	US	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	22.11	0.455	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
142	Arch	15	0.38	Mainline	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	Pipe	258.938	258.442	51.97	0.010	Upsize	No	Upsized culvert to take 1:200 year flow Bed Material added to culvert	Increased length of fixed channel position Loss of natural banks and erodible natural bed	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert and natural bed in crossing	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to new culvert	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
142	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	2 Drain outfalls	-	-	-	-	-	No	Number of outfalls has been reduced	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
143	Natural channel	-	-	DS	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	41.05	0.030	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral
143	Straightened channel	-	-	US_2	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	10.07	0.049	-	No	Some improvement in planform when compared to the previously straightened baseline channel 1:2 year low flow channel	Loss of adjusted channel	Small improvement likely in flow conditions	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral	Improve low flow channel planform Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral
143	Pipe	35.5	0.03	Mainline	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	Pipe Culvert	262.250	260.422	42.03	0.043	Upsize	No	Upsized culvert to take 1:200 year flow Bed material added to culvert	Increased length of fixed channel position Loss of natural bed and banks	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to culvert	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral
143	-	-	-	-	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	3 Drain outfalls	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
143	Straightened channel	-	-	US_1	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	18.10	0.102	-	No	Some improvement in planform when compared to the previously straightened baseline channel 1:2 year low flow channel	Loss of adjusted channel	Small improvement likely in flow conditions	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral	Improve low flow channel planform Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral
148	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	2 SUDS outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
148	Natural channel	-	-	DS	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	32.29	0.120	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
148	Natural channel	-	-	US	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	14.61	0.160	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
148	Pipe	35.3	0.07	Mainline	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	Arch Culvert	237.330	235.570	36.86	0.048	Upsize	No	Upsized culvert to take 1:200 year flow Bed material added to culvert Reduced length of culvert compared to previous design	Increased length of fixed channel position Loss of natural banks Change in flow patterns and sediment supply	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert and natural bed in crossing	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
152	Bridge	13.2	-	Mainline	Very High	Overall- Good Water, flows and levels-Good Physical condition- Good	Bridge	-	-	-	-	Upsized to pass more flow	No	Removal of piers from channel Part removal of embankment from floodplain	None	Improved flow and sediment transport conditions upstream (Approx 3 Km) and downstream during flood flows (due to opening of embankment) and more locally during all flows (due to removal of piers from channel) Reduced fixing of the channel position through removal of embankment and piers	Good to Moderate (one change down status)	1.5-5	Small	Long (More than 6 years)	Major	Large beneficial impact, by increasing channel-floodplain connectivity and natural flow conditions	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	1.5-5	Small	Long (More than 6 years)	Major	Large beneficial impact, by increasing channel-floodplain connectivity and natural flow conditions
152	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 Suds outfall	-	-	-	-	-	No	Outfall removed or set to infiltrate in floodplain	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	-	-	-	-	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	2 Drain outfalls	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	137.380	0.010	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to change in downstream sediment supply	Improve planform of channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	Straightened channel	-	-	DS	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	66.09	0.006	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to change in downstream sediment supply	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	Straightened channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	9.62	0.011	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to change in downstream sediment supply	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	Straightened channel	-	-	DS AT	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	47.95	0.006	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to change in downstream sediment supply	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	Natural channel	-	-	Track-ATT1	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	TBC	-	-	-	-	-	No	None	Increased length of fixed channel position Loss of natural bed and banks Change in downstream sediment continuity due to increase unnatural bed	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to change in downstream sediment supply and additional culverted channel	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure an erodible bed through culvert Ensure Scour pool downstream of culvert to dissipate energy	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	Natural channel	-	-	Track-ATT2	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	New Box culvert	TBC	TBC	TBC	TBC	New crossing	No	None	Increased length of fixed channel position Loss of natural bed and banks Change in downstream sediment continuity due to increase unnatural bed	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to change in downstream sediment supply and additional length of culverted channel	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure an erodible bed through culvert Ensure Scour pool downstream of culvert to dissipate energy	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	Pipe and catch pit	-	-	Mainline	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Pipe to Box culvert	-	-	-	-	-	No	Pipe to Box culvert Bed Material added to culvert removal of catchpit	Increased length of fixed channel position Reduced downstream flow and sediment transport Loss of natural bed and banks Change in flow patterns and sediment supply	More natural channel dimensions Sediment in the culvert	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to change in downstream sediment supply and increased length of culvert	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
155	Culverted channel	-	-	US AT	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	102.54	0.044	-	No	Bed Material added to culvert	None	Removal of hard engineering restoring a small length of bed and bank and sediment supply	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight beneficial due to daylighting of channel	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight beneficial due to daylighting of channel
156	Straightened channel	-	-	DS	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	18.69	0.045	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral
156	Straightened channel	-	-	DS	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	-	-	-	-	-	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral
156	Culvert	No data	No data	US	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	33.66	0.032	-	No	1:2 year low flow channel Daylighting of existing culvert	None	Removal of hard engineering restoring a small length of bed and bank and sediment supply	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral
156	Pipe	19	0.01	Mainline	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	Arch	227.987	226.762	46.24	0.026	Upsize	No	Upsized culvert to take 1:200 year flow Bed material added to culvert	Increased length of fixed channel position Loss of natural banks Change in flow patterns and sediment supply	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert and natural bed in crossing	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	0.5-1.5	Very small	Long (More than 6 years)	Minor	Neutral
156	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 SUDS outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
156	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	4 Drain outfalls	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
157	Straightened channel	-	-	US	High	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	46.73	0.109	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
157	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	3 Drain outfalls	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral

Baseline							Design																	Residual significance- After additional mitigation applied				
Hydro ID	Baseline type	Baseline length (m)	Baseline slope (m/m)	Works location	Sensitivity of Receptor	Existing WFD Status	Proposed Works Type	Upstream watercourse bed invert level	Downstream watercourse bed invert level	Total length of works	Proposed Gradient (m/m)	Change in crossing discharge	Is Single Activity limit threshold crossed?	Embedded mitigation	Negative impacts of scheme	Positive impacts of scheme	Worst case degree of change in WFD Status	Spatial extent of Impact	Scale of Impact	Duration of Impact	Magnitude of Impact	Significance	Additional mitigation	Spatial extent of Impact	Scale of Impact	Duration of Impact	Magnitude of Impact	Significance
157	Straightened channel	-	-	DS	High	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	37.06	0.033	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
157	Pipe	37	0.06	Mainline	High	Overall- Good Water, flows and levels-Good Physical condition- Good	Box culvert	228.020	225.432	64.26	0.040	Upsize	No	Upsized culvert to take 1:200 year flow Pipe to Box culvert Bed Material added to culvert	Increased length of fixed channel position Loss of natural banks Change in flow patterns and sediment supply	Naturalised flow, due to increased discharge through crossing. Will reduce risk of upstream deposition and blockage. Improved continuity of sediment transfer due to upsized culvert and natural bed in crossing Improved flow width through crossing	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight beneficial due to increased discharge at high flows, and more natural downstream sediment transfer	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new channel Reduce deposition problems and risk of blockage	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight beneficial due to increased discharge at high flows, and more natural downstream sediment transfer
159	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 Drain outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
161	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 Drain outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
161	Pipe	49	No data	Mainline	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Arch	226.350	225.907	50.90	0.009	Upsize	No	Upsized culvert to take 1:200 year flow Bed material added to culvert Reduced length of culvert compared to previous design	Increased length of fixed channel position Loss of natural banks Change in flow patterns and sediment supply	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert and natural bed in crossing	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight beneficial due to naturalised discharge at high flows, and more natural downstream sediment transfer	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight beneficial due to naturalised discharge at high flows, and more natural downstream sediment transfer
159	Pipe	70	0.08	-	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Box culvert	232.699	232.174	51.85	0.010	-	No	Increase in discharge Reduced length of culvert compared to baseline Change from Pipe to Box Bed material added to culvert	None	Reduced length of culvert Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert and natural bed in crossing	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Beneficial	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Beneficial
159	Straightened channel	-	-	DS	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	129.36	0.124	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
159	Straightened channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	15.32	0.150	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
161	Straightened channel	-	-	DS	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	24.35	0.026	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
161	Straightened channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	66.56	0.074	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
159	Straightened channel	-	-	US AT	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	12.13	0.045	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
159	Straightened channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	9.464	0.142	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
159	Straightened channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	9.464	0.010	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
159	Straightened channel	-	-	DS	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	9.464	0.250	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
162	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 SUDS outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
162	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	4 Drain outfalls	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
162	Bridge	14.2	No data	Mainline	High	Overall- Good Water, flows and levels-Good Physical condition- Good	Bridge	-	-	-	-	Upsize	No	Upsized crossing	Loss of natural bank form due to extension of bridge Fixing channel position	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized crossing	Good to Moderate (one change down status)	<0.5 (any positive change in flow and sediment transfer will be limited by road)	Negligible	Long (More than 6 years)	Negligible	Neutral	Set back embankments further from the channel banks Restore channel upstream and downstream to reduce deposition problem under Broad bridge	<0.5 (any positive change in flow and sediment transfer will be limited by road)	Negligible	Long (More than 6 years)	Negligible	Neutral
165	-	-	-	-	-	-	1 Drain outfall	-	-	-	-	-	No	Number of outfalls has been reduced	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
165	Pipe and catch pit	-	-	Mainline	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	Box culvert	233.804	233.041	76.25	0.010	Upsize	No	Upsized culvert to take 1:200 year flow Pipe to Box culvert Bed Material added to culvert	Increased length of fixed channel position Loss of natural banks	Naturalised flow, due to increased discharge through crossing More natural flow width Improved continuity of sediment transfer due to upsized culvert and addition of bed material	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to new culvert	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
165	Natural channel	-	-	DS	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	52.45	0.041	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
165	Natural channel	-	-	US	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	32.18	0.330	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
165	Natural channel	-	-	-	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	42.86	0.059	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
166	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 Drain outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
166	Pipe	58	No data	Mainline	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	Box culvert	242.912	242.523	38.43	0.010	Upsize	No	Upsized culvert to take 1:200 year flow Pipe to Box culvert Bed Material added to culvert Reduced Length of culvert from baseline	Fixed channel position	Naturalised flow, due to increased discharge through crossing More natural flow width Improved continuity of sediment transfer due to upsized culvert and addition of bed material Reduced length of culvert	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to new culvert	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
166	Straightened channel	-	-	DS	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	52.08	0.255	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
166	Straightened channel	-	-	US	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	95.52	0.050	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
168	Pipe	67	No data	Mainline	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Box culvert	240.806	240.217	43.11	0.014	Upsize	No	Upsized culvert to take 1:200 year flow Pipe to Box culvert Bed Material added to culvert Reduced Length of culvert from baseline	Fixed channel position	Naturalised flow, due to increased discharge through crossing More natural flow width Improved continuity of sediment transfer due to upsized culvert and addition of bed material Reduced length of culvert	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to new culvert	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
168	Straightened channel	-	-	DS	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	38.81	0.515	-	No	Some improvement in planform when compared to the previously straightened baseline channel 1:2 year low flow channel	Loss of adjusted channel	Small improvement likely in flow conditions	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
168	Straightened channel	-	-	DS of B9152	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	137.26	0.002	-	No	Some improvement in planform when compared to the previously straightened baseline channel 1:2 year low flow channel	Loss of adjusted channel	Small improvement likely in flow conditions	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
168	Straightened channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	95.52	0.110	-	No	Some improvement in planform when compared to the previously straightened baseline channel 1:2 year low flow channel	Loss of adjusted channel	Small improvement likely in flow conditions	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
170	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 Drain outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
170	Natural channel	-	-	DS	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	3.83	0.135	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
170	Natural channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	40.59	0.082	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form Potential for increased deposition and change in flow patterns and sediment transport	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
170	Unknown	-	-	Mainline	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Pipe	224.638	223.992	64.74	0.010	Not upsized	No	Bed Material added to culvert	Increased length of fixed channel position Loss of natural banks	Improved continuity of sediment transfer due to natural bed in crossing	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
138_1	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	Drain outfall	-	-	-	-	-	No	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
138_1	Pipe	-	-	Mainline	-	Overall- Good Water, flows and levels-Good Physical condition- Good	-	-	-	-	-	-	No	Additional crossing removed	-	-	-	-	-	-	-	-	-	-	-	-	-	-
138_2	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	-	-	-	-	-	-	No	Drainage outfalls have been removed	None	None	-	-	-	-	-	-	-	-	-	-	-	-
138_2	Pipe and catch pit	-	-	Mainline	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Pipe Culvert	261.490	261.14	40.93	0.009	Upsize	No	Upsized culvert to take 1:200 year flow Bed material added to culvert	Increased length of fixed channel position Loss of natural bed and banks Change in downstream sediment continuity due to increase unnatural bed	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Beneficial due to upsized culvert allowing natural downstream flows and a natural bed	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to culvert	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Beneficial due to upsized culvert allowing natural downstream flows and a natural bed
138_2	Small natural channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	-	-	-	102.73	0.071	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Negative as more uniform channel replaces natural channel	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Negligible	Negligible	Neutral
138_2	Small natural channel	-	-	US AT	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	38.15	0.143	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight Negative as more uniform channel replaces natural channel	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Negligible	Negligible	Neutral
138_2	Small natural channel	-	-	Track	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Pipe Culvert	255.674	TBC	-	TBC	Upsize	No	None	Increased length of fixed channel position Loss of natural bed and banks Change in downstream sediment continuity due to increase unnatural bed	None	Good to Moderate (one change down status)	0.5-1.5	Very small	Long (More than 6 years)	Minor	Slight adverse due to new culvert fixing the channel position and creating artificial bed and banks	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure an erodible bed through culvert Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
144_1	Straightened channel	-	-	DS	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	14.75	0.630	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
144_1	Straightened channel	-	-	US	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	12.29	0.402	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
144_1	Arch	27	0.12	Mainline	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	Pipe	261.555	260.120	35.06	0.041	Upsized	No	Upsized culvert to take 1:200 year flow	Increased length of fixed channel position Loss of natural banks	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
144_1	Culvert	-	-	Track	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	Pipe	-	-	-	-	New crossing	No	None	Increased length of fixed channel position Loss of natural bed and banks Change in downstream sediment continuity due to increase unnatural bed	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Ensure a low flow channel (designed for a 1:2 year flow) through the crossing Ensure an erodible bed through culvert Ensure Scour pool downstream of culvert to dissipate energy Add suitable grade of bed material to new culvert	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral

Baseline							Design																	Residual significance- After additional mitigation applied				
Hydro ID	Baseline type	Baseline length (m)	Baseline slope (m/m)	Works location	Sensitivity of Receptor	Existing WFD Status	Proposed Works Type	Upstream watercourse bed invert level	Downstream watercourse bed invert level	Total length of works	Proposed Gradient (m/m)	Change in crossing discharge	Is Single Activity limit threshold crossed?	Embedded mitigation	Negative impacts of scheme	Positive impacts of scheme	Worst case degree of change in WFD Status	Spatial extent of Impact	Scale of Impact	Duration of Impact	Magnitude of Impact	Significance	Additional mitigation	Spatial extent of Impact	Scale of Impact	Duration of Impact	Magnitude of Impact	Significance
144_1	Straightened channel	-	-	-	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	1 Drain outfall	-	-	-	-	-	No	Number of outfalls has been reduced	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
144_1	Straightened channel	-	-	DS AT	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	23.69	0.008	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Neutral
145_1	Pipe	50	0.05	Mainline	Medium- due to length of modified channel downstream of the crossings	Overall- Good Water, flows and levels-Good Physical condition- Good	Box culvert	246.488	245.670	76.77	0.011	Upsize	No	Upsized culvert to take 1:200 year flow Pipe to Box culvert so improved flows and bed	Increased length of fixed channel position Loss of natural bed and banks Change in flow patterns and sediment supply	Naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert	Good to Moderate (one change down status)	1.5-5	Small	Long (More than 6 years)	Moderate	Moderate beneficial due to more natural flows downstream	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	1.5-5	Small	Long (More than 6 years)	Moderate	Moderate beneficial due to more natural flows downstream
145_1	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 SUDS outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
145_1	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	3 Drain outfalls	-	-	-	-	-	No	Number of outfalls has been reduced	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
145_1	Natural channel	-	-	DS	Medium- due to length of modified channel downstream of the crossings	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	14.91	0.017	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and small change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight adverse	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
145_1	Natural channel	-	-	US	Medium- due to length of modified channel downstream of the crossings	Overall- Good Water, flows and levels-Good Physical condition- Good	-	-	-	-	-	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and small change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight adverse	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
146_1	Pipe and catch pit	-	-	Mainline	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	Box culvert	236.365	233.368	72.62	0.041	Upsize- but not fully to take a 1:200 year flow	No	Upsized culvert to take greater than existing flow Pipe to Box culvert Bed Material added to culvert	Increased length of fixed channel position Loss of natural bed and banks Change in flow patterns and sediment supply	More naturalised flow, due to increased discharge through crossing Improved continuity of sediment transfer due to upsized culvert, but still problems associated with the catch pit More natural flow width and depth	Good to Moderate (one change down status)	1.5-5	Small	Long (More than 6 years)	Moderate	Moderate beneficial due to more natural flows downstream	Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy	1.5-5	Small	Long (More than 6 years)	Moderate	Moderate beneficial due to more natural flows downstream
146_1	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	1 SUDS outfall	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
146_1	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	2 Drain outfalls	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
146_1	Natural channel	-	-	DS	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	40.26	0.038	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight adverse	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
146_1	Natural channel	-	-	US	Medium	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	41.51	0.116	-	No	1:2 year low flow channel	Loss of natural bed and bank - more uniform form and change in flow patterns and sediment supply	None	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight adverse	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
147_1	Large natural channel	-	-	US	Low	Overall- Good Water, flows and levels-Good Physical condition- Good	High Impact realignment	-	-	191.47	0.010	-	No	1:2 year low flow channel	Change in flow in 147_1 under the bridge	None	Good to Moderate (one change down status)	<0.5	Very Small (length of channel realignment)	Long (More than 6 years)	Minor	Neutral	Improve planform of low flow channel Add varied bed and bank morphology suitable for the channel gradient and type Ensure suitable size and grade of substrate for channel conditions	<0.5	Very Small (length of channel realignment)	Long (More than 6 years)	Minor	Neutral
147_1	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	2 SUDS outfall	-	-	-	-	-	No		Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
147_1	2x Arch Culvert	47.5	-	Mainline	High	Overall- Good Water, flows and levels-Good Physical condition- Good	2x Box culverts	-	-	-	-	Upsized	No	Upsized crossing	Loss of natural bed and banks through extension of culvert Loss of existing bed material from culvert more uniform form and change in flow patterns and sediment supply Increased length of fixed channel position	Upsizing will increase downstream discharge to natural levels	Good to Moderate (one change down status)	0.5-1.5	Very Small	Long (More than 6 years)	Minor	Slight Adverse due to loss of natural bed and banks and downstream changes in sediment movement	Bridge with embankment set well back from the channel Or Arch culvert with erodible bed Ensure a low flow channel (designed for a 1:2 year flow) Add suitable grade of bed material to new culvert Ensure Scour pool downstream of culvert to dissipate energy Improve or remove downstream crossing	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral
147_1	-	-	-	-	-	Overall- Good Water, flows and levels-Good Physical condition- Good	4 Drain outfalls	-	-	-	-	-	No	None	Very small change in flow Very small loss of natural bed and bank due to headwall	None	Good to Moderate (one change down status)	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral	Direct each outfall downstream to minimise impacts to flow patterns Avoid projecting the outfall into the 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 Direct outfall away from the banks Minimising the size/extent of the outfall headwall	<0.5	Negligible	Long (More than 6 years)	Negligible	Neutral

Annex 11.4.6

Geomorphological Channel Design

Background

11.4.6.1 This note is intended to provide a summary of geomorphological information on the characteristics of different River Types found in the UK. This information is intended to provide guidance to the engineering team to aid in the design of sustainable channel realignments, with suitable morphology for the river setting.

Fluvial concepts theory

11.4.6.2 The established conceptual model of river system operation suggests that their key driving variables are the inputs of water and sediment. These independents interact with boundary characteristics (slope/ topography, bed and bank materials, and riparian vegetation) to generate the channel form (e.g. Knighton, 1998; Sear & Newson, 2010). As a consequence of these interactions a variety of channel forms (geometric characters) exist. These are described across a number of planes of adjustment, within which there are a number of representative parameters. Knighton (1998) classifies these broadly as:

- Cross-sectional form (size and shape parameters, e.g. width, depth, area etc.);
- Bed configuration (e.g. sand or gravel beds);
- Channel pattern (form of channel as viewed from above, e.g. straight, meandering or braided; descriptive parameters include sinuosity, meander arc length etc.);
- Channel bed slope (i.e. gradient, which is related to channel pattern).

11.4.6.3 The adjustment of these channel geometry parameters and that of the shorter-term variations of flow geometry, are interdependent; therefore a change in one parameter may manifest a response in others such that a river channel can perform its function, i.e. the transference of energy and matter, ideally in dynamic equilibrium (if conditions permit). Variations result in complex patterns of form, flow, and materials across both space and time.

11.4.6.4 This conceptual basis is important, as it establishes that channel design has to take into consideration the complexities of the river environment, and that by understanding these principles, more effective channels may be designed to work with nature.

Planform type

11.4.6.5 Mean valley slope and design bankfull discharge can be used to determine the most likely/ desirable channel planform type (Figure 11.4.6.1 and Table 11.4.6.1).

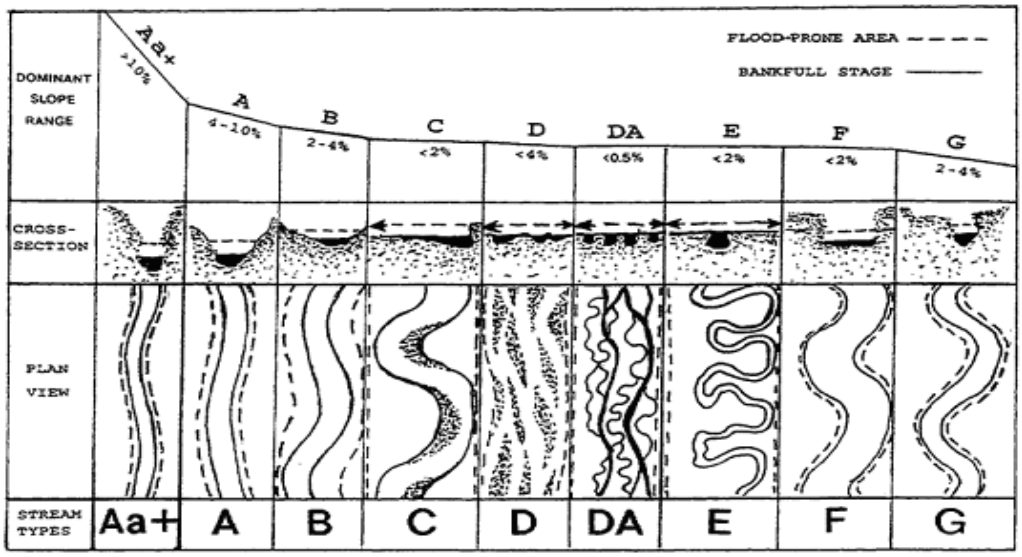

Figure 11.4.6.1 Longitudinal, cross sectional and plan views of major stream types (Rosgen, 1994)

Table 11.4.6.1 Channel characteristics based on Rosgen, 1994.

Characteristics	Type Aa+	Type A	Type B	Type C
General	Very steep, deeply entrenched, debris transport streams	Steep, entrenched, step- pool streams, high energy	Moderately entrenched, moderate gradient, riffle dominated channel with infrequent pools, stable planform and long profile	Low gradient, meandering, point bar, riffle/pool, alluvial channel with broad floodplain
Entrenchment ratio (width of flood prone area/bankfull channel width)	<1.4	<1.4	1.4-2.2	>2.2
Width/depth ratio	<12	<12	>12	>12
Sinuosity	1.0-1.1	1.0-1.2	>1.2	>1.4
Slope (m/m)	>0.1	0.04-0.1	0.02-0.039	<0.02
Slope (%)	>10	4-10	2-3.9	<2
Meander width ratio (beltwidth /bankfull width)	N/A	1-3	2-8	4-20

Bed morphology

11.4.6.6 Channel bed slope is a major driver of channel bed form (Rosgen, 1994); hence bed slope, planform and bed morphology are highly interrelated in natural channels. In order to best account for this association, mean channel bed slope and proposed planform information can be used in association with the literature (Figure 11.4.6.2 and Table 11.4.6.2) to suggest appropriate channel bed morphology.

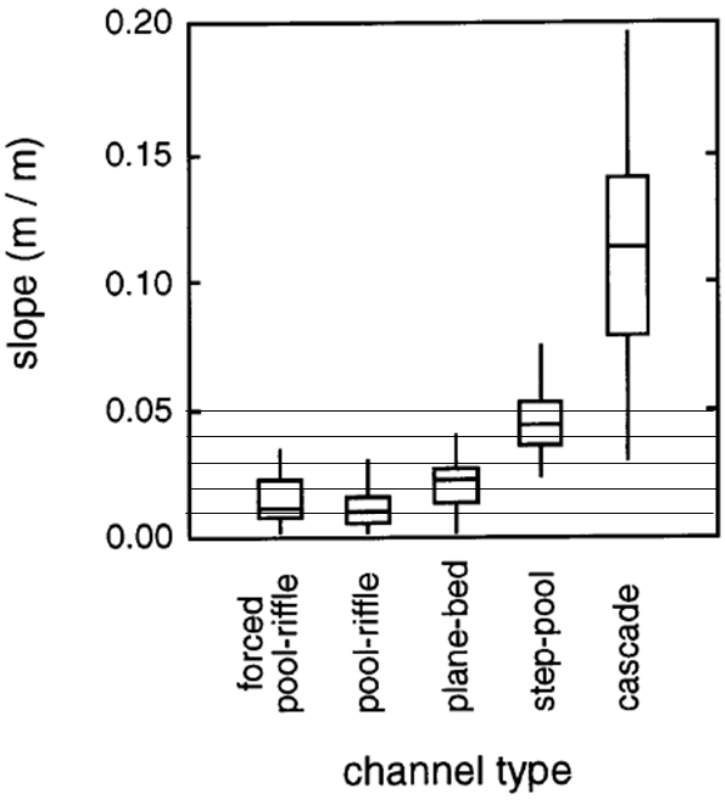

Figure 11.4.6.2 Slope distribution for different channel reaches (Montgomery and Buffington, 1997)

Table 11.4.6.2 River Types (based on SEPA, 2011)

Geology	Slope		Sinuosity	Type
Bedrock	Any		Any	Bedrock, Cascade
Not Bedrock	>0.1		Any	Cascade
	>0.03	≤0.1	Any	Step-pool, Plane Bed
	>0.005	≤0.03	≤1.1	Step-pool, Plane Bed
			>1.1	Plane-riffle, Braided, Wandering
	>0.001	≤0.005	Any	Plane-riffle, Braided, Wandering
	>0.0005	≤0.001	≤1.4	Plane-riffle, Braided, Wandering
			>1.4	Actively Meandering
	>0.0001	≤0.0005	Any	Actively Meandering
	≤0.0001		Any	Low Gradient Passive Meandering

Characteristics of Cascade morphology

11.4.6.7 The channel should typically have the characteristics outlined below and in Figures 11.4.6.3, 11.4.6.4 and 11.4.6.5 (Montgomery and Buffington, 1997):

- Tumbling flow around large clasts
- Steep slopes (over 0.1 m/m)
- Confined channel by valley sides
- Low sinuosity
- Lack of in channel storage
- Bed dominated by large particle size
- Supply limited channels

Figure 11.4.6.3. Example cascade (Montgomery and Buffington, 1997)

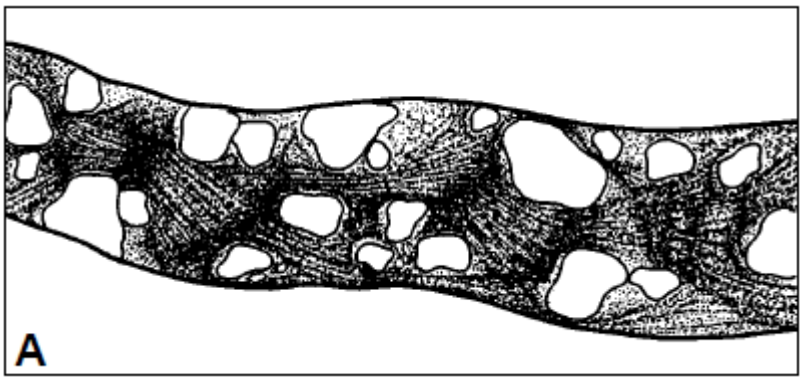

Figure 11.4.6.4. Example cascade planform (Montgomery and Buffington, 1997)

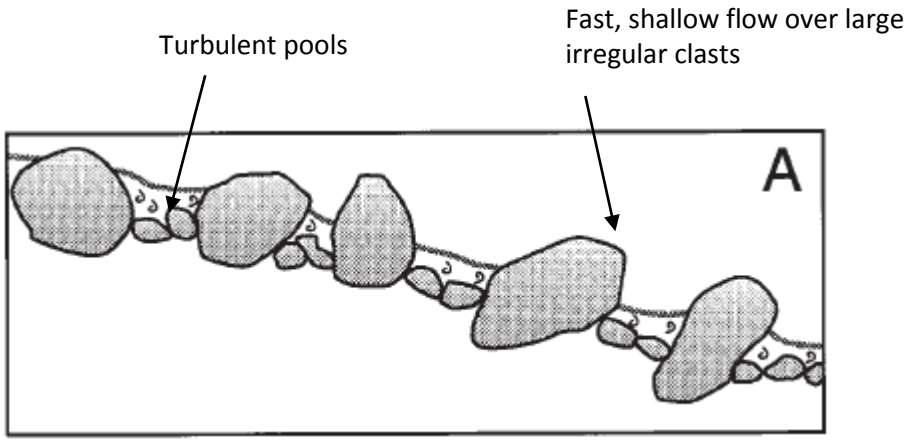

Figure 11.4.6.5. Example cascade long profile (Montgomery and Buffington, 1997)

Characteristics of Step-Pool bed morphology

11.4.6.8 These channel types form on steep slopes, with energy dissipation through tumbling flow over and around large clasts (cobbles and boulders) (Figure 11.4.6.6). Bed material is a mix of stable coarse casts, and finer material that gets trapped around the coarse material, and mobilised during flood flows (Montgomery and Buffington, 1997). These systems have a high transport capacity relative to sediment supply and will rapidly supply sediment downstream in the event that is available (i.e. supply limited system).

11.4.6.9 The channel should typically have the characteristics outlined below and in Figures 11.4.6.7, 11.4.6.8 and 11.4.6.9 (Knighton, 1998, and Montgomery and Buffington, 1997):

- Pools and alternating bands of channel-spanning flow obstructions typically occur at a spacing of every 1–4 channel widths;
- Typical gradients of 0.03–0.1 m/m
- Low sinuosity
- Fast water at steps/falls and chutes, slow water at pools.
- Step spacing increasing with decreasing channel bed slope, with $L=0.31s^{-1.19}$ where s=mean slope m/m and L=Step wavelength parallel to mean slope
- Step height is controlled by the largest particle, and pool scour (with approximately 1/3 of the mean step height due to pool scour)
- Pool width approximately 20% greater than steps (Thomas *et al*, 2000)
- Boulders, interlocked with each other and the bed, and arranged in a broad v-shape, with the apex of the weir pointing upstream to prevent bank erosion

Figure 11.4.6.6. Example of a step pool channel (Montgomery and Buffington, 1997)

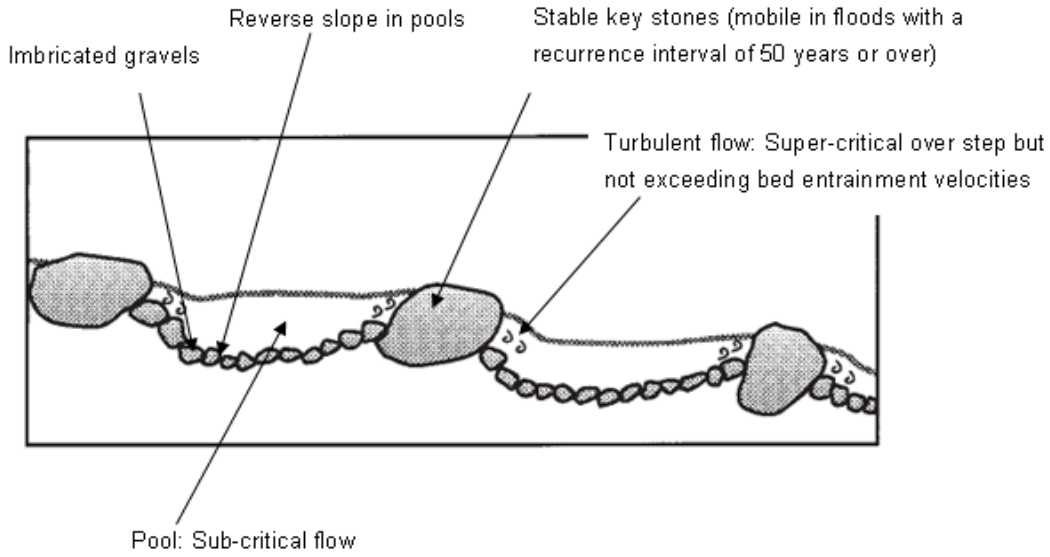

Figure 11.4.6.7 Example long profile of step –pool channel (based on Montgomery and Buffington, 1997)

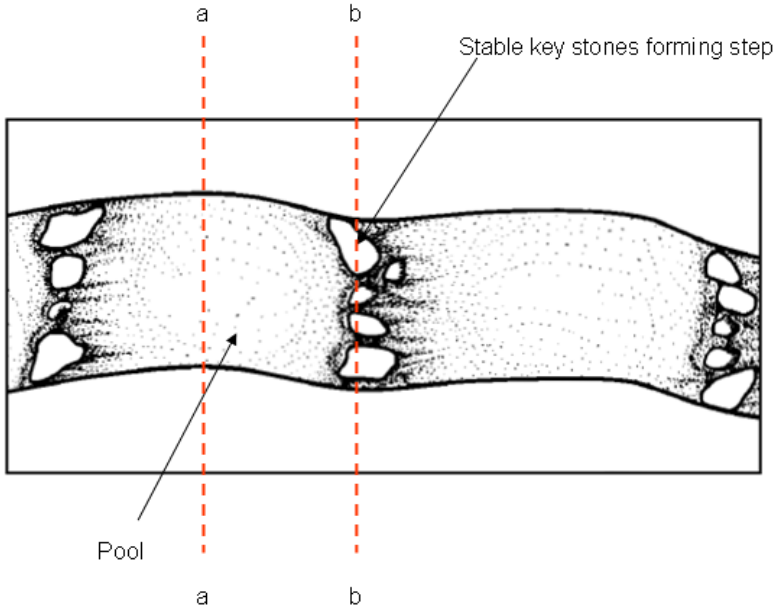

Figure 11.4.6.8 Example planform for a step –pool channel (based on Montgomery and Buffington, 1997)

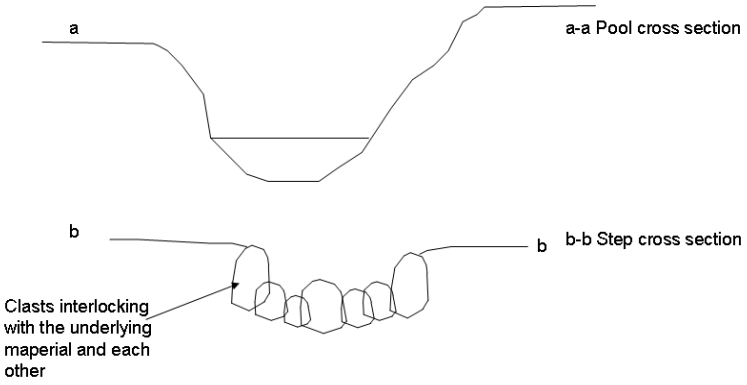

Figure 11.4.6.9 Example cross sections for a step- pool channel

11.4.6.10 Longitudinal spacing of step and pool sections is important for stability and function of the channel. Step crest wavelength (L) (Figure 11.4.6.10) can be calculated by $L=0.31s^{-1.19}$ where (s=mean slope m/m). The shape and size of the transition between each step and pool also needs to be carefully considered.

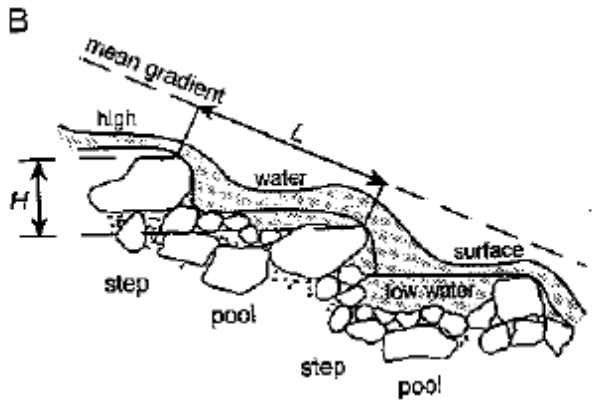

Figure 11.4.6.10. Example positioning of steps and pools (Knighton, 1998)

Characteristics of Plane bed

11.4.6.11 The channel should typically have the characteristics outlined below and in Figures 11.4.6.11, 11.4.6.12 and 11.4.6.13 (Montgomery and Buffington, 1997):

- Large values of relative roughness (90th percentile grain size to bankfull flow depth)
- Lack of discreet bars and bed forms
- Straight channels
- Moderate to high slopes
- Dominated by cobble and gravel bed

Figure 11.4.6.11. Example of a plane bed channel (Montgomery and Buffington, 1997)

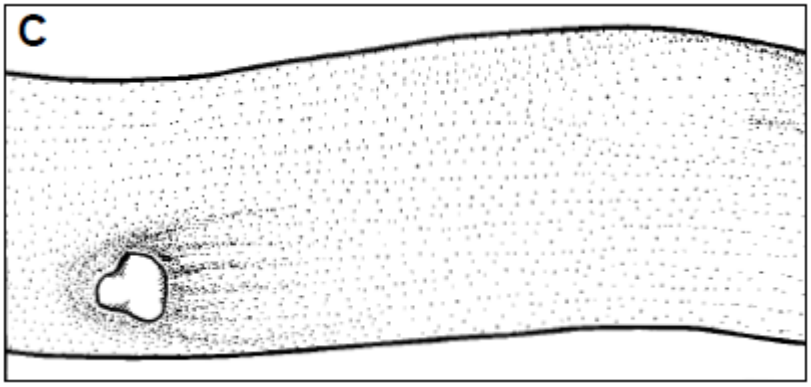

Figure 11.4.6.12. Example of a plane bed channel planfrom (Montgomery and Buffington, 1997)

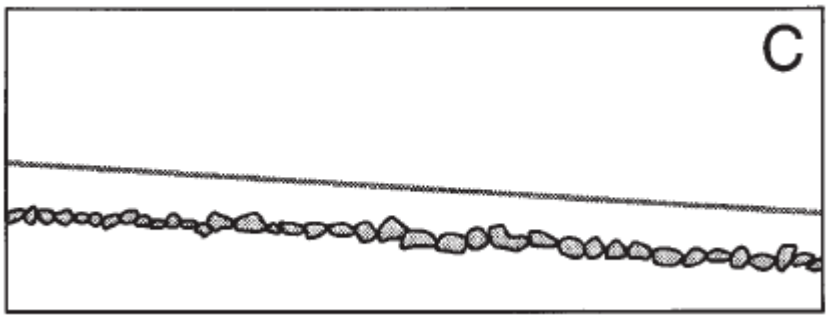

Figure 11.4.6.13. Example of a plane bed channel long profile (Montgomery and Buffington, 1997)

Characteristics of Plane-Riffle bed morphology

11.4.6.12 Plane - riffle bed channels have characteristics that fall between pool-riffle and plane bed types (SEPA, 2011). Typically, this will include deposition on the inside of bends forming small point bars and poorly defined shallow pools on the outside of bends. These will then be separated by both riffles and plane bed extents, at inflexion locations between the bends (Figures 11.4.6.14, 11.4.6.15 and 11.4.6.16). More detailed characteristics of pools and riffles are outlined in Table 3; however it should be noted that this information originates form research on pool-riffle channels, not plane- riffle channels, and therefore should only be used with this in mind. Other characteristics will fit with the proposed Type A planform, of width/depth ratios less than 12 and sinuosity between 1 and 1.2 (Table 11.4.6.1).

11.4.6.13 Plane – riffle bed morphology will require a collection of cross sections. Bends will need greater cross sectional asymmetry (Figure 11.4.6.16) to create small pools on the outside of bends and bars on the inside; with wider, shallower straighter sections, to form riffles and plane bed units.

11.4.6.14 Shields (1996) recommends:

- Outer banks of bends should have slopes of 1V [V= vertical]: 2H [H= horizontal] or steeper to cause convergence of high flows;
- Inner banks, where point bars may develop should have bank slopes of 1V: 3H or less;
- Inflexion points are shallower and more symmetrical in shape.

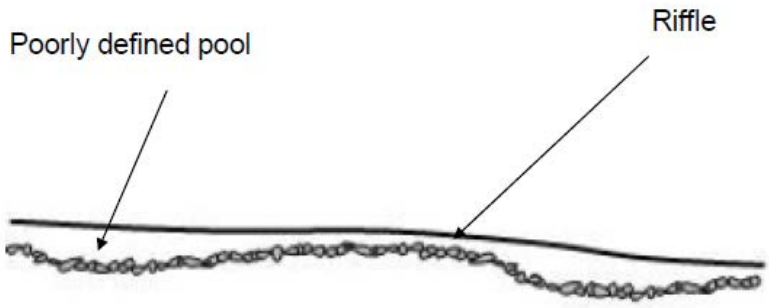

Figure 11.4.6.14 Example long profile of a plane – riffle channel (SEPA, 2011)

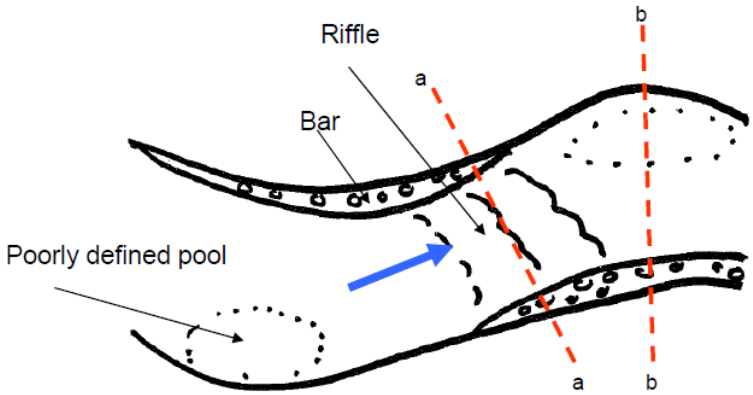

Figure 11.4.6.15 Example planform of a plane – riffle channel

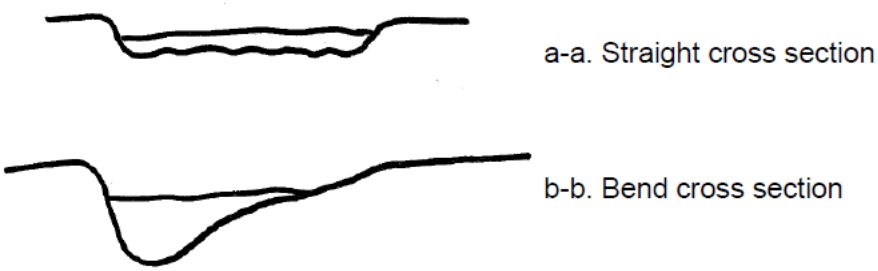

Figure 11.4.6.16 Example cross sections for plane- riffle channels

Table 11.4.6.3 Recommendations for the reinstatement of pools and riffles, focussing on key geomorphic attributes (Thorne et al., 2010; Brookes & Sear, 1996)

Feature	Characteristic	Recommendation
Pool	Size	• Occupy over 50% of the river length • 25% narrower than associated riffles • At least 0.3 m below the mean bed elevation • Maximum scour depths typically don't exceed 4 times the depth in the approach channel upstream
	Shape	• Asymmetrical cross sections • Shallow progressively downstream to the next riffle, with the deepest point within the upstream half of the pool's length
	Location	• Located at bends in the meander planform (around and downstream of a bend apex)
	Sedimentology	• Bed composed of loose and un-compacted mixed gravels (and coarser), overlain by fines during low flows
Riffle	Size	• Collectively occupy 30-40% of river length • 0.3 to 0.5m above mean bed level • 25% wider than associated pools
	Shape	• Near symmetrical cross sections • Variable planform geometries
	Location	• Locally steep, shallow section of the channel profile • Slopes typically 0.005 to 0.200 m/m • At cross over points in the meander planform
	Longitudinal riffle spacing	• 3 to 10 times the bankfull channel width between riffle crests (1 wavelength), but more typically 5 to 7 widths apart. Although some variability in spacing would be natural • Shorter spacing where bed slopes are higher • In straight reaches they are found in alternate channel side locations
	Sedimentology	• Coarse armour, overlying mixed gravel substrate. This may be created by flow winnowing away some fines • Avoid uniform size gradations and over-large substrate • Size gravels according to that in similar undisturbed reaches, or within the floodplain or palaeochannels • High proportion of angular gravels to permit particle interlocking. But avoid excessive imbrication as this limits their ecological benefits • Ideally locally derived substrate
	Riffle stability	• In the absence of coarse sediment supply from upstream material should be static under all flows or replaced periodically

11.4.6.15 The location and sequencing of these cross sections is important to achieving the required planform and long-profile morphology. In planform there is a need for the asymmetrical bend cross sections to alternate between the right and left bank side of the channel, with the deeper section always on the outer bank side (OB), and the shallower bank on the inner bank (IB) (Figure 11.4.6.17). These bend sections then join the straight sections via a transitional section, that flairs smoothly between the two which have differing side slope angles (Figure 11.4.6.17). The spacing of the morphological units (cross sections) is also important to create a suitable long profile

(**Figure 11.4.6.14**). The straighter sections (riffles/ planes) should be located at inflexion locations between bends (pools).

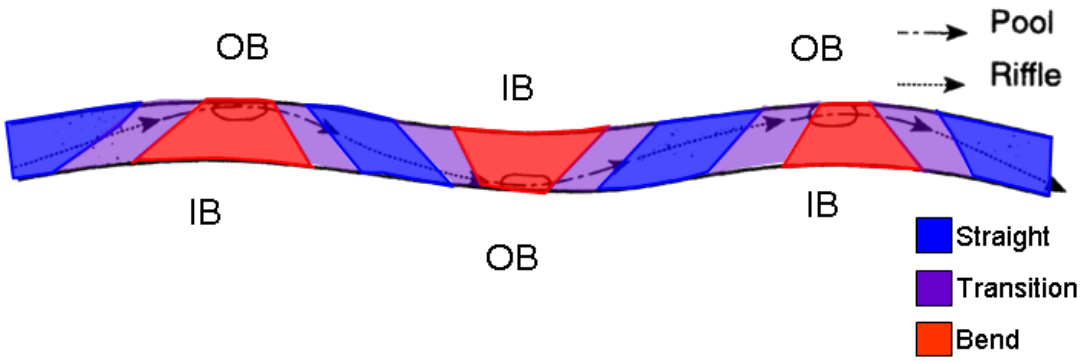

Figure 11.4.6.17 Example locations of plane - riffle cross sections

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