Clachan Flood Study

Phase 3 Options Screening Report

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Quality information

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1. Introduction

1.1 Purpose of the report

Argyll and Bute Council (ABC) are looking to address flood risk in Clachan. The Flood Risk Management Act (Scotland 2009) has given ABC the power and potential funding mechanism, primarily through Scottish Government, to address this risk but also to enhance the local area with proposed measures. AECOM Ltd was commissioned to undertake a Flood Study (FS) for Clachan. The objective of the study is to propose new flood mitigation measures to reduce surface water and fluvial flooding. This will enable ABC to make an informed decision moving forward on the most economically, environmentally and socially viable options to alleviate flooding in Clachan.

At this point in the study, significant work has been carried out to understand the flood mechanisms affecting Clachan and to identify constraints and opportunities with regard to potential flood mitigation options. The purpose of this report is to summarise the work that has been undertaken to inform the optioneering process. This includes developing a long list of potential solutions and screening this to a short list of feasible options which will be developed in more detail. The scope of the report includes:

- Summarising the process to date
- Summary of baseline modelling results
- Mitigation options – Long list
- Option screening
- Preliminary Environmental Appraisal
- Public consultation event summary
- Mitigation options - Short list
- Next steps

1.2 The process

The project is being carried out in a phased approach in line with Scottish Environment Protection Agency (SEPA) and Scottish Government Guidance[1][2]. **Figure 1.1** provides a high level overview of the study development process.

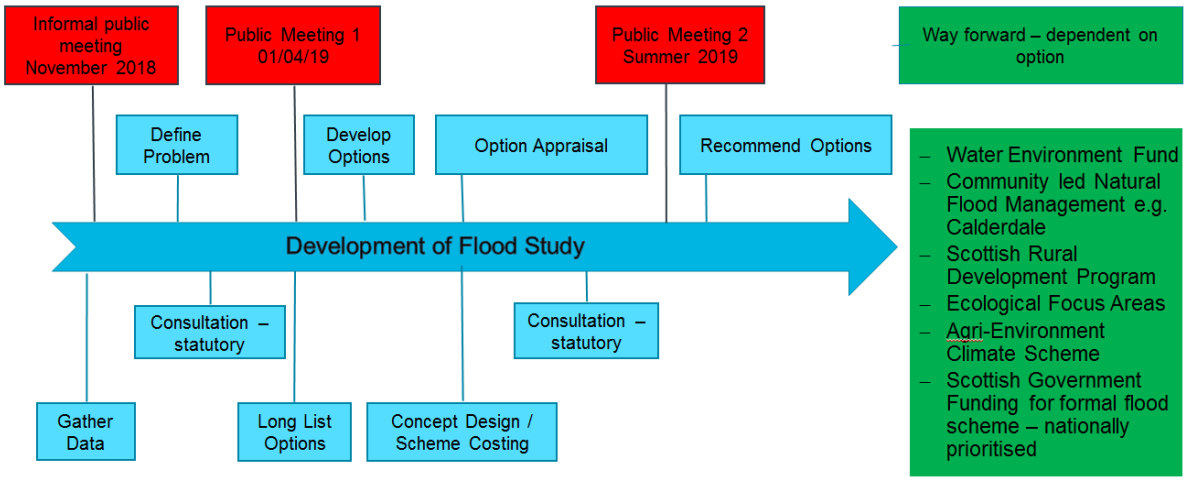

Figure 1-1 The study process

[1] Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities, Scottish Government, May 2016.
[2] Local Authority flood study checklist, Version 2, SEPA, June 2017.

Significant work has been carried out to understand the flood sources and mechanisms affecting Clachan. During Phase 1[3] we collated the existing information and carried out a gap analysis to determine the quality of the data and what additional information was needed in order to undertake the assessment of flood risk.

The flood mechanisms and extents currently experienced in Clachan were confirmed in Phase 2[4]. This was achieved by developing a 1D-2D model to simulate flooding from watercourses and a 2D catchment model to assess the influence of forestry management on watercourse flows. The findings of this stage are summarised in **Section 2**. This was further informed through public consultation with residents in Clachan, where we discussed their experience of historic flooding and key hotspots, and used this information to sense check the modelling outputs.

The study is currently at Phase 3; now we know the drivers of flooding and the scale of the problem, we are in a position to develop options to mitigate flood risk. This process has been informed by additional assessments including; ecological and environmental desk studies, a study of Natural Flood Management potential and high level hydraulic modelling to identify constraints to and opportunities for flood alleviation options.

Consultation has been a key part of the Phase 3 process. Statutory stakeholders such as SEPA, Forestry Commission (FC) and Scottish Water (SW) have been involved through technical workshops and residents of Clachan have been involved in one public consultation event and have been represented at the stakeholder workshops.

This information has then been layered up to drive decision making in the optioneering process. The purpose of this report is to summarise the work that has been done to inform the optioneering process and the next steps to develop the options.

The Scottish Government Guidance on Options Appraisal for Flood Risk Management sets out a clear approach to identify and prioritise mitigation measures. The following steps are highlighted:

- Define the purpose of the appraisal and set objectives.
- Identify “long list” of potential measures
- Screen to create a “short list” of measures
- High level appraisal of short listed measures

AECOM have adopted this approach for Phase 3 of this study. A long list of potential measures to mitigate against the causes of flooding were identified. This report sets out the decision making behind the long list of options and also details how the short list has been created based on known feasibility issues. This approach ensures resources are expended on assessing the most suitable options which are most likely to give a return in flood risk benefit.

At the end of Phase 3 we will have a short list of potential options which will be developed through detailed modelling, outline design and cost benefit appraisal in Phase 4. The way forward will then be dependent on the option recommendations. If a formal scheme is determined to be the best option, the findings of this study would be passed to SEPA for inclusion in the next round of SEPA FRM Strategies.

The Strategies set out a prioritised list of actions for flood risk on national scale. If the scheme is prioritised for funding, it will then be submitted for approval to Scottish Government and the scheme details presented to the public for comment. Following this, detailed design will commence with funding statements compiled and approved prior to tender and construction. As funding of a formal scheme depends on the level of priority assigned relative to other schemes identified throughout Scotland, alternative funding for some options has been identified where appropriate.

[3] Clachan Gap Analysis report, AECOM, July 2018
[4] Clachan Flood Study Phase 2 Report Baseline conditions, AECOM, December 2018

2. Baseline Modelling Results - Summary

There are two mechanisms of flooding affecting Clachan; pluvial and fluvial, and these are a result of the topography of the area and the nature of the river catchments. Pluvial flooding is caused by direct surface runoff flowing overland and ponding in low areas, causing flooding before reaching a watercourse. The steep topography of the village and its surrounding area is such that during high rainfall events, there is little infiltration and high runoff is generated. In the past, this has caused problems of flooding and damage for the A83 road, the old road on the north side of the village and some properties.

Fluvial flooding is caused when a river overtops its banks. The village lies on the banks of the Clachan and Allt Mor burns, which can both be prone to bank overtopping. Both catchments have extensive commercial forestry cover, with a programme of cyclical felling and replanting in operation.

In order to investigate the nature of the fluvial flood risk to Clachan, a 1D-2D model of the Clachan Burn and Allt Mor has been developed. This baseline model was run for a series of storm events to determine existing flood conditions. The inflows to this model are fed by a second fully 2D model of the whole catchment which wasconstructed in Tuflow to assess the impact of forestry management on fluvial flows downstream and to allow for testing of Natural Flood Management (NFM) options as the study progressed. The catchments of both the Allt Mor and Clachan Burns are shown in **Figure A1, Appendix A**. This model was run for a series of storm events to determine flows reaching downstream channels. Although sufficient data was not available to fully calibrate the catchment model, historic flood records and rainfall have been used for high level verification of the model. This work is fully detailed in the Phase 2 Report[5].

The 1:200 year + climate change flood outline for Clachan is shown in **Error! Reference source not found.** below.

Baseline assessment indicated that fluvial flooding in Clachan is driven by a lack of capacity in the channels as well as a backwater/sedimentation effect from the weir downstream of the village.

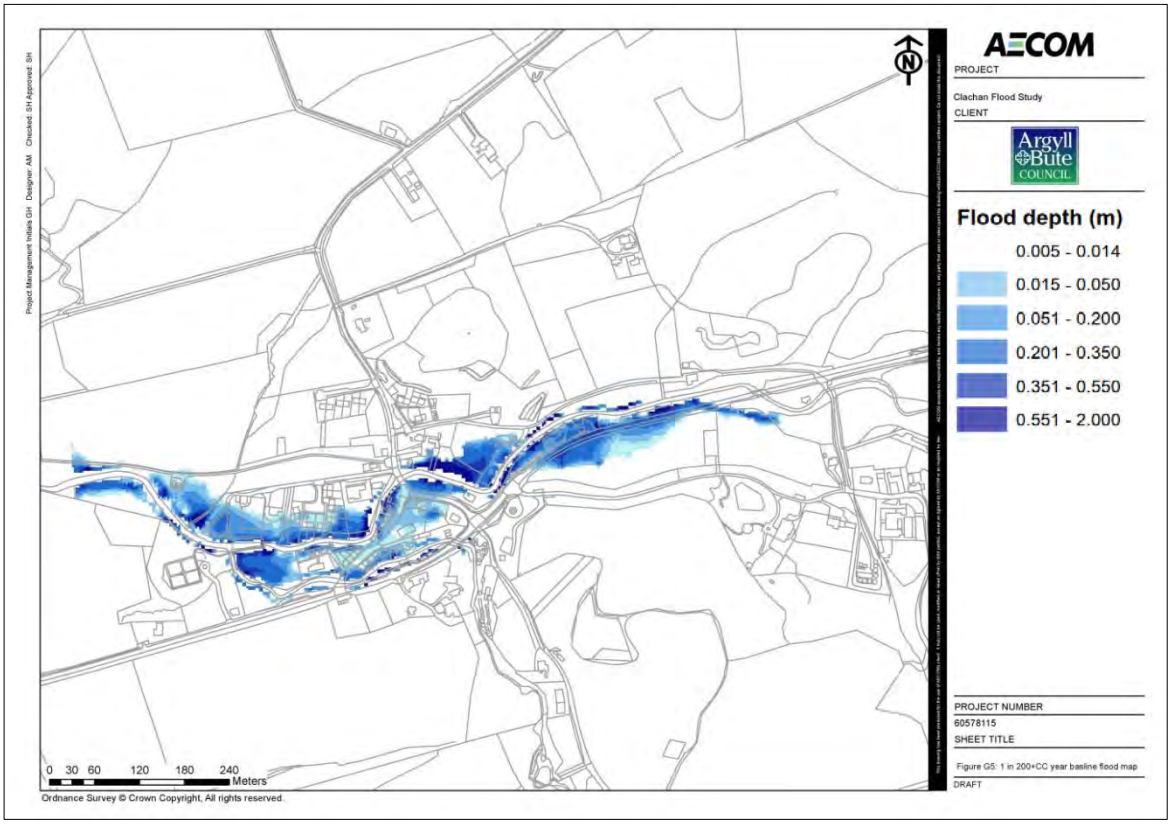

Figure 2-1 Baseline 200 year plus climate change flood extents (1D-2D model output for Clachan and Allt Mor burns)

[5] Clachan Flood Study, Baseline Modelling Report, AECOM, December 2018

2.1 Clachan Burn catchment

Flooding from the Clachan Burn is shown to affect farmland upstream of Clachan, roads and a number of properties and gardens within the village. Overtopping of the burn occurs first at the filling station, on the A83 road and into the fields upstream during a 1:2 year event. This is likely related to a lack of capacity in the channel at this location, with a low left bank and steep right bank, allowing water to spill out of the channel. The topography in this location is such that floodwater cannot escape and builds up on the filling station and road. The field to the east of the confluence of the Clachan Burn and Allt Mor is also affected by flooding during this magnitude of event.

From the 1:5 year flood event, water spills from the burn to gardens on the left bank, downstream of the road bridge within the village and on the right bank into gardens at Mansecroft and the caravan park.

2.2 Allt Mor catchment

The Allt Mor is a very steep watercourse, but is impacted by the regulation of flows from Loch Ciaran. Flooding from this burn is shown to occur from the 1:2 year event on mainly the left bank downstream of the A83 and around its confluence with the Clachan Burn. This is likely due to the sudden reduction in gradient of the burn downstream of the road. At the 1:5 year event, flooding around the confluence covers a wider area and there is some increase in inundation on the left bank downstream of the A83. A relatively large number of properties are predicted to be affected during the 1:200 year + climate change event.

2.3 Pluvial Flooding

Pluvial flooding has been experienced on at least two occasions in Clachan (August 2012 and February 2016) and is related to the steep fields surrounding the village. Key locations where this mechanism has been seen are:

- on the north side of the village where flow has exceeded road culverts and is routed down the old road;
- on the south side of the village where flow is generated from the steep fields to the west of the Allt Mor and flows onto the A83 and down the local road into Clachan;
- the slopes above Balinakill House are also very steep and rapid runoff is generated here, leading to flow through the grounds of the properties in this area and across fields towards the A83;
- the hillslopes along the A83 to the east of the village (on the north side) are very steep and runoff can lead to overtopping of roadside ditches and subsequent flooding of the road.

Surface water management planning is outwith the scope of this study. However, site visits and historic information have helped identified pluvial flooding as a separate source and options will be recommended to better manage the catchment from this aspect. At present, the level of detail required to model and test the potential pluvial options with a degree of confidence is not available due to the low quality of ground model data and lack of survey for key drainage routes. As such high level recommendations will be made for pluvial options rather than a full assessment.

2.4 Summary

Given the nature of flooding from multiple sources, a single option scheme is unlikely to have a significant benefit to flood risk in Clachan. It is likely that separate options on each watercourse will be required to deal with fluvial flood risk and different interventions required to deal with pluvial flooding.

2.5 Subcatchment Analysis

A watershed analysis using the digital elevation model (NEXTMap DTM) has been carried out on the catchment areas of both watercourses in order to identify the major subcatchments (**Appendix A, Figure A2**). Peak flow and hydrograph timings from the 2D modelling for each subcatchment have been reviewed. This analysis has helped to identify which subcatchments contribute most significantly to flooding in Clachan and therefore which tributaries have hydrograph synchronisation

with the main watercourses and should be targeted to provide maximum impact on runoff reduction. Mapping this information alongside current land use management information has helped to focus on developing the most effective options.

Results from the catchment model for the 200 year, 10 year, and 2 year return periods were assessed to determine the level of contribution each subcatchment made to peak flow in the watercourses at the village. Analysis of the 1 in 10 year event is shown in **Table 2-1** for Clachan Burn and **Table 2-2** for Allt Mor. Note that the peak flows in the subcatchments do not necessarily occur at the same time as the peak flow in the village, and therefore the total flow in the village is not a sum of the peak flows from each subcatchment.

Table 2-1 Clachan Burn subcatchment analysis (1 in 10 year event)

Subcatchment	Time to peak (hrs)	Peak flow (m3/s)	Area (m2)	Flow per km2	Comments
CB1	2.75	0.032	417600	0.08	attenuated u/s by Lochan Fraoich
CB2	2.417	0.003	439275	0.01	attenuated u/s by Lochan a Chreimh
CB3	2.833	1.423	575324	2.47	attenuated d/s by Loch Chorra
CB4	2.833	0.099	611469	0.16	attenuated d/s by Loch Chorra
CB6	2.75	1.721	680557	2.53	attenuated d/s by Loch Chorra
CB11	3.167	2.350	2348223	1.00	
CB7	2.667	0.059	2282924	0.03	attenuated by Loch na Gad
CB8	3.167	6.277	2629222	2.39	
CB9	3	1.367	796823	1.71	
CB10	3.333	5.376	474118	11.34	
CB12	2.667	1.698	590475	2.88	
CB15	4.167	13.763	2786163	4.94	
Clachan total	3.417	**26.848**			

Table 2-2 Allt Mor subcatchment analysis (1 in 10 year event)

Subcatchment	Time to peak (hrs)	Peak flow (m3/s)	Area (m2)	Flow per km2	Comments
AM1	3	1.531	992750	1.54	attenuated by Loch Ciaran
AM2	3.33	3.574	2524875	1.42	attenuated by Loch Ciaran
AM3	2.75	0.200	767050	0.26	attenuated by Loch Ciaran
AM4	2.917	2.041	902163	2.26	attenuated by Loch Ciaran
AM5	3	2.906	1071983	2.71	attenuated by Loch Ciaran
AM6	2.917	2.699	857857	3.15	attenuated by Loch Ciaran
AM7	3.167	6.789	701010	9.68	attenuated by Loch Ciaran, partially planted Tallatol
AM8	2.917	5.695	1901775	2.99	attenuated by Loch Ciaran, partially planted Tallatol
AM9	5.5	7.442	1751270	4.25	attenuated by Loch Ciaran, partially planted Tallatol
AM10	2.75	1.476	1316025	1.12	Partially planted Tallatol
AM11	2.917	2.505	378469	6.62	Partially planted Tallatol
AM12	2.667	0.069	340171	0.20	Partially planted Tallatol
Allt Mhor total	5.25	**8.254**	13505398		

Subcatchments that contribute a high proportion of flow to the total runoff, that provide space for measures (eg. are not fully forested), and are not already significantly attenuated by lochs are highlighted. The highest contributor to flow in the Clachan Burn in the upper catchment is CB8. This rises on the slopes of Cruach nam Fiadh, east of Clachan village, draining in a south westerly direction towards Scotsmill. The majority of the area is unforested, with flatter upper areas dominated by boggy ground, and lower reaches characterised by steep hillslopes and channel gradients. Immediately downstream CB10 indicates the highest runoff per area of all the subcatchments, and contributes 20% of the peak flow in the village. Immediately downstream of this, CB15 drains the land immediately upstream of the village, and contributes over half of the peak flow.

AM7 is the subcatchment with the greatest contribution of flow within Alt Mor catchment. However, AM7 and the majority of the Allt Mor catchment (85%) drain through Loch Ciaran which has a

significant attenuating effect. Downstream of the reservoir, the highest runoff contribution comes from subcatchment AM11, nearest the village. The majority of the subcatchment to the west of the watercourse will be included in the Tallatol plantation.

3. Long List – Flood Protection Mitigation Options

Flood risk objectives aim to provide a common goal and shared ambition for managing floods. As Clachan was not included as a PVA in the first round of SEPA FRM Strategies no flood risk objectives for the area have yet been set. As such this study has attempted to set objectives based on assessment of the underlying evidence of the causes and impacts of flooding.

Primary Objectives for the Clachan area are:

- Reduce overall flood risk
- Reduce flood risk in Clachan from river flooding

Secondary Objectives are:

- To manage surface water flooding in a more effective way in order to reduce flood risk from this source
- To make the public more aware of causes of flood risk
- To encourage the community to develop a “community flood action group” to improve flood planning and resilience locally
- To allow the environmental enhancement of the waterbodies
- To improve wider catchment management practices

A wide range of structural and non-structural measures have been identified to achieve the objectives of the study in a way that is most sustainable. Options locations are shown in **Figures A3 – A8, Appendix A.** Measures are intended to address the flooding at source, along its pathways and protect the receptors of the flooding. Impacts of fluvial flooding from the watercourses come directly from high water levels in the channel. Mitigation measures can aim to directly defend against these levels (for example direct defences such as walls or embankments, or Property Flood Protection), or to reduce the water levels, either by increasing channel capacity (for example weir removal and/or sediment removal), or by reducing the peak flow (for example runoff reducing measures within the catchment).

Structural measures include:

- Upstream Storage
  - On line
- Diversions
- Infrastructure upgrade (culverts)
- Direct defences

Non-structural measures include:

- Natural Flood Management including
  - Across slope tree planting
  - Promote hedgerows
  - Understory planting in native/semi natural woodland areas
  - Wetland enhancement
  - Increase riparian buffer strips
- Individual Property Flood Protection (PFP)
- Self help

Options not considered include:

  - Flood warning has been discounted due to the fast response time of the catchments surrounding Clachan

- Relocation has not been considered at this stage however if options presented within the short list are found to not be viable this will be reconsidered.

A summary of all options considered and the flood receptor they would benefit along with a unique ID is set out in **Table 3.1**.

Table 3-1 Long List Options

Category	Type of Measure	Measure	ID	Flood receptor (location)	Figure
Local Options	Maintenance -quick win	Redirect overland flow and drainage to the unnamed watercourse.	**1.1**	Reduce surface water runoff flooding down old road through Clachan and subsequent tarmac damage.	A3
	Property Flood Protection (PFP)	Assess properties within 0.6m flood depth as optimum for PFP as a resilience rather than prevention technique.	**1.2**	At targeted properties in village	A3
	Ongoing Forestry Management	Ensuring best practise is adopted	**1.3**	Reduce flooding in Clachan village from both Burns	N/A
	Self Help	This includes preparing a flood plan and flood kit, installing property flood protection, signing up to Floodline and Resilient Communities initiatives, and ensuring that properties and businesses are insured against flood damage.	**1.4**	Properties in Clachan Village	N/A
NFM measures – surface runoff	Tree planting in the form of cross contour buffer strips.	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	**2.1**	Reduce flooding through Balinakill, across fields and on A83 from rapid surface water runoff.	A4
	Understory planting in existing woodland	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	**2.2**	Reduce flooding through Balinakill, across fields and on A83 from rapid surface water runoff.	A4
	Hedgerow planting and associated swales	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	**2.3**	Reduce flooding through Balinakill, across fields and on A83 from rapid surface water runoff.	A4
	Land management measures	Farm measures to improve soil infiltration and soil water storage on agricultural land, to reduce surface runoff	**2.4**	Reduce flooding in Clachan village from surface water	A4
	Leaky barriers on steep watercourses	Increase roughness, reduce risk of blockage and coarse sediment and reduce flooding through Clachan	**2.5**	Reduce flooding in Clachan village from surface water	A4
NFM measures – Clachan Burn	Wetland enhancement to south east of Balinakill	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	**2.6**	Reduce runoff to small watercourse and therefore Clachan Burn	A5
	Wetland enhancement & ditch blocking to north of Scotmill	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	**2.7**	Attenuate flow from several sub-catchments on Clachan Burn	A5
	Riparian woodland	To increase roughness higher in catchment to create restriction and storage for flood water	**2.8**	Increase roughness of the Clachan Burn corridor to reduce flooding from Clachan burn	A5
	Wetland enhancement & ditch blocking to south	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	**2.9**	Attenuate flow on Clachan burn	A5

	west of Loch nan Gad				
	Reduce sediment input to Clachan watercourses	Reduce impact of flooding in Clachan by reducing build-up of coarse sediment in low gradient sections and at structures	**2.10**	Reduce impact of flooding in Clachan by reducing build-up of coarse sediment in low gradient sections and at structures	N/A
Hard engineered options	Weir modification/or removal	Removing structure may reduce back up effect and improve conveyance through channel	**3.1**	Reduce flood levels up to road bridge in Clachan.	A6
	Upstream storage area	Store and attenuate significant portion of flow higher in catchment and release at controlled rate	**3.2**	Reduce flow entering Clachan in storm to protect village.	A7
	Flood defences – embankment or wall	Flood defences along the Clachan Burn at vulnerable locations in the village	**3.3**	Protect properties along banks of Clachan and Allt Mor Burns	N/A
	Culvert upsize	Improve conveyance across the A83 by upsizing culvert	**3.4**	Reduce ponding on A83	A6
	High flow diversion channel	Divert high flows to location downstream of the village	**3.5**	Protect properties along banks of Clachan Burn	A6
	Culvert upsize	Upsize culvert at driveway	**3.6**	Reduce ponding on A83	A6
	Overland flow capture	Divert overland flow from road to Balinakill House back into watercourse	**3.7**	Reduce ponding on A83 and damage to fences	A6
	Upstream storage area	Loch Nan Gad catchment – enhance storage CB7 with hard structure	**3.8**	There is potential to attenuate flow from several sub-catchments	A7
	Upstream storage area	Loch Chorra-riabhaich catchment – enhance storage	**3.9**	Potential to store more here	A7
	High flow diversion channel	High flow bypass channel - Maintain existing channel but remove high flows	**3.10**	Reduce flooding of properties along banks of Allt Mor and within Clachan	A6
Allt Mor Options	Upstream storage	Modify management regime for Loch Ciaran to maximise flood storage available	**4.1**	Reduce flooding of properties along banks of Allt Mor and within Clachan	A8
	Upstream storage	Increase storage in Loch Na Beiste to maximise flood storage available	**4.2**	Reduce flooding of properties along banks of Allt Mor and within Clachan	A8
	Natural Flood Management	Work with RDS for benefit from Talatoll scheme	**4.3**	The scheme has been approved and it can provide additional benefit through a design which considers the existing pluvial flood risk to Clachan and the A83.	A8
	Natural Flood Management	Tree planting and leaky barriers on tributary	**4.4**	Increase roughness and out of bank flow from tributary to Allt Mor	A8
	Wetland enhancement	Wetland/ storage area on right bank of Allt Mor	**4.5**	Increase floodplain storage	A8

3.1 Quick wins

Initially several quick wins were discussed with ABC. These mainly included options for roadside and culvert maintenance at key locations to enable surface water to drain more freely to the watercourses and not impact properties and roads. Two quick wins have been taken forward by ABC and have therefore been removed from the study for future phases. These are discussed further in **Section 10**.

3.1.1 Forestry management

It arose from the early dialogue with the Clachan community that there is a perception that poor forestry management practices have contributed to flooding events in recent years. This has been assessed using the 2D catchment model. Analysis indicated that felling should not have contributed significantly to flood risk, however it remains possible that local instances of poor practise such as “clear felling” have contributed to flood risk. The Forestry Commission have been involved in this project since the outset and are obligated/committed to regulating forestry practises in the catchment. As such this option is outwith ABC regulation so has been taken off the long list of options. However we recommend that Argyll and Bute Council, Forestry Commission and Forestry Enterprise continue to engage with the forestry operator to ensure ongoing opportunities for mutually beneficial improvements in flood risk management are fully utilised.

4. Long List Screening

The long list of options has been screened for technical, financial, legal and environmental feasibility. The purpose of this was to remove any potential measures that are clearly unfeasible or unrealistic at an early stage. **Table 4.1** sets out the criteria that were used for screening out unfeasible or unrealistic options. The guidance of screening from long list to short list is set out within the Flood Risk Management (Scotland) Act 2009.

Table 4-1 Screening Criteria

Feasibility	Description	Metric
Technical	Removal of any measures that are not technically feasible. E.g. is land available for above ground storage, no meaningful impact on flood risk etc.	Categorical – Y/N Expert Judgement – Scoring
Legal	Removal of any measures that represent insurmountable legal issues including health and safety.	Categorical – Y/N Expert Judgement – Scoring
Financial	At this stage, is there evidence that the costs will be disproportionate compared to the benefits? Rapid assessment of cost estimates against key economic and social benefits. Please note this should not be considered a detailed cost benefit analysis.	Categorical – Y/N Estimated build and maintenance costs of measure vs benefits to economy and key social impacts (risk to life/human health) – Scoring
Environmental	Removal of any measures that would have a negative environmental impact long term that could not be offset through management plans	Categorical – Y/N Expert Judgement – Scoring

Expert judgement is used within this process and as such will open option selection up to a degree of subjectivity. During this process we have carried out multiple consultation events with ABC, Forestry Commission, the community, Scottish Water and SEPA in order to gather as many opinions as possible to inform the decision making process. These events are detailed in **Section 4.1**. Additional studies were also carried out to help inform the optioneering process by identifying opportunities and constraints at an early stage. These studies are detailed in **Section 5 - 8**.

4.1 Stakeholder engagement

4.1.1 Argyll and Bute Council

Following completion of the baseline studies and site walkovers, the long list was created by AECOM. To review the feasibility of the long list, ABC and AECOM held a workshop on 31st January 2019, which enabled all of the relevant client personnel to input into the screening process. ABC technical and policy staff were in attendance, and AECOM gathered feedback from the session. AECOM specifically asked ABC to comment on the technical, legal, environmental and financial feasibility of all options presented. All comments made were noted and are summarised in **Table 9-1**.

4.1.2 Scottish Water, Forestry Commission (Forest Research), Clachan Community and SEPA

Having gained ABC's input to the long list, Scottish Water, Scottish Natural Heritage, Forestry Commission (Forest Research), a Clachan Community representative and SEPA were then consulted. The consultation took the form of a half day workshop held on 25th February 2019 where AECOM brought all the parties up to date on the project and then summarised the long list of options. The outputs from consultation with ABC were discussed and any additional points highlighted where necessary. High level modelling tasks were identified to provide results which would be useful to inform the screening process. The additional modelling carried out is detailed in **Section 4.3**.

Scottish Water's response centred around the importance of the protection of the pipe bridge in Clachan. AECOM are aware of planned protection works to this area and have been liaising with ABC to ensure the optimal solution is developed, taking flood risk into consideration.

The Forestry Commission provided useful insights to the implementation of leaky barriers by highlighting the importance of landowner agreement and potential compensation requirements. The different influences of these measures were also discussed. It was made clear that leaky barriers can increase roughness and slow flows in steep catchments but would provide storage within low to moderate gradient locations.

Forestry Commission also supported the conclusion that the Talatoll scheme will provide flood risk benefit to Clachan. They also stated it is a condition of grant approval that good forestry practice is applied in line with the UK Forestry Standard, which sets out a range of legal and good forestry practice requirements. FC also indicated that although it will take a while for the scheme to establish, it will provide benefits to water quality and soil infiltration in a much shorter timeframe.

SEPA agreed NFM options could be viable but felt it was likely that NFM alone will not solve flooding issues in the catchment. SEPA were supportive of the other options discussed including weir removal, upstream storage, Property Flood Protection (PFP) and direct defences and stated further assessment would be required. This was reiterated in a letter response received 2^{2nd} March 2019. SEPA also suggested consideration of sediment management. This has now been included particularly when looking at the influence of the weir. The issue of woody debris in the channel causing blockages has been highlighted but this is believed to have been a result of poor management practises during the last cycle of felling which exacerbated flooding rather than a general issue in the natural catchment.

A representative from the community also attended the workshop to provide their views. The view was that a hard engineered solution of direct defences or upstream storage would be welcomed. In addition the removal of the weir would be strongly supported as there is a perception in the village that this is reducing channel capacity. The residents also fed back that they would have expected more measures to be included higher in the catchment. This was reassessed based on this comment and some additional locations have been added to the longlist for more detailed testing. However, much of the Clachan catchment is forested or attenuated by existing Lochs, so in fact do not contribute a significant proportion of the overall flow in the Clachan Burn. Mitigation opportunities have therefore been focused in the locations most likely to show a benefit. This was further discussed at the public consultation event on 1st April 2019. All comments received as a result of this session have been recorded and fed into the screening process.

4.2 Additional studies

Broader consideration has been undertaken of environmental impacts (human and natural) to support the optioneering process. This has been addressed through the following exercises:

- Preliminary Ecological Appraisal, summarised in **Section 5**
- Planning and Environmental Appraisal, summarised in **Section 6**
- Baseline Economic Damages Assessment, summarised in **Section 7**
- Public Consultation, summarised in **Section 8**

These studies have provided more information on opportunities and constraints with regards to the environmental, social and economic impacts of the potential options and helped inform the appraisal of options to progress from the long list to the short list. The studies are summarised in the sections noted above and the full reports are within the appendices.

4.3 High level modelling of options

In order to refine the long list down to only those options that have benefits to Clachan and reduce flood risk to its residents, some high level modelling of the long listed options was undertaken. This included:

- Model the impact of weir removal

- Model impact of weir removal and associated sedimentation in channel
- Model the impact of increased storage at Loch Nan Gad (engineered and natural)
- Model the impact of wetland enhancement within subcatchment
- Model the impact of increased storage near Scotmill (engineered and natural)
- Model the impact of leaky barriers on Allt Mor downstream of Loch Ciaran
- Model the impact of increased storage on Loch Chorra-riabhaich

The results of this modelling are summarised in **Sections 4.3.1 to 4.3.9**. It should be noted that the modelling employed is high level in order to inform short list options rather fully investigate these options. This will carried out in the next phase. Furthermore these options have been assessed in isolation to ensure their benefits are identified without the risk of the effectiveness being skewed by a benefit from separate interventions. However, given the separate mechanisms that contribute to flooding, a multi-solution scheme will be required to address the flood risk within Clachan.

Initial solution testing has been carried out for a 1 in 25 year storm event as a majority of the solutions being tested are more likely to have impact during more frequent events. A full suite of storm events will be assessed in Phase 4.

4.3.1 Weir removal

As discussed previously the Clachan community have repeatedly indicated that they believe the capacity of the Clachan Burn channel has been reduced over time due the presence of the weir, immediately upstream of its confluence with the Allt Mor. A scenario was run in the 1D-2D model with the weir removed to test the impact on water levels and velocity in the reach upstream. It should be noted that this modelling exercise was carried out solely to determine if any positive benefit could be gained from this option to take it through to short list for further investigation. No consideration of erosion impacts has been undertaken at this stage.

Modelling has shown small benefit from the removal of the weir. There is a reduction in flood level of approximately 100mm immediately upstream of the weir. In addition, flood levels are reduced by around 200mm in the Allt Mor channel immediately upstream of the confluence. The reduction in the Allt Mor is because there is less overtopping from the Clachan Burn due to the removal of the restriction, therefore less out of bank flow from the Clachan re-enters the Allt Mor channel upstream of the confluence, reducing flood levels locally. The key receptors impacted by this reduction are largely fields and the caravan park at the downstream end of the village. This is likely because the weir structure itself is a minor structure.

This option alone offers some flood risk benefit. Managing the associated sedimentation due to the weir would likely increase this flood risk benefit by increasing overall channel capacity. It is likely this would occur naturally when the weir is removed, as sediment would no longer be trapped behind the structure and channel processes would return to their more natural form.

4.3.2 Sedimentation due to weir

Modelling the removal of the weir showed some benefit in flood risk to properties in Clachan. Based on anecdotal evidence of the area there is a perception that the capacity of the burn has been reduced due to sedimentation in the channel over time. The presence of the weir will reduce velocities in the channel, with the result that sediment is deposited in the channel upstream. It is likely this is occurring as far upstream as the main road bridge on the Clachan Burn. A high level check on the potential impact of sedimentation has been carried out by looking at the likely natural gradient of the burn based on the upstream and downstream reaches. The weir was removed from the 1D-2D model and the likely natural bed levels were then estimated downstream of the road bridge. Bed levels of cross-sections from downstream of the road bridge to the weir were altered as a rough check to determine if this option was worth exploring further.

The potential benefit from this option is greater than weir removal alone as it reduces water levels up to the road bridge so that properties would experience the benefit. Flood depths are shown to be reduced at by 150mm at Mansecroft and 100mm at the cottages on the left bank of the burn. Although this option will not significantly increase the standard of protection to residents in Clachan, the outputs

indicate it could be effective in conjunction with runoff reduction measures higher in the catchment and would generally have a positive influence on flood risk. As such it is recommended this option remains on the short list for further exploration.

It should be noted at this stage that velocities upstream of the weir are shown to increase by up to 30%; therefore careful consideration of the geomorphological impacts of any works and the need for bank erosion protection will need to be considered as part of this option. Significant increase in velocity is localised to the area between the weir and Mansecroft therefore it is likely suitable bank protection could be put in place with reasonable cost to offset the erosion impacts of weir/sediment removal. The assessment also needs to include consideration of increase in flooding to any receptors downstream.

4.3.3 Increased storage at Loch Nan Gad – engineered 3.8

As part of the long list of options, Loch Nan Gad (**Appendix A, Figure A7**) was assessed as having potential to accommodate increased storage through restricting its outflow. A review of topography using DTM indicated that the loch currently has the potential to store approximately 193,000m^3 assuming the spill level is 79.6mAOD and the depth is 1.6m (extracted from DTM). Restricting the outflow has the potential to increase this to approx. 460,000m^3, assuming the outflow is set at 81mAOD (extracted from DTM). The dimensions of the embankment could be approx. 20m long by 3m high.

Modelling indicated there is no benefit in increasing storage in Loch Nan Gad. A 1-D ESTRY unit was used to represent a weir in the TUFLOW catchment model to act as a new control structure downstream of the existing loch outlet. However, Loch Nan Gad is already providing significant storage and attenuation of flows from this subcatchment. Analysis indicates this subcatchment contributes only 0.2% of the total peak flow reaching the village; therefore there is no significant benefit to be gained providing further flood storage here. Managing the loch for increased flood storage would require supervision under the Reservoirs Act, with significant cost implications. Therefore, this option is discounted on the basis that it provides no real benefit, and because of legal, cost and technical challenges.

4.3.4 Increased storage at Loch Nan Gad – NFM

As outlined in **Section 4.3.3** above, Loch Nan Gad is capable of storing a large volume of flow and already provides significant attenuation of flows. Provision of additional storage through natural means such as a leaky barrier will have even less benefit that an engineered option, and is unlikely to be acceptable given the vulnerability of the village below. Therefore this option has also been discounted.

4.3.5 Storage area on Clachan Burn – engineered 3.2

A similar process as the Loch Nan Gad storage assessment as set out in **Section 4.3.3**, was carried out whereby the storage potential of the upper Clachan Burn near Scotmill was assessed. The location is shown as 3.2 in **Figure A7**. An embankment height of 1m was used (set at 104mAOD) and the volume of storage available within this was calculated. Approx. 96,000m^3 of storage may be possible in this area. However, the topography is such that a long embankment (260m) would be required. It is unlikely that the cost of such a structure would balance the benefit achieved.

Engineered storage at this location, was tested by altering the DTM in the catchment model to represent the likely embankment height. This allowed water to back up behind the structure. An ESTRY rectangular culvert unit was then used for simplicity to throttle flood flow so that a controlled/reduced flow would continue down the watercourse. Modelling indicated this option could have significant benefit with a reduction in peak flow of around 25%. This attenuating hydrograph was run through the 1D-2D model of the watercourses within the village of Clachan. The flood extent at cottages along the left bank of the Clachan Burn was eliminated at the 1 in 25 year event, and the extent at Mansecroft significantly reduced affecting only the bottom of the gardens. Flood depths here are significantly reduced by around 200mm. No benefit was shown for properties along the Allt Mor as this is a separate flood source which would not be impacted by works in the upper Clachan catchment.

Although this option showed reasonable flood risk benefit, it would require significant capital investment to construct which is highly unlikely to achieve a positive in cost benefit. Therefore this option has been discounted.

A second area was assessed for formal storage potential, upstream of the forestry road in subcatchment CB8. An embankment height of 3m was used (set at 144mAOD) and the volume of storage available within this was calculated to be approx. 260,000m^3. However, the topography is such that a large embankment (180m x 3m) would be required and this is likely to be cost prohibitive On this basis this location was ruled out for formal storage, but has been explored as a potential NFM location. This area is shown as the northern most area marked as 2.7 on **Figure A5**.

4.3.6 Storage area on Clachan Burn – NFM 2.7

Storage potential in the upper Clachan Burn near Scotmill has been identified as a key location for storage as the subcatchments here are high contributors of flow to the burn compared to more forested parts of the catchment (see section 2.5). The creation of wetland storage through more natural intervention such as ditch blocking and leaky barriers has been assessed to determine if this could have a positive impact.

Two locations have been identified where ditch blocking and leaky barriers could be utilised to provide wetland storage. These are shown as 2.7 in **Figure A5**. Ditch blocking was represented in the locations identified, by a 100% flow constriction to cells in the 2D model. A leaky barrier was also modelled across the tributary feeding the Clachan Burn as a line of flow restriction of 50%.

At a 1 in 25 year event this measure was shown to have a small impact, reducing peak flow by 5% in the village and increasing the time to peak by 15 minutes. This translates to a reduction in flood depth of around 50mm downstream in the village. Although this indicates a small gain, a measure such as this would not be implemented as a standalone option. It would be implemented with other land management and NFM measures to achieve cumulative gains throughout the upper catchment for the village. This check is high level and the implementation of this option could be optimised further to maximise storage and increase benefit achieved. This option would be very low cost and quick to implement and would offer environmental benefits such as morphological diversity for aquatic life. On this basis, this impact is deemed to be worth exploring further as a short list option.

4.3.7 Storage area on Clachan Burn – NFM 2.9

Storage potential in the upper Clachan Burn near Strathnafanaig has been identified as a key location for storage as the subcatchments here are high contributors of flow to the Burn compared to more forested parts of the catchment. The creation of wetland storage through more natural intervention such as ditch blocking and leaky barriers has been assessed to determine if this could have a positive impact.

One location has been identified where ditch blocking and leaky barriers could be utilised to provide wetland storage. This is shown as 2.9 in **Figure A5**. Ditch blocking was represented in the locations identified by a 100% flow constriction to cells in the 2D model. A leaky barrier was also modelled across the tributary feeding the Clachan Burn as a line of flow restriction of 50%.

At a 1 in 25 year event this measure was shown to have a small impact, reducing peak flow in the village by 10% and increasing time to peak by 15mins. This translates to a reduction in flood depth of around 70mm downstream in the village. Although this indicates a small gain, again a measure such as this would not be implemented as a standalone option. It would be implemented with other land management and NFM measures to achieve cumulative gains throughout the upper catchment for the village. Further to this the check is high level and the implementation of this option could be optimised further to maximise storage and increase benefit achieved. This option would be very low cost and quick to implement and would offer environmental benefits such as morphological diversity for aquatic life. On this basis, this impact is deemed to be worth exploring further as a short list option.

4.3.8 Increase storage area at Loch Chorra Riabhaich – engineered 3.9

A similar process as the Loch Nan Gad storage assessment as set out in **Section 4.3.2**, was carried out whereby the storage potential of Loch Chorra Riabhaich was assessed. A review of topography using DTM indicated that the loch currently has the potential to store approx. 274,400m^3 assuming the

spill level is 164mAOD and the depth is 4m (extracted from DTM). Restricting the outflow has the potential to increase this to approx. 466,000m^3, assuming the outflow is set at 165mAOD (extracted from DTM). The dimensions of the embankment could be approx. 100m long by 1m high. Managing the loch for flood storage would require supervision under the Reservoirs Act, with significant cost implications. The location of this option is shown in **Figure A7.**

Modelling indicates there is no benefit in increasing storage here. An ESTRY unit was used to represent a weir to act as a new control downstream of the existing control structure. A negligible impact was shown to flows downstream. This is because the loch and the 2 lochs higher in this subcatchment already provide significant storage and attenuation so that the contribution to the Clachan Burn from subcatchments here is only around 9% of the total catchment. There is limited opportunity here to increase this impact further, therefore this option has been discounted based on technical feasibility.

4.3.9 Allt Mor – NFM 4.5

Potential mitigation options on the Allt Mor catchment are more limited due to the attenuating impacts of Loch Ciaran dominating much of the catchment. The catchment downstream of Loch Ciaran is very steep, limiting potential for storage through NFM or an engineered solution. However, one location was identified as a potential wetland area based on the existing topography. This would likely be created through a leaky barrier in the channel. This was represented in the model with a line of cells with a 50% flow restriction to represent this impact. Given the steep nature of this catchment at this location, a reasonable volume of storage can be achieved for the already heavily attenuated flows. Further benefit is gained from slowing the flow, with the time to peak of the Allt Mor hydrograph increasing by 1 hour. This results in the new hydrograph being at the lower end of the falling limb of the Clachan Burn hydrograph downstream compared to baseline where it was much higher. This means the backwater effect of high flows in the Clachan Burn on the Allt Mor is much reduced due to desynchronization in hydrographs.

Modelling has shown this measure to have a substantial potential benefit at the 1 in 25 year event return period. Overtopping of the Allt Mor is no longer predicted at cottages along the A83. Overtopping from the Clachan Burn is unaffected. There is potential that this option would also reduce flooding from the Clachan Burn at higher return periods where the interaction between the Allt Mor and Clachan Burn is greater. The location of this option is shown in **Figure A8**.

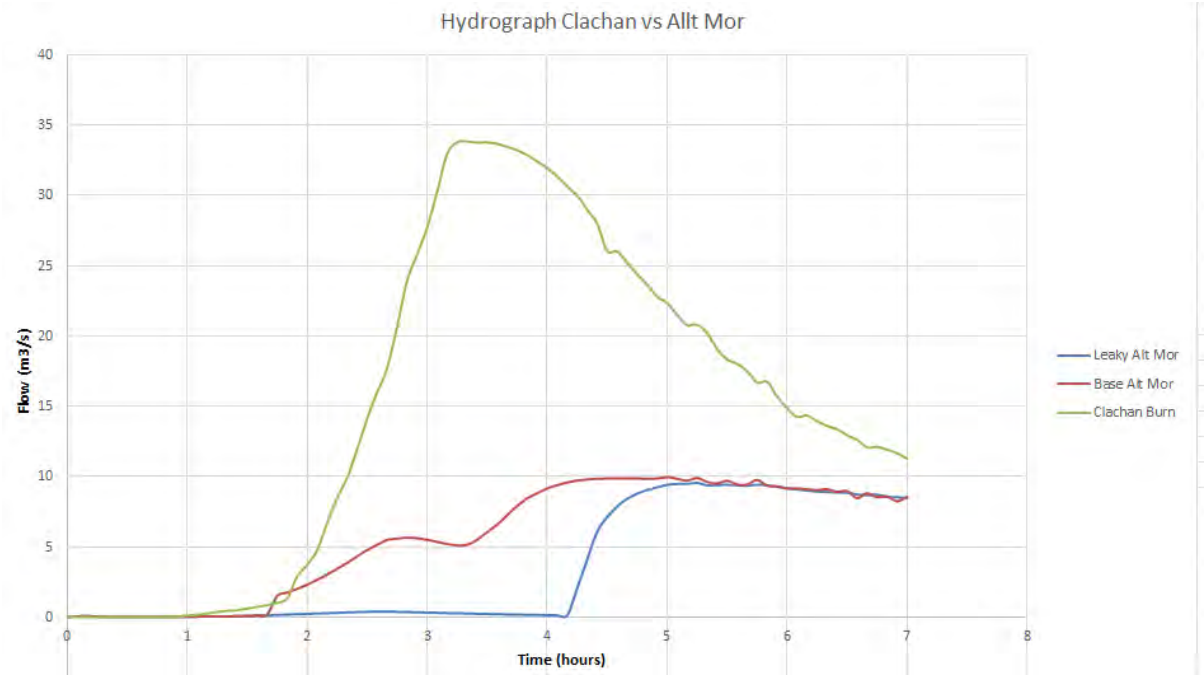

Figure 4-1 Impact of Allt Mor Leaky Barrier

5. Ecological Preliminary Appraisal - Recommendations

Below are the recommendations taken from the Preliminary Ecological Appraisal. The full report can be seen in **Appendix C**.

As the proposed development is in the preliminary stages of design, specific ecological recommendations cannot be made. Ecological receptors considered to be potentially relevant, and which may represent a high level of constraint to the proposed development, are identified below.

5.1 Nature Conservation Designations

5.1.1 Kintyre Goose Roosts SPA and Ramsar, Kintyre Goose Loch SSSI and Rhunahaorine Point SSSI

The sole qualifying feature of the Kintyre Goose Roosts Special Protection Area (SPA) and Ramsar site and notified feature of Kintyre Goose Lochs Site of Special Scientific Interest (SSSI) are over-wintering Greenland white-fronted goose. This is also a notified feature of Rhunahaorine Point SSSI, along with breeding little tern and shingle. The three parts of the SPA within the relevant search distances are Loch Garasdale (444 m from Site) and Loch an Fhraoich (4.8 km from Site), both of which are overlapped by the Kintyre Goose Lochs SSSI, and Rhunahaorine Point (6 km from Site), overlapped by the Rhunahaorine Point SSSI.

Any land utilised by the qualifying species for which a SPA is designated, even if not within the defined SPA boundary, has potential to be 'functionally linked' to the designation and must be taken into account when assessing potential impacts upon it. European sites and their qualifying features are of great ecological importance and are strictly protected under the Habitats Regulations.

It is noted in the SPA citation that Greenland white-fronted goose roosts exist on the Kintyre Peninsula out-with the defined SPA area. However, although functionally linked to the SPA, they are used only sporadically and by smaller numbers of geese than is considered to be nationally important. Non-designated potentially suitable roosting and foraging habitat (not noted in the SPA citation) is present within the Site in the form of lochs and improved agricultural land around Clachan village, and connectivity between the SPA / Ramsar site and SSSIs and the Site is possible, with Loch Ciaran only 2.3 km from Loch Garasdale. Therefore, habitat which may be used by foraging geese (and therefore may be functionally-linked to the SPA) does occur within the Site.

Such habitat may be affected both during the construction and operational phases of a proposed flood Scheme (the magnitude of any operational effects being closely related to the frequency with which any proposed flood storage areas will be used). If a significant area of improved grassland habitat in this area will be lost to a proposed Scheme (even sporadically during flood events), or significant disturbance is possible during construction, it is considered possible that there may be a Likely Significant Effect (LSE) on the SPA qualifying feature. To assess if such a LSE is possible, a Habitats Regulations Appraisal (HRA) Screening exercise will be required to assess whether the proposed works may have a significant adverse effect on the SPA or its qualifying feature. It is therefore recommended that an HRA Screening assessment is carried out in relation to any proposed Scheme. SNH should be involved throughout the Screening process and approached for any relevant data they may hold. Depending on the data available (from SNH and other sources), there may be a requirement for wintering bird surveys to be carried out to collect data on the use of the Sites by Greenland white-fronted geese.

As noted above the long-list of flood scheme options includes wetland enhancement upstream to attenuate and store water. Consideration should be given to which areas include land functionally linked to the SPA as discussed above.

5.1.2 Loch Ciaran LNCS and Loch an Eilean Group LNCS

These Local Nature Conservation Sites (LNCS) should not be adversely impacted on as part of any future Scheme.

5.1.3 Blanket Bog

Blanket bog has been mapped in the north east of the study area and should be protected as part of any future Scheme.

5.1.4 Other habitat

Watercourses are identified as requiring to be protected and this includes the fish species that may be present. A number of options seek to enhance habitat for fish species.

5.1.5 Bird species

Greenland white-fronted goose, red-throated diver and black grouse have all been identified as potentially using the study area.

5.1.6 Protected mammals

Bat species, otter, pine marten and red squirrel are assessed as being potentially present within the study area and therefore posing a high level constraint to a future Scheme. Additional survey will be required to inform this and protected species licences may be necessary.

5.2 Notable Habitats

Several areas of ancient or semi natural woodland included on the ancient woodland inventory exist within the survey area (around Balinakill). Due to the predominance of natural flood management measures proposed, any impacts upon Ancient Woodland are considered unlikely. However, all broadleaved woodland, particularly semi-natural, has ecological value and there is a general presumption in planning policy against its removal without significant public benefit; cognisance should be given to this during development of any future Scheme.

5.3 Protected and Notable Species

A number of protected species including European Protected Species, those protected under the Wildlife and Countryside Act 1981 (WCA) and other notable species including those which are non-native with the potential to be invasive have been recorded within the search area or have the potential to be present.

Given the above, a full suite of protected species and habitat surveys, including for the survey of non-native species, will be required to inform future stages of the project. As noted previously, given the nature of the flood scheme options, protected and invasive species associated with watercourses are likely to be of particular relevance. The scope for future surveys should be informed by this report but refined based on the specific locations and design of the development, and should take the form of a full Preliminary Ecological Appraisal, involving site survey, and/or an Ecological Impact Assessment (EcIA) in accordance with CIEEM guidance.

5.4 General Recommendations

Detailed mitigation measures will be based on the results of the surveys recommended above and the final design of any proposed works. Local planning policy requires that all development must be designed with cognisance of minimising impact on biodiversity and the natural environment.

For information, other general measures are likely to include the following:

- SEPA guidance should be strictly adhered to (and this will likely be a requirement as part of the necessary Water Environment (Controlled Activities) (Scotland) Regulations 2011 ('CAR') licence applications). SEPA Pollution Prevention Guidelines (PPGs) and Guidelines for Pollution Prevention (GPPs, which have now replaced some PPGs) should be strictly adhered to.
- Undertaking scrub and vegetation clearance outside the breeding bird season (March to August, inclusive) to avoid illegal obstruction/destruction of bird nests.

- Production of a Construction Environmental Management Document (CEMD) and Construction Method Statements will be required (CMS, produced by the contractor and agreed with the relevant authority in advance of construction). This will detail site specific environmental effects, mitigation measures, timescales and responsibilities.

5.5 Enhancement

National planning policy outlines that the planning system should seek biodiversity benefits from new development where possible. Any future Scheme could incorporate a number of ecological enhancement measures and this concept should be built-in from an early stage and refined as the Scheme progresses. Suggestions for potential enhancement measure are outlined below:

- It is understood that the watercourses within the study have a number of modifications such as weirs and impoundments, which may affect the presence of protected and notable species. Removing obstacles to migration (for both fish and mammals such as otter) and improving the immediate riparian habitat to improve connectivity could constitute significant ecological enhancement as part of any Scheme.
- Wetland restoration upstream of Clachan to attenuate and store water before it reaches the village is being considered as a measure. This could increase ecologically valuable habitat and could constitute significant ecological enhancement. Areas of proposed enhancement would have to be carefully selected to ensure a net gain in biodiversity is achieved, and that the natural function of ecologically valuable habitats is maintained (including land which may be functional to specially protected sites as noted above).
- If non-native species are found to be present these will need to be managed, most likely through the production of an Invasive Species Risk Assessment and Management Plan (RAMP). If such plans are required these would constitute an ecological benefit in themselves by cataloguing the species present and avoiding the further spread of such species. There is potential to widen the ecological benefit of such plans by increasing their scope to the entire catchment (which in this area is not particularly large). A catchment-wide approach will have far-reaching ecological benefit and may help to address the risk of invasive-non-native species spreading back into the Scheme area in the future.

6. Planning and Environmental Constraints

A high level desk study of any potential planning and environmental constraints was carried out. This was to inform the optioneering process by highlighting any areas of significance but also to potentially identify opportunities to protect or enhance assets.

6.1 Environmental Constraints

The desk study has highlighted several key environmental aspects that could impact of the proposed options and should be considered when screening the long list of options. See **Figure A9, Appendix A** for the extents and location of these. The main constraints and opportunities to consider include:

- Scheduled Monuments – there are two areas of scheduled monuments within Clachan. These are Clachan Churchyard, Cross, Cross Slabs & Tombstones and Ballinakill House cross, both of which have cultural significance. Any proposed options within the vicinity of these monuments will take this into account and be designed so as not to impact upon them negatively.
- Woodland – areas of long established and ancient (semi natural) woodland have been identified. Ideally any options would look to avoid these areas.
- Listed Buildings – there are a number of Grade B and C listed buildings in Clachan. The flood study is aiming to reduce flood risk to these properties however works that directly impact these buildings should be avoided.

6.2 Planning Constraints

The desk study has highlighted several key planning constraints that should be taken into account when screening the proposed long list of options; see **Figure A10, Appendix A**, which highlights their extent and locations. The main planning constraints and opportunities are summarised below:

- Open Space Protected Areas – These areas are set aside and are not to be developed. These include the Primary School playing field and an area of land adjacent to Mansecroft. There is an opportunity for the school ground to be used for flood protection measures should such an option be progressed as it will not be used for development. However, this will need to be carefully considered and developed in partnership with ABC and the local community.
- Special Built Environment Area (SBEA) – “areas which do not have the presence, continuity or quality of ‘conservation areas’ but, which exhibit special built and land form characteristics which should be safeguarded and promoted when considering development potential and proposals.” The character of the village is a key consideration when appraising flood mitigation options.
- Area for action – “areas which, subject to resource availability during the plan-period, will be the focus for partnership or community action. Area remits for these AFAs are being worked up in the Supplementary Information and Guidance report; these area remits may include investment and funding packages, land assembly and asset management programmes, development and redevelopment proposals, infrastructure provision and environmental enhancement proposals. Depending on circumstances, AFAs may coincide with other categories of sites such as potential development areas.” Any flood mitigation proposals taken forward will have a strong community involvement and buy in. As Clachan is an AFA, there may be funding available to enhance the local area as part of any proposed works.

7. Baseline Damages Impact Assessment

7.1 Introduction

Flooding can have economic, social and environmental impacts. The aim of this section is to set out the results of the baseline impact assessment. The full results and methods are presented in the technical report in **Appendix C.**

7.2 Methods

The assessment process used here follows the Scottish Government guidance[6] and, as such, will be compatible with the aims of the Flood Risk Management (Scotland) 2009 Act. Whilst the Scottish Government guidance covers the main principles of the assessment set out below, the Multi-Coloured Manual (MCM)[7] and Multi-Coloured Handbook (MCH)[8] cover the detailed procedure and standard data used for the assessment.

The baseline damage assessment is based on a "do nothing" scenario. This allows for the benefits of "doing something" to be assessed at a later stage. Damages were estimated using the flood extents and depths from the 1D-2D hydraulic model. **Table 7.1** sets out the approach used for each component. A more detailed description of the proposed approach taken for selected receptors is included within the technical report.

Table 7-1 - Summary of Economic Damage Assessment Components

Receptor	Damage assessment approach
Economic impacts	
Residential properties	Included. Properties classified by type, age and regional social grading
Non-residential properties	Included. Properties classified by MCM code.
Vehicles	Included. Based on number of properties at risk (detailed information on number of vehicles within the study area is not readily available).
Evacuation	Included. Evacuation costs based on property type and flood depth (detailed local data is not readily available)
Distributional impacts	Included. Based on 2011 census data for Clachan.
Indirect impacts on non-residential properties	Applied as basic 3% uplift to direct damages
Local authority, emergency and recovery costs	Included. Uplift factor from MCM data.
Infrastructure	
Electricity and gas	Described
Water and waste water	Described
Telecommunications	n/a – no vulnerable infrastructure present within study area
Schools	Described
Hospitals	n/a – none at risk of flooding within study area
Transport	

[6] Scottish Government, 2016. Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities. Edinburgh: Scottish Government.
[7] Penning-Rowsell et al. (2013). Flood and Coastal Erosion Risk Management. A Manual for Economic Appraisal. Oxon: Routledge.
[8] Penning-Rowsell et al. (2017). Flood and Coastal Erosion Risk Management. A Handbook for Economic Appraisal. [Online] London: Middlesex University

Receptor	Damage assessment approach
Road disruption	Described
Rail disruption	n/a
Agriculture	n/a
Social impacts	
Risk to life	Quantified based on flood hazard, number of properties and likelihood
Health	Monetised based on standard of protection provided.
Social vulnerability	Described
Recreation, community and way of life	Described
Environmental impacts	
Water environment	Described
Biodiversity, flora and fauna	Described
Air and soil	Described
Climatic factors	Described
Landscape	Described
Cultural heritage	Described

7.3 Results

The number of properties affected by flooding during a 'do nothing' scenario in the study area are shown in **Table 7-2**. The corresponding damages are shown in **Table 7-3**. These results do not include the impact of capping or write-offs, as those factors are only taken into account when damages are discounted over the appraisal period.

Table 7-2 - Number of properties affected by flooding in the study area

		Return period (years)								
Scenario	**Property Type**	2	5	10	25	50	100	200	200+CC	1000
Present Day	Residential	0	6	7	9	10	11	15	34	40
	Non-Residential	0	2	3	5	5	5	6	10	13
Total no. of properties affected by flooding		0	8	10	14	15	16	21	44	53

* Damages for residential properties start to be accrued when the water is within 300mm of the floor level as water enters the sub-floor area.

Table 7-3 - Baseline monetised flood damages by return period

			Return period (years)						
Category		2	5	10	25	50	100	200	1000
Residential	£0	£0	£4,178	£5,659	£6,955	£9,653	£14,976	£31,801	£481,773
	£0	£0	£0	£0	£0	£0	£2,882	£11,528	£77,816
	£0	£0	£0	£0	£0	£832	£2,555	£4,972	£78,335
	£0	£0	£1,129	£1,529	£1,879	£2,607	£4,045	£8,590	£130,134
	£0	**£0**	**£5,307**	**£7,187**	**£8,834**	**£13,092**	**£24,459**	**£56,891**	**£768,058**
Non-Residential	£5,476	£5,476	£19,736	£27,389	£44,298	£58,270	£73,141	£91,262	£336,871
	£164	£164	£592	£822	£1,329	£1,748	£2,194	£2,738	£10,106
	£5,641	**£5,641**	**£20,328**	**£28,210**	**£45,627**	**£60,018**	**£75,336**	**£94,000**	**£346,977**
Other	£586	£586	£2,559	£3,536	£5,484	£7,268	£9,429	£13,168	£87,595
	£0	£0	£0	£0	£0	£1,013	£3,039	£5,065	£32,417
	£586	**£586**	**£2,559**	**£3,536**	**£5,484**	**£8,281**	**£12,468**	**£18,233**	**£120,012**
Total		**£6,227**	**£28,193**	**£38,934**	**£59,945**	**£81,391**	**£112,262**	**£169,124**	**£1,235,046**

Average Annual Damages (AAD) are the expected value of damages within a typical year: ∑*Damages x Probability.* AAD is shown below calculated from current value damages and probability; and for future probability for the climate change horizons. Due to the frequency of flooding, one property was considered to be written off (and were not included in the AAD total). The increased frequency of flooding with climate change means that the ADD does not increase linearly. **Table 7-4** shows the AAD for the assessed climate change scenarios.

Table 7-4 - Baseline average annual damages

		AAD for each epoch			
Category		**Current**	**2020s**	**2050s**	**2080s**
Residential	Direct	£6,216	£7,457	£9,846	£6,890
	Vehicles	£674	£856	£1,233	£789
	Indirect	£649	£820	£1,166	£798
	DIA	£1,679	£2,014	£2,660	£1,861
	Subtotal	**£9,218**	**£11,148**	**£14,905**	**£10,339**
Non-Residential	Direct	£18,134	£5,614	£7,384	£7,282
	Indirect	£544	£168	£222	£218
	Subtotal	**£18,678**	**£5,783**	**£7,605**	**£7,500**
Other	Emergency	£1,364	£732	£965	£794
	Health	£352	£445	£631	£335
	Subtotal	£1,716	£1,177	£1,596	£1,129
Total		**£17,967**	**£29,611**	**£18,108**	**£24,106**

Present Value Damage (PVD) represents the damages expected to be accumulated over the appraisal period (100 years). The total damages accrued are also “discounted” to a Present Value (see the full report in **Appendix D**). PVD is derived from the sum of all probability damages accrued, capped and discounted: ∑ (Damages x Probability) capped x discount rate. Where required, properties were written off in the year that the flood frequency is expected to exceed once every three years, with a discount factor applied where necessary. Table 7-5 shows the present value damage per type for Clachan and Table 7-6 shows a summary of these results.

Table 7-5 Baseline present value damages by type

Category	PVD	PVD CC

Residential	Direct	£103,399	£196,497
	Vehicles	£9,151	£16,120
	Indirect	£8,890	£16,132
	DIA	£27,930	£43,623
	Subtotal	£149,369	£272,372
NRP	Direct	£134,801	£187,646
	Indirect	£2,115	£1,129
	Subtotal	£136,916	£188,776
Other	Emergency	£25,487	£40,101
	Health	£4,711	£7,590
	Subtotal	£30,199	£47,691
Total		**£316,484**	**£508,838**

Table 7-6 Present Value Damage Summary

Totals	Total PVD	Total PVD (CC)
Clachan	**£320 K**	**£510 K**

The study area was split into 'flood cells' – areas which flood from the same location(s) and which could potentially be protected independently. This allows for further investigations to focus on those areas which are most affected. **Table 7-7** shows the present value damage (PVD) for each flood cell. A plan showing the location of the flood cells is shown in **Figure 7-1.** Flood cells 1 and 2 are affected by flooding from the Clachan Burn, 3 from the Allt Mor, and flood cell 4 is affected by pluvial flood mechanisms which are not included in this assessment. The damage estimates indicate that flooding from the Clachan Burn accounts for nearly ¾ of the damages (73%). Measures to reduce flooding from the Clachan Burn are therefore likely to provide the best return.

Table 7-7. Baseline present value damages

Flood cell	Residential	Non-residential	Other	Total	Proportion of total
1	£117,631	£74,195	£64,233	£256,060	50.32%
2	£19,845	£102,814	£20,254	£142,913	28.09%
3	£59,021	£10,637	£40,207	£109,866	21.59%
4	£0	£0	£0	£0	0.00%
Total	**£196,497**	**£187,646**	**£124,695**	**£508,838**	**100.00%**

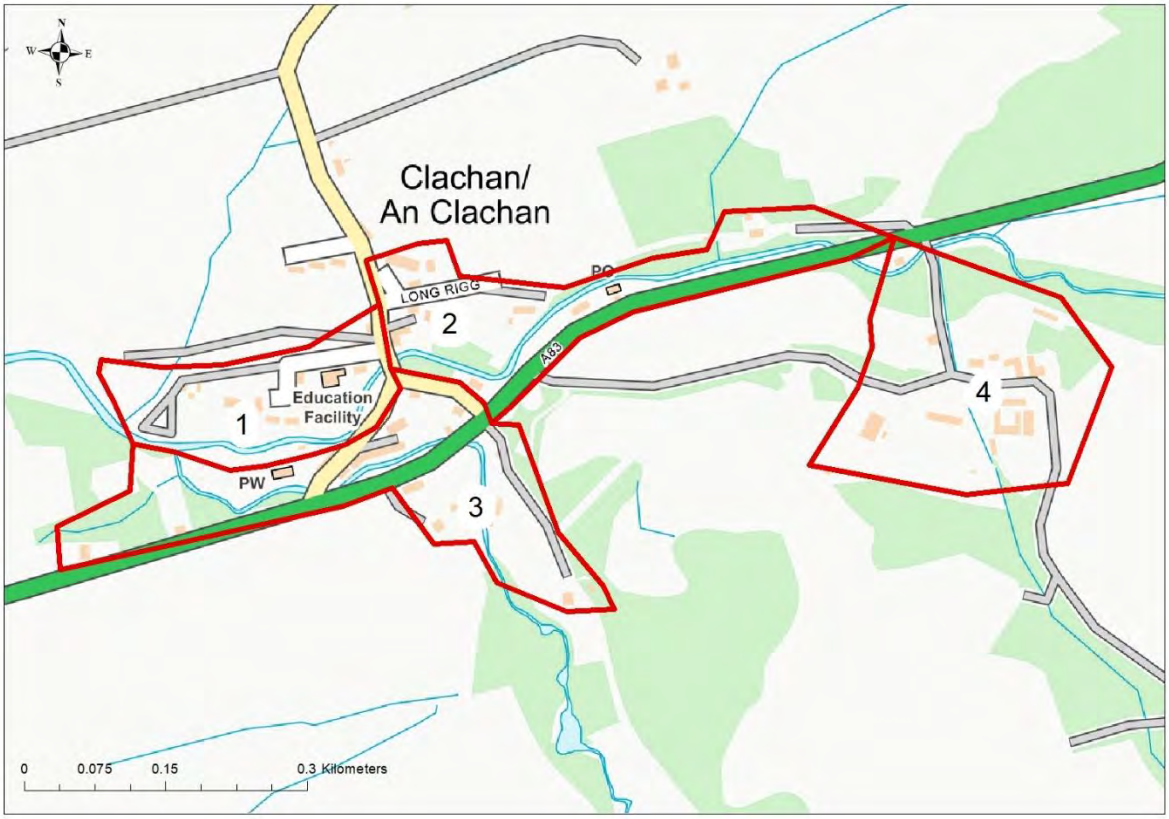

Figure 7-1 Flood Cells

The flooding impacts assessed in this report are broadly in line with the impacts experienced during historical flood events; the greatest impacts are located in those areas that have flooded most frequently in recent years. Key non-monetised impacts include flooding of roads and associated disruption, risk to life, damage to key community assets and pollution of watercourses. The frequency of such an event is expected to increase as a result of climate change.

The non-monetised impacts should also be taken into account as part of any appraisals and decision-making. Clachan is a small village and therefore flooding to the centre of the village and main through road would seriously impact the recreation, community and way of life for the majority of residents.

7.4 Sensitivity Analysis

Uncertainty is inherent in economic damages assessments, given the process involves layering together different datasets with their own individual uncertainties and simplifying assumptions across areas. MCM guidance recommends the use of sensitivity analysis to be aware of these uncertainties. The chosen method is in line with best practice and industry standard approaches which aim to provide a managed, efficient and conservative method to economic damages assessment.

The sensitivity analyses have shown there to be some uncertainty in flood damages, particularly at an individual property level. The flood depth within properties, are highly sensitive to localised features such as kerbs, boundary walls, alleyways and the location of property openings (doors and air bricks). This is typical of a study of this kind.

The damages presented here are based on a best estimate of each of the variables; however the potential for variation in the total damages (both positive and negative) needs to be borne in mind in any decision-making. As shown in the sensitivity analysis above, variations of +/- 25% would not be unexpected.

8. Public Consultation Event

The first formal public consultation event was held on 1st April 2019 in Clachan Village Hall.

Previous engagement has included quarterly community update newsletters distributed to Clachan Filling Station. In addition, an informal meeting was held in November 2018 with key representatives in the community where an update on baseline modelling and potential options was provided. A representative from the community was also in attendance at the stakeholder workshop n February 2019 where the representative fed back community comments on the baseline report and potential options.

The public event comprised a public "drop-in" session between 6pm and 7pm followed by an AECOM led presentation and a Q&A session between 7pm and 8pm and further 'drop-in' session from 8pm-9pm. 3 AECOM staff and 2 ABC staff were on hand to explain the process and answer queries. The public event was attended by a total of 18 members of the public. The majority of attendees were residents of Clachan who had been impacted by past flooding.

Figure 8-1 Public Consultation Event "Drop in"

8.1 Key messages

In general there was support for the flood study and attendees were encouraged at the progress being made. There were a number of key messages that emerged from the informal discussions:

- There was a general understanding and support for catchment scale interventions. Different contributions from the subcatchment analysis and opportunities for space were explained.
- There was a general understanding that a positive cost-benefit ratio for hard-engineered solutions may be difficult to achieve for Clachan and softer measures may be more suitable.
- There was strong support for the removal of the weir. The general feeling was that this creates a large restriction in the channel and the channel should be cleared of sediment to increase capacity. It was noted multiple times that there are no vulnerable receptors downstream so this should not result in any detriment downstream.

- There was also general agreement with AECOM's explanation of the need to assess velocities and potential bank protection associated with this measure so as to ensure integrity and protection of river banks and structures along them.
- There was concern from attendees on the delivery of a solution from a funding perspective and the time scale for implementation.
- A number of people voiced support for PFP solution as "quick win".
- The need to consult with landowners at an early stage was also raised. This is something AECOM are aware of and once feasibility of options is fully known, this will be undertaken. It was emphasised that locations are theoretical at this stage and purely for feasibility.
- There was still some concern about management of commercial forestry in the catchment and that the Talatoll scheme will result in more clear felling. AECOM reiterated the input Forestry Commission is having as the regulator to the private company RDS. Attendees expressed the view that the town is now exposed due to the clear fell of forestry upstream.
- Residents raised concern that in the past property owners along the river would have maintained the channel themselves but now this is not allowed by SEPA and residents feel this is a large contributor to flooding. The community want to see the channel taken down to its historic level. Then the longer term is the soft approach upstream.

8.2 Summary of Q&A Session

Following the AECOM led presentation (introduced by Graham Nash of ABC and delivered by Sally Homoncik and Aisling McGilloway of AECOM), the Q&A session considered the following raised points:

Q - Can we test the options we are proposing in the hydraulic model? Can we bring this to the next event?

A – Yes we have already done some high level checks and will fully test the final options in the model.

Q – What would be the benefit of removing the weir? Would there be any negative influence?

A – Removal of the weir reduces water levels locally, and in conjunction with removal of sediment in the channel upstream, reduces water levels as far upstream as the main road bridge. One clearance of sediment would likely be required and increased velocities in the channel following removal of weir would likely prevent sediment building up again without the need for continual dredging. However, higher velocities may create risk of bank erosion and stability but this would be fully assessed and designed for. Removal of the weir may result in higher flows downstream but there are no sensitive receptors here so this is unlikely to be an issue.

Q – Would weir removal trigger bank erosion? It was noted during the 2012 flood; the river covered a wide area and did a lot of damage along banks downstream. Sand martins were affected that year and footpath affected. This would need to factor into the design.

A – Yes there is potential for this and a full hydromorphology assessment would be required to look at velocities and shear stresses to determine if bank protection is required to prevent erosion. Points have been noted for future consideration. ABC stressed their key requirement would to make sure there are no detrimental impacts to any base conditions.

Q – What impact will the proposed Scottish Water work to existing pipe bridge have on channel capacity?

A – AECOM and ABC have fed back through planning process that there was potential to reduce the already limited channel capacity with gabions that were originally proposed. Scottish Water have taken on board these comments and the design has since been amended to remove gabions.

Q – Where would money for PFP come from for individuals?

A – ABC could provide PFP to affected houses under Scottish Government funding as a community wide scheme if this was found to be the most cost effective option. Exact mechanism of this would need to be decided as there is no specific council policy at present. This could be through a grant scheme or purchased and installed by ABC. Maintenance and operation of any PFP would then fall on the homeowner. Maintenance is a challenge and is essential for the long term life of these measures.

Q – What are the potential timescales and sources of funding? Residents view that the channel capacity needs to increase now in tandem with other measures and some sort of a cohesive scheme around properties in the village. Would different measures proposed be tied together/complement each other?

A – The solution which comes out of the next phase will drive the answers to this. A more engineered capital scheme such as direct defences or upstream storage would go into prioritisation for SG funding under Flood Risk Management Act cycles. However, this would be funded from cycle 2 which begins in 2022 and is based on national prioritisation. Alternative sources for NFM measures were discussed including SRDP, Ecological Focus etc. These will be further explored and it may be measures are done in stages. This is likely a quicker route. A catchment management scheme similar to those developed by Tweed Forum would be beneficial.

However, ABC acknowledged that residents would not be left alone to drive a catchment scheme. This would need a partnership approach with guidance provided from different statutory representatives and officer support from ABC. Formation of a Flood Action group to drive this and to develop resilience measures is a good starting point.

Q –Have AECOM/ABC come across uncooperative landowners elsewhere?

A – Yes that happens but we do our best to work with people and can only progress options that are agreed. Consultation with landowners will be a key part of the process once we know which options are likely to give the best return.

Q – Queried the benefit of understory planting in some of the areas of existing woodland marked. There may not be much opportunity as there is a lot of rhododendron on the existing old/native woodland although some of this has been cleared due to disease.

A – Noted and will be considered moving forward.

Q –Wetlands sound like a good option but should these be looked at higher up in Forestry? Has bad practice been rectified? Is there more that could be done? Who could look at that?

A – This is out-with AECOM's remit and we've made that clear. We don't believe there is much more to be done in the forestry that hasn't already been taken on board by RDS or will be worked through with FC. The areas are commercially sensitive and wetlands here pose the risk of great impact for only a minor gain. Our modelling shows that the forestry provides a significant benefit to the town in terms of reducing flood risk.

Q –1982-2012**,** Allt Mor rose but never overtopped many times. Then clear felling led to the flood in 2012.

A – Bad practices are known to have contributed to the severity of that flood event. FC are working with RDS to ensure this doesn't happen again. ABC have also noted that ditches and drains for surface water have been cleared.

9. Scoring the long list

To robustly and clearly screen the long list of options to a short list, a high level scoring system was developed. This considered stakeholder views and expert judgement on feasibility in terms of technical, legal, financial and environmental aspects of the proposals. **Table 4-1** sets out the criteria used for screening out unfeasible or unrealistic options. Expert judgement was involved in making these decisions, which involved some elements of subjectivity however by consulting main stakeholders and being transparent in our approach we have been able to appraise each measure fairly.

Each criterion, of which there are 4, was scored out of 5, with 5 being the highest available score and 1 being the lowest. The total available score is 20. A score of 5 was given to options that categorically had no obstacles whereas a score of 1 was given to options that had many obstacles already apparent that are thought to be substantially prohibitive. Where there were no real positives or negatives against an option it has been given a score of 3.

For example, if an option is clearly technically feasible it would score 5, and if legally there was no known obstacles such as land ownership it would also score a 5 and finally if the option was going to be extremely costly and the expert's opinion was the impact would be limited, the score for cost would be 1. If there were no real environmental benefits or negatives a score of 3 would be granted. This would give a total score of 14, which could be ranked against other options.

The scoring of the options is set out in **Table 9-1** along with the key decision points raised by ABC, FC, SW, SEPA, and the public noted. Where a score of 12 or more was achieved the option has been taken forward to the short list for more detailed assessment and appraisal during Phase 4.

A summary table has also been provided (**Table 9-2**). Options highlighted in green in this table have been taken forward whilst those in red have been discounted and discussed in **Section 10.1.** Where an option is being taken forward as an action for a third party or the impacts of the options require further discussion with third parties or more data gathering they have been highlighted in orange.

Table 9-1 Long List Screening

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
Local Options	Maintenance - quick win	Redirect overland flow and drainage to the unnamed watercourse.	1.1	Reduce surface water runoff flooding down old road through Clachan and subsequent tarmac damage.	• Potential quick win where maintaining ditch would allow flow which should be going to burn to get there. This would prevent fast flow down road as seen in the 2016 storm event where road surface was badly damaged • A trash screen or more frequent maintenance of the culvert may be of benefit • It would be useful to review potential for NFM to reduce flow to this drain • Discussion with landowners at Caravan Park will be required. • Potential to look at resilience whereby regrade road so that in event of blockage the 1 in 200yr flow would shed to fields rather than down road. • Initial works have already been undertaken by ABC operations with regard to upgrade of culvert down the road and building up of verge at intake for local storage when inlet is choked and to direct exceedance away from the village - can be taken off list as being dealt with and flagged as ongoing maintenance requirement 5	• Although naturally water should be going to Clachan Burn, potential for this measure to affect to Caravan site. Landowner may be required to undertake maintenance work. • SEPA felt no real issue here if water should be draining here naturally and would support this as a quick win. 4	• Low cost quick win which could be taken on by roads team. • Re-grading would incur a higher cost 4	• FC queried if there is potential to look at this as more of a land use management issue by capturing flow at source and directing to original catchment. Feeling was there is a capacity issue here also and may direct overland flow paths more towards village than current mechanism. ABC also raised a lot of complex drainage routes feeding culvert which haven't been identified so this would be challenging to do with confidence in impacts. • Two related points worth considering: potential to split/interrupt flow along long ditch so that smaller, more manageable volumes discharge elsewhere, such as directly downslope to Clachan Burn; and, case for considering soil condition in local fields to see if can reduce surface runoff via soil improvements or targeted tree planting. • No real issues from environmental perspective 3	18	A3
	Property Flood Protection	Assess properties within 0.6m flood depth as optimum for PFP as a resilience rather than prevention technique.	1.2	At targeted properties in village	• Would offer lower standard of protection to some properties • Properties are all unique so would require surveys to understand requirements • Currently no real uptake – a few people have airbrick covers as these are quite low cost. Along Allt Mor footbridges have been raised to reduce blockage risk and garden walls raised in response. • Potential to allow quick solution • Can be less public confidence in these measures but there seemed to be an appetite for this from some residents at public consultation as a quicker solution • Does not reduce flood risk to other infrastructure such as roads • Depending on flood routes, all properties in a block may need to be protected • Relatively low flood levels at more frequent events which could make it more feasible compared to direct defence 4	• No council policy but could implement as part of a scheme if shown to be most cost-effective solution • Owner needs to be responsible for maintenance etc. • Is there an issue of blight on a property? 3	• SFF offered to support. We could reach out to them to carry out surveys to reduce costs and provide support. • Issue in how this is funded as homeowner may struggle to resource • Needs to be replaced every 25 – 30 years –uncertainty in who takes on this cost 3	• Prevention of flood water entering home • Low intensity local measure with no negative environmental impact 4	14	A3
	Ongoing Forestry Management	Ensuring best practise is adopted	1.3	Clachan village	• Hard to capture in this study as FC have governance over this issue • Modelling assessment of impact of past clear-felling on flood flows during baseline assessment indicated felling is not fully responsible for flooding issues. • FC noted previous instances of poor restocking practice, which have been raised with forest manager and action taken to remedy issues. Effects of poor practice have been localised and assessed as highly unlikely to impact on downstream flooding. Forest manager is required to implement good forestry practice in line with the UK Forestry Standard. • NS mentioned consultation on EIA for Talatoll is closed 26th February. Feeling that the scheme has been well assessed by FC and will likely have flood risk benefit to Clachan. 4	• It is a condition of Forestry grant approval that good forestry practice is applied in line with the UK Forestry Standard, which sets out a range of legal and good forestry practice requirements – powers are there to ensure impact is positive. • Limited in providing more than guidance under ABC remit which FC are already undertaking. 3	• FC responsibility to regulate commercial forestry which involves relatively low cost and is in line with good practice • Grant scheme is financial incentive for good practise • Good practise is low cost and would not need to come from ABC budget 5	• Good practice also helps to ensure other soil and water quality benefits, including protecting water quality and biology. • It will take considerable time for the full benefits of the forest planting to be realised however in the context of climate change this is a reasonable timescale. Also some benefits will be quickly realised such as improvements to soil infiltration. 5	17	N/A

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
Local Options	Self Help	This includes preparing a flood plan and flood kit, installing property flood protection, signing up to Floodline and Resilient Communities initiatives, and ensuring that properties and businesses are insured against flood damage.	1.4	Clachan village	• Active and engaged community so setting up a resilience group could help in short term • Flooding pods – Containers within the community with small scale food gates and sandbags etc. Clackmannanshire as example. • Would people need support & training in setting some of the apparatus up? • Needs coordinated approach but could work as interim measure • SEPA operate regional flood warning for Argyll and Bute so community should be encouraged to sign up for these updates • Will not solve flood risk but will help resilience. 4	• Would Council take over stocking and maintenance of these pods? 3	• Fairly low cost • Uncertainty over how this would be funded. 3	• Doesn't provide any environmental benefit or negative impact 3	15	N/A
NFM – Surface Water Management	Tree planting in the form of cross contour buffer strips.	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.1	Reduce flooding through Balinakill, across fields and on A83 from rapid surface water runoff.	• Full impact would not be realised immediately but a variety of planting & natural structures could be used • Enhancing existing buffer strips so not technically challenging • Easy to target slopes contributing greatest runoff • As with all NFM measures, there is less confidence than with traditional hard engineering solution • Low standard of protection likely as a standalone option • Local community feel water should be captured higher in the catchment, however these measures target rapid surface runoff and less so Clachan Burn flows • Testing would need to be done to ensure hydrographs peaks are not synchronised. • FCS indicated that we need to consider source of runoff, with photos showing large volumes that may result from stream overflow. Such volumes could overload buffers. • Difficult to test as robustly for smaller ditches/overland paths based on current DTM and survey. Should be explored as it's own study with refined ground model developed. 3	• Landowner buy in required but schemes available for compensation • Grant system is dependent on long term maintenance so there is incentive to make sure it stays effective • Will require catchment/joined up approach to implement and clear setting out of responsibilities as landowners 3	• Low cost with other funding streams available SRDP • Responsibility would be on landowner to maintain but the grants support this long-term maintenance • Would work well as community driven scheme 4	• Creates/improves ecological corridors and links • Benefits soil protection • Low intensity 5	15	A4
	Understory planting in existing woodland	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.2	Reduce flooding through Balinakill, across fields and on A83 from rapid surface water runoff.	• Full impact would not be realised immediately but a variety of planting & natural structures could be used • As with all NFM measures, there is less confidence than with traditional hard engineering solution • Low standard of protection likely as standalone option • Much of the existing woodland around Balinakill is on steep slopes therefore these measures have good potential to reduce runoff • Difficult to test as robustly for smaller ditches/overland paths based on current DTM and survey • Less potential due to invasive species	• Landowner buy in required but schemes available for compensation • Grant system is dependent on long term maintenance so there is incentive to make sure it stays effective 3	• Low cost with other funding streams available SRDP • Responsibility would be on landowner to maintain but the grants support this long-term maintenance • Would work well as community driven scheme 4	• Creates/improves habitat • Benefits soil protection • Low intensity 5	15	A4

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
					3					
NFM – Surface Water Management	Hedgerow planting and associated swales	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.3	Reduce flooding through Balinakill, across fields and on A83 from rapid surface water runoff.	• Full impact would not be realised immediately but a variety of planting & natural structures could be used • Enhancing existing buffer strips so not technically challenging • Easy to target slopes contributing greatest runoff • As with all NFM measures, there is less confidence than with traditional hard engineering solution • Low standard of protection likely as standalone option • Difficult to test as robustly for smaller ditches/overland paths based on current DTM and survey 3	• Landowner buy in required but schemes available for compensation • Grant system is dependent on long term maintenance so there is incentive to make sure it stays effective 3	• Low cost with other funding streams available SRDP • Enhance field boundaries so available land retained • Responsibility would be on landowner to maintain but the grants support this long-term maintenance • Would work well as community driven scheme 4	• Creates/improves ecological corridors and links • Benefits soil protection • Low intensity 5	15	A4
	Land management measures	Farm measures to improve soil infiltration and soil water storage on agricultural land, to reduce surface runoff	2.4	Farm measures to improve soil infiltration and soil water storage on agricultural land, to reduce surface runoff	• Individual farmers can reduce soil compaction through mechanical aeration. • Livestock rotation management may ease pressure • Avoid using heavy machinery on wet soils • Overseed grassland to increase infiltration (e.g. Clover) • Winter cover crops can help reduce soil loss 3	• There should be no legal constraints 3	• Low cost measures 4	• Benefits soil protection • Low intensity 5	15	A4
	Leaky barriers on steep watercourses	Increase roughness, reduce risk of blockage and coarse sediment and reduce flooding through Clachan	2.5	Increase roughness, reduce risk of blockage and coarse sediment and reduce flooding through Clachan	• These tributaries are predominantly in existing wooded areas and therefore adding some woody structures into these would be in keeping with their natural form and wood material would be readily available. • Structures would be designed to capture trash, reducing the risk of blockages downstream. • Would need to check storage behind leaky dams wouldn't adversely impact farming land unless by agreement • As with all NFM measures, there is less confidence than with traditional hard engineering solution • Low standard of protection likely as standalone option • FC highlighted these measures wouldn't provide much storage given how steep much of the watercourse is but would slow flows and reduce blockage. • Potential scour of banks could be an issue • NS raised issue that new flow routes to previously unaffected properties must be avoided. This will be checked in modelling. 4	• This type of measure could work well within a catchment partnership group project • Landowner buy in needed 3	• Low cost intervention and again could be volunteer lead • Link up with RDS to source materials for leaky dams 4	• No real environmental impact during "construction" compared to traditional scheme , low plant and labour intensity • Potential benefits include: morphological diversity for aquatic life, rooting habitat and areas of growth for microbes, algae and fungi • If fish are present they may create a barrier so would need to be appropriately designed 4	15	A4

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
NFM measures – Clachan catchment	Wetland enhancement to south east of Balinakill	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	2.6	Reduce runoff to small watercourse and therefore Clachan Burn	• Technically feasible as the area is currently wet and this would be enhanced. • As with all NFM measures, there is less confidence than with traditional hard engineering solution • Benefit may be limited without large engineered structure to impound i.e. much smaller % of peak flow reduction and less attenuation capacity compared to an engineering solution shown with modelling • Likely to be one of many solutions – no one solution likely for Clachan • Leaky barrier within this reach of low-moderate gradient would promote out-of-bank flows and flood water storage. 4	• Landowner buy in needed – currently not useful ground so likely to be positive interaction 4	• Additional sources of funding available • Fairly low cost for probably a reasonable degree of attenuation • Long term maintenance cost requirements are minimal • Compensation would be required • Maintenance cost would be much lower than with an engineered solutions 4	• Provide a gain in biodiversity. Wetland conditions and planting would likely cause new species to establish and create diversity in what is already there • Highly unlikely to have negative impact on existing species as we are enhancing current land condition 4	16	A5
	Wetland enhancement & ditch blocking to north of Scotmill	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	2.7	Attenuate flow from several sub-catchments on Clachan Burn	• Technically feasible as the area is currently wet and this would be enhanced. • Artificial ditching to be blocked and enhanced with planting to create the wetland • Location identified is one of the highest runoff contributing catchments so makes sense to target here. Also, no lochs and limited tree planting on this subcatchment • Attenuation/storage is limited without engineered structure though would still provide reasonable benefit at lower return periods as illustrated by testing in model • Access may be an issue. There is a private track and then access by foot. Temporary access track would need to be constructed. However, long term maintenance would be minimal and would not require heavy machinery so not a long-term issue • Given isolated location unlikely to require permeant walking access. However, if there was an appetite in community to explore this it could be investigated. • As with all NFM measures, there is less confidence than with traditional hard engineering solution • General feel that this is a good option with support for capturing more flow upstream • Modelling indicates potential benefit. 4	• Storage without reservoir implications • Landowner buy in needed – currently not useful ground so likely to be positive interaction • If desire for future public access would need to assess access and land requirements 4	• Additional sources of funding available • Fairly low cost for probably a reasonable degree of attenuation • Long term maintenance cost requirements are minimal compared to hard engineered structure • Compensation would be required • Maintenance cost would be much lower than with an engineered solutions 4	• Provide a gain in biodiversity. Wetland conditions and planting would likely cause new species to establish and create diversity in what is already there • Highly unlikely to have negative impact on existing species as we are enhancing current land condition • Main area of habitat in catchment based on habitat mapping so would make sense to enhance this 5	17	A5
	Riparian woodland	To increase roughness higher in catchment to create restriction and storage for flood water	2.8	Increase roughness of the Clachan Burn corridor to reduce flooding from Clachan burn	• Lag time in effectiveness for tree growth • Increase infiltration and limit overland flow paths through simple intervention. • Would be enhancing riparian corridors already in place • As with all NFM measures, there is less confidence than with traditional hard engineering solution • Would have less impact than larger measure but could add to cumulative gain across catchment 3	• Landowner buy in • Maintenance responsibility of landowner supported by grants to incentivise 3	• Other funding sources • There may be an impact on farming activities including the need for additional fencing and livestock watering arrangements, therefore compensation may be required. 4	• Enhance ecological corridors along banks and improve bank stability • Water quality and shade benefits • FC and SEPA supportive of this • Aid to reduce climate change 5	15	A5
	Wetland enhancement & ditch blocking to south west of Loch nan Gad	Provide storage and attenuation to reduce flows entering Clachan	2.9	Attenuate flow on Clachan burn	• Technically feasible as the area is currently wet and this would be enhanced. • Artificial ditching to be blocked and enhanced with planting to create the wetland • Location identified is one of the highest runoff contributing catchments so makes sense to target here. Also, no lochs and	• Storage without reservoir implications • Landowner buy in needed 4	• Additional sources of funding available • Fairly low cost for probably a reasonable degree of attenuation • Long term maintenance cost	• Provide a gain in biodiversity. Wetland conditions and planting would likely cause new species to establish and create diversity in what is already there • Highly unlikely to have negative impact on existing species as we are enhancing current	18	A5

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
NFM measures – Clachan catchment		Burn higher in catchment			limited tree planting on this subcatchment • Attenuation/storage is limited without engineered structure though would still provide reasonable benefit at lower return periods as shown in model testing. • Access may be an issue. There is a private track and then access by foot. Temporary access track would need to be constructed. However, long term maintenance would be minimal and would not require heavy machinery so not a long-term issue • Given isolated location unlikely to require permeant walking access. However, if there was an appetite in community to explore this it could be investigated. • As with all NFM measures, there is less confidence than with traditional hard engineering solution 4		requirements are minimal compared to hard engineered structure • Compensation would be required • 4	land condition 5		
	Reduce sediment input to Clachan watercourses	Reduce impact of flooding in Clachan by reducing build-up of coarse sediment in low gradient sections and at structures	2.10	Reduce impact of flooding in Clachan by reducing build-up of coarse sediment in low gradient sections and at structures	• Sediment sources are likely to be local to the channel bed and banks containing glacial till deposits along with some inputs from forestry tracks and other manmade structures. No large scale erosion is seen in the catchment, and therefore it is unlikely that a feasible method of reducing erosion could be implemented. • Fine sediment delivery is likely from felled forestry areas and through farming practices. These could be reviewed as part of NFM work and through continued guidance from FC to RDS. • Limited opportunity to place physical solution to manage this. Operating best practise would be more appropriate. 2	• Need for landowner buy in, do this through NFM network • It is a condition of grant approval that good forestry practice is applied in line with the UK Forestry Standard, which sets out a range of legal and good forestry practice requirements –good practise will reduce sediment from felling. 2	• Fairly low cost to do this as NFM 4	• Provide a gain in biodiversity. • Enhance ecological corridors along banks and improve bank stability 3	11	N/A
Hard engineered options	Weir modification/or removal	Weir modification/or removal	3.1	Potential to reduce backwater effect and reduce flood levels up to road bridge.	• Little merit in having notch in weir given flashy response of burn but removal of weir could eliminate backwater effect • Ensure there is no scour/erosion of road bridge upstream by changing flow regime which could undermine foundations • Need to ensure no bank erosion due to increased velocities • Impact downstream would need to be assessed, although there are no vulnerable receptors downstream • Unlikely to solve all issues as weir is drowned in more extreme events but may provide benefit for more frequent flood events and work in tandem with another options • Issue of sedimentation due to weir – can see islands forming in river. Local view is if this impact could be removed it would increase capacity of Burn which is main driver of flooding • No modern purpose – previously diverted fish to other watercourse. So no functional issue to remove • Certain balanced level of investigation is required at this stage – knowing if it would have enough of an impact on flood levels before full hydromorphological assessment • Modelling has indicated benefit of removing weir and managing sediment build up associated with it. 5	• Not historically significant so no challenges from this aspect • Landowner is supportive • Risk of bank instability would be owned by ABC 4	• May require additional works such as bank protection which may be costly • Small-scale weir so not likely to be intensive construction cost wise • Other sources of funding available e.g WEF 5	• Removing barrier to fish may improve channel migration • Should extensive erosion protection be required may not be acceptable to ABC and SEPA • There should be an overall benefit to natural sediment transport processes • SEPA hydromorph team will feed in comments from RBMP perspective 5	19	A6
	Upstream storage area	Upstream storage area	3.2	Attenuate flow upstream to protect village.	• This would be at proposed wetland location • Would realise significant storage with structure in place therefore increased attenuation • More control in what can be designed in terms of pass forward flows • Would need a permanent access which will be challenging	• May fall under reservoirs act – more stringent safety legislation and inspection/maintenance regime ABC would have to take on • Would go through FRM Act	• Would need to buy footprint of structure and access – increase cost • Flooded land would also require compensation • Given number of properties impacted and typical capital	• No real ecological benefits as would not be permanently wet so no species to be gained. • Permanent less natural structure which may disrupt species	11	A7

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
					given current arrangements and levels • Would need to be designed to meet Reservoir Act requirements which would be much onerous on ABC with regard to spillway requirements and dam height • Modelling indicated reasonable benefit 4	as scheme so would go into prioritisation 3	cost of scheme like this it is likely to be difficult to achieve positive benefit cost ratio 2	2		
Hard engineered options	Flood defences – embankment or wall	Flood defences along the Clachan Burn at vulnerable locations in the village	3.3	Protected properties along banks of Clachan and Allt Mor Burns	• 1 in 200yr flood level unlikely to be appropriate here as this would block river connection • Likely this could form part of a combination option with one of the wider catchment options and be designed to lower standard of protection to balance approach • Bunds can be used where there is space to limit visual intrusion and cost. NS was v supportive of bunding along most vulnerable properties at river bank. • Confidence in solution as tried and tested • Would need to make sure higher flows being passed downstream has no bank stability issues or flood risk issue to any receptors downstream. • Appropriate back of wall/bund drainage would need to be considered to avoid walls trapping and increasing pluvial flood waters 4	• Multiple landowners to manage though feedback from consultation was supportive • Maintenance would land with council for survey etc. but this would be minimal • Residents have fed back they are more concerned about the more frequent flooding, therefore lower standard of protection may be supported 5	• Walls can be expensive but balanced approaches in terms of realistic standard of protection and combination with softer option could boost changes of a positive benefit cost ratio • Most of cost is in foundation of wall so SOP will not massively change CBR • Given damages for village may be difficult to achieve unity in CBR • Health and wellbeing benefits to people's mental health seeing a visible defence line which provides confidence in SOP but conversely may take away amenity • 3	• Would block habitat corridors – surveys will reveal if this is a significant risk • Need to be designed in a sensitive manner so character of area is retained • Would significantly impact character of village 3	15	N/A
	Culvert upsize	Improve conveyance across the A83 by upsizing culvert	3.4	Reduce ponding on A83	• Information on culvert size, catchment and location is needed • Would disrupt the road significantly • Increased maintenance may be all that is needed and this should be considered • May move issue further downstream 2	• Transport Scotland culvert ownership 2	• Cost may be prohibitive – services, road digging, relaying larger dia pipe unlikely to get positive cost benefit • If only maintenance required, this should e low cost 2	• Potential for increased pollutants from road washing into river 2	8	A6
	High flow diversion channel	High flow diversion channel – divert high flows to location downstream of the village	3.5	Protect properties along banks of Clachan Burn	• Would be extremely challenging to find a route in some locations. • Likely to have access and difficult excavation issues • Would not benefit flooding from Allt Mor which also impacts village • Initial hydraulic calcs indicated significant size of culvert and excavation up to 6m would be required in parts making options technically challenging for limited return 2	• Multiple landowners • Impact on utilities would need to be agreed • Ongoing maintenance for ABC 3	• Highly expensive due to length required and pipe would need to be reasonably large due to size of catchment to convey high flows in extreme event – initial costing indicates this would achieve near a CBR of 1 • Services needed to be dug up with associated fees and diversions. 1	• Would provide benefit if it was open channel but due to gradient in space this is not achievable. 2	8	A6
	Culvert upsize	Upsize culvert at driveway	3.6	Reduce ponding on A83	• The existing structure is very small and the road ditch is overgrown and blocked with silt. • Would need to make sure this doesn't exacerbate current flood conditions or move problem downstream • Would likely have minimal benefit given the size of natural drainage path	• Determine whose responsibility this culvert is 3	• This is a small length so upsizing here would be relatively inexpensive and could be undertaken under maintenance budget	• Potential for increased pollutants from road washing into river 2	10	A6

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
					2		3			
Hard engineered options	Overland flow capture	Divert overland flow from road to Balankill House back into watercourse	3.7	Reduce ponding on A83 and damage to fences	• No concrete information available on drainage network in operation around the estate buildings and the mechanisms of flooding experienced despite investigations. Difficult to propose intervention with a reasonable degree of confidence. • Minor flood risk to Clachan compared to greater fluvial sources so should be looked at as a surface water measure following study 2	• Maintenance of any new structure would be essential 3	• Likely to be relatively low cost measure 3	• No real issues. 2	10	A6
	Upstream storage area	Loch Nan Gad catchment – enhance storage CB7 with hard structure	3.8	There is potential to attenuate flow from several sub-catchments	• Makes use of topography so minimises the need for large structures. • Risk that attenuation here creates synchronisation of hydrographs peaks and exacerbates issues, but this can be tested • Modelling indicates this subcatchment is well attenuated at present therefore no real benefit to be gained by enhancing this 1	• Reservoirs Act implications and safety issues 2	• Long term maintenance needs to be considered in costing and reservoir act implications • Structure required would be small scale based on existing levels • Benefit will likely not balance cost based on benefit shown in modelling output 1	• Enhancing existing loch storage so unlikely to have negative impact apart from short term in construction which would be minimal • Need to ensure low flows are maintained for ecology in channel 3	7	A7
	Upstream storage area	Loch Chorra-riabhaich catchment – enhance storage	3.9	Potential to store more here	• NS queried potential to store additional water in this loch as it is high in catchment • AECOM feel opportunity is limited given the routing effects already in place from loch system here so capturing flow here would have limited impact compared to steeper area downstream of this loch. • Modelling has confirmed that contribution from this subcatchment is limited due to 3 lochs attenuating flow. Restricting flow from here had a very minor impact downstream on peak flows and time to peak. • Likely access would be difficult for construction 1	• Reservoirs Act • Landowner agreement needed 2	• Long term maintenance needs to be considered in costing and reservoir act implications • Structure required would be significant (100m by 1m high) which would be costly for likely limited benefit • Benefit will likely not balance cost output 1	• Enhancing existing loch storage so unlikely to have negative impact apart from short term in construction which would be minimal • Need to ensure low flows are maintained for ecology in channel 3	7	A7
	High flow diversion channel	High flow bypass channel - Maintain existing channel but remove high flows	3.1	Reduce flooding of properties along banks of Allt Mor and within Clachan	• The route indicated is slightly less complex than Clachan Burn diversion as there is more free space for a working area. • In addition the topography along the route is less extreme and excavation would be up to 2m over small sections (Figure 9 4). • A key challenge would be crossing the A83. This could be challenging depending on road make-up and if there are any existing services to work with. • 3	• Maintenance of the structure would be essential • Multiple landowners though mostly fields affected • Liaison with Transport Scotland required • Diversion of utilities would need to be agreed 3	• Could be very costly compared to damages given this will only solve issue on Alt Mor • Utilities will impact costs greatly. 2	• Flows in the main channel would require to be maintained for sediment transport processes, amenity and ecology. 3	11	A6

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
Allt Mor catchment options	Upstream storage	Modify management regime for Loch Ciaran to maximise storage available	4.1	Reduce flooding of properties along banks of Allt Mor and within Clachan	• Large storage capacity available in this the loch given surface area. However there may be limited benefit to be gained given the Loch is already attenuating 85% of the catchment to such a degree • The loch and outflow are utilised for a fish hatchery and regime changes may not be acceptable. • From last inspection some improvement works are needed to increase spillway capacity. Some options to do this, such as increasing spillway length have the potential to increase pass forward flow and consequently increase flood risk to village. Other options, such as increasing dam height could increase storage, reduce flow downstream and therefore reduce flood risk, but likely to be very challenging and expensive due to access and levels • Other options such as permanently lowering the top water level or abandoning the dam are not likely to be acceptable to the owner as this would reduce the permanent storage capacity and reduce flow available for hatchery • New inspection report is due later this year. Possible different inspecting engineer may have a different recommendation. 2	• From last inspection some improvement works are needed under Reservoir Act. These have the force of law. • Reservoir owner is responsible for what works are done – we can just begin dialogue to advise. • New inspection due this year. Possible that new inspecting engineer may have a different recommendation. Timing means it will be difficult to tie in with this study • Any safety works proposed will require planning permission. ABC Planning Dept should consider including a condition that pass forward flows are not increased or if possible are reduced for flood events up to the 1 in 200+CC year 2	• Opportunity to partner with reservoir owner if improvement works are needed soon – shared funding opportunity however likely timing of works means this is unlikely to tie in • Need to develop solution that doesn't negatively impact the economic viability of hatchery business • Costs are likely to be significant in comparison to damages from Alt Mor. Unlikely to achieve positive benefit cost ratio 2	• Could disrupt fish by changing flow regime- needs to be carefully designed 3	11	A8
	Upstream storage	Increase storage in Loch Na Beiste to maximise storage available	4.2	Reduce flooding of properties along banks of Allt Mor and within Clachan	• The existing structure is ad hoc and unlikely to be suitable for use to formally store a greater volume of water. • The catchment area to the loch is small and therefore the benefit would be minimal, flow from the loch is already controlled via pipes at varying levels and a small spillway. Limited opportunity for further flood risk benefit. • Risk that attenuation here creates synchronisation of hydrographs peaks and exacerbates issues. 2	• Reservoirs Act may be applicable if modified for larger volume of storage • Makes use of existing infrastructure so would be less intensive than new capital intervention 2	• Reservoirs Act may be applicable if modified for larger volume of storage 2	• Enhancing existing storage so limited negative influence 3	9	A8
	Natural Flood Management	Work with RDS for benefit from Talatoll scheme	4.3	The scheme may well be going ahead anyway and it can provide additional benefit through a design which considers	• Initial modelling indicates this was likely to have positive impact on Allt Mor catchment at lower return period events. As with any NFM measure there is uncertainty in this assessment compared to a tried and tested solutions. • Minor input from design team to ensure opportunities are maximised for not just good forestry practise but locating features with flood risk benefit appropriately • Would give RDS tools to build relationship with community • It will take considerable time for the full benefits of the forest planting to be realised however in the context of climate change this is a reasonable timescale. • Some benefits may be realised in the shorter term, such as increased soil infiltration.	• It is a condition of grant approval that good forestry practice is applied in line with the UK Forestry Standard, which sets out a range of legal and good forestry practice requirements • Could enforce best practise through planning consents • Community may not be supportive given current perception of forestry	• Minor input from ABC/AECOM team – low cost • Needs to be balanced with commercial viability of forestry 3	• Foresting area will have knock on positive impacts on water quality, landscape, biodiversity, carbon sequestration, and air pollution absorption etc. even though there will be a cyclical nature of felling and restocking as this is commercial enterprise • Forest rotations are likely to extend over 40-60 years and thus the cyclical nature is relatively long-term. 5	11	A8

Option Category	Type of Measure	Measure	ID	Flood receptor (location)	Feasibility – Technical	Feasibility - Legal	Feasibility - Cost	Feasibility – Environmental	Total Score	Figure Number
Allt Mor catchment options				the existing pluvial flood risk to Clachan and the A83.	• Based on feedback from FC probably not much more AECOM can add in terms of what has already been done from their side e.g. timing of planting, utilising slopes, what species are being planted, layouts – FC have fed into this and assessed are responsible for regulating this 2	• FC to enforce best management practise which will be key to this measure's success • ABC have limited powers to enforce best practice. Modelling suggests this has been the issue rather than over-felling. Will continue to engage with FC on the ongoing management of forestry. 1				
	Natural Flood Management	Tree planting and leaky barriers on tributary	4.4	Increase roughness and out of bank flow from tributary to Allt Mor	• Structures would be designed to capture trash, reducing the risk of blockages downstream. • Would need to check storage behind leaky dams wouldn't adversely impact farming land unless by agreement • As with all NFM measures, there is less confidence than with traditional hard engineering solution • Low standard of protection likely as standalone option • FC highlighted these measures wouldn't provide much storage given how steep much of the watercourse is but would slow flows and reduce blockage. • Potential scour of banks could be an issue • NS raised issue that new flow routes to previously unaffected properties must be avoided. This will be checked in modelling. 3	• Landowner buy in • Maintenance responsibility of landowner supported by grants to incentivise • 3	• Other funding sources • There may be an impact on farming activities including the need for additional fencing and livestock watering arrangements, therefore compensation may be required. • 4	• Enhance ecological corridors along banks and improve bank stability • Water quality and shade benefits • FC and SEPA supportive of this • Aid to reduce climate change • 5		A8
	Wetland enhancement	Wetland/ storage area on right bank of Allt Mor	4.5	Increase floodplain storage	• Technically feasible as the area is currently wet and this would be enhanced. • As with all NFM measures, there is less confidence than with traditional hard engineering solution • Likely to be one of many solutions – no one solution likely for Clachan • Modelling indicated reasonable benefit for further assessment at 1 in 25year in terms of storage and increasing time to peak 4	• Landowner buy in needed – currently not useful ground so likely to be positive interaction • Compensation would be required • Maintenance cost would be much lower than with an engineered solutions • Construction cost will be fairly small scale 4	• Additional sources of funding available • Fairly low cost for probably a reasonable degree of attenuation • Long term maintenance cost requirements are minimal 4	• Provide a gain in biodiversity. Wetland conditions and planting would likely cause new species to establish and create diversity in what is already there • Highly unlikely to have negative impact on existing species as we are enhancing current land condition 4		A8

9.1 Long List Summary Score Summary

Table 9-2 Long List Score Summary Table

Option Category	Type of Measure	Measure	ID	Feasibility				Total Score	Figure
				Technical	Legal	Cost	Environmental		
Local Options	Maintenance -quick win	Redirect overland flow and drainage to the unnamed watercourse.	1.1	5	4	4	3	18	A3
	Property Flood Protection	Assess properties within 0.6m flood depth as optimum for PFP as a resilience rather than prevention technique.	1.2	4	3	4	4	15	A3
	Ongoing Forestry Management	Ensuring best practise is adopted	1.3	4	3	5	5	17	N/A
	Self Help	This includes preparing a flood plan and flood kit, installing property level protection, signing up to Floodline and Resilient Communities initiatives, and ensuring that properties and businesses are insured against flood damage.	1.4	4	3	3	3	15	N/A
NFM – Surface water management	Tree planting in the form of cross contour buffer strips.	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.1	3	3	4	5	15	A4
	Understory planting in existing woodland	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.2	3	3	4	5	15	A4
	Hedgerow planting and associated swales	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.3	3	3	4	5	15	A4
	Land management measures	Farm measures to improve soil infiltration and soil water storage on agricultural land, to reduce surface runoff	2.4	3	3	4	5	15	A4
	Leaky barriers on steep watercourses	Increase roughness, reduce risk of blockage and coarse sediment and reduce flooding through Clachan	2.5	4	3	4	4	15	A4
Clachan Burn – NFM options	Wetland enhancement to south east of Balinakill	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	2.6	4	4	4	4	16	A5
	Wetland enhancement & ditch blocking to north of Scotmill	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	2.7	4	4	4	5	17	A5
	Riparian woodland	To increase roughness higher in catchment to create restriction and storage for flood water	2.8	3	3	4	5	15	A5

Option Category	Type of Measure	Measure	ID	Feasibility				Total Score	Figure
				Technical	Legal	Cost	Environmental		
	Wetland enhancement & ditch blocking to south west of Loch nan Gad	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	2.9	4	4	4	5	18	A5
	Reduce sediment input to Clachan watercourses	Reduce impact of flooding in Clachan by reducing build-up of coarse sediment in low gradient sections and at structures	2.10	2	2	4	3	11	N/A
Hard engineered options	Weir modification/or removal	Weir modification/or removal	3.1	5	4	5	5	19	A6
	Upstream storage area	Upstream storage area	3.2	4	3	2	2	11	A7
	Flood defences – embankment or wall	Flood defences along the Clachan Burn at vulnerable locations in the village	3.3	4	5	3	3	15	N/A
	Culvert upsize	Improve conveyance across the A83 by upsizing culvert	3.4	2	2	2	2	8	A6
	High flow diversion channel	High flow diversion channel – divert high flows to location downstream of the village	3.5	2	3	1	2	8	A6
	Culvert upsize	Upsize culvert at driveway	3.6	2	3	3	2	10	A6
	Overland flow capture	Divert overland flow from road to Balinakill House back into watercourse	3.7	2	3	3	2	10	A6
	Upstream storage area	Loch Nan Gad catchment – enhance storage CB7 with hard structure	3.8	1	2	1	3	7	A7
	Upstream storage area	Loch Chorra-riabhaich catchment – enhance storage	3.9	1	2	1	3	7	A7
	High flow diversion channel	High flow bypass channel - Maintain existing channel but remove high flows	3.10	3	3	2	3	11	A6
Allt Mor Options	Upstream storage	Modify management regime for Loch Ciaran to maximise storage available	4.1	2	2	2	3	9	A8
	Upstream storage	Increase storage in Loch Na Beiste to maximise storage available	4.2	2	2	2	3	9	A8
	Natural Flood Management	Work with RDS for benefit from Talatoll scheme	4.3	2	1	3	5	11	A8
	Natural Flood Management	Tree planting and leaky barriers on tributary	4.4	3	3	4	5	15	A8
	Wetland enhancement	Wetland/ storage area on right bank of Allt Mor	4.5	4	4	4	4	16	A8

10. Short List

Following the screening exercise, the short listed options are set out in **Section 11**. A more detailed discussion of reasons for removing options is set out in **Section 10.1**.

The remaining short list has discounted options which are not technically, economically, legally or environmental feasible when weighing up potential benefits against opportunities and constraints of each option. Those which remain will be investigated more thoroughly in terms of their performance with regard to flood risk which will be informed through detailed modelling and the benefits to be gained for each option in terms of economic damages avoided, environmental benefit from human an natural impacts and social benefits.

10.1 Discounted Options – reasoning

10.1.1 Improve conveyance of ditch – North side of Clachan

Option 1.1 has been identified as a 'quick win' for ABC through improved maintenance and is therefore removed from the flood study.

10.1.2 Ongoing forestry management

Option 1.3 ongoing forestry management has been highlighted as an action that should be taken as ongoing dialogue between ABC, FC and the operator. It arose from the early dialogue with the Clachan community that there is a perception that poor forestry management practices have contributed to flooding events in recent years. This has been assessed using the 2D catchment model. Analysis indicated that felling has not contributed significantly to flood risk therefore it is possible that local instances of poor practice have contributed to flood risk rather than felling itself.

FC have been involved in this project since the outset and are obligated/committed to regulating forestry practises in the catchment to enforce good practise. As such this option is out with formal ABC regulation so has been taken off the long list of options.

10.1.3 Surface water measures

It should be noted at this stage that measures to manage surface water flooding (2.1 – 2.5) have been removed from the short list. As stated previously, these are out-with the scope of this study and cannot be suitably tested within the current modelling approach.

The recommended options however should be taken forward for advisement to ABC following completion of this study and considered to enhance with any land management or catchment approach. Further to this, some of these options were identified as quick wins to be taken forward by the council and are discussed in **Section 11.**

10.1.4 Reduce sediment input to Clachan watercourses

Sediment build up has been flagged as an issue in the Clachan Burn. The main driver for this is largely the weir causing restriction on the burn causing sediment to build up. Woody debris has been noted as an issue in the past as this is a heavily forested catchment. The worst instances of this was during the 2015 event though this was believed to be result of poor forestry practise and clear felling which has now been addressed and will continue to be monitored by the Forestry Commission. Given the removal of the weir is being assessed as a standalone option it is likely this will manage the worst of the sediment issues in the catchment.

Ensuring appropriate forestry and farming practises on a catchment wide scale as part of improved catchment management is likely to be more suitable than deploying infrastructure such as catch pits. These are likely to be difficult to target given the widespread of commercial and ancient woodland as well as farmed areas across the catchment. A Catchment partnership group could facilitate this and should be considered as part of "Self help" option and as part of a wider NFM approach. As such this option has been removed from the short list for further appraisal but taken on board as a shared management requirement for the different responsible authorities.

10.1.5 Storage in the upper Clachan Burn catchment

Option 3.2, engineered storage on the Clachan Burn, has been tested by hydraulic modelling and is likely to have a reasonable reduction in flood risk from the Clachan Burn. However, an approximate estimate of capital construction cost for an embankment of this size would be in the region of £610K for the impoundment structure alone based on typical Environment Agency unit costs for similar projects. In the context of the economic damages estimated for this region partnered with the fact that this solution would not resolve flooding from the Allt Mor, this option is deemed to be too cost intensive for the likely benefit in terms of damages avoided.

10.1.6 Culvert upsize at A83

Option 3.4, improve conveyance across the A83 by upsizing culvert was removed as this would be technically challenging to construct given the need to excavate the road surface which would also likely cut Clachan Village off as there is no alternative diversion route. This option is likely to be cost prohibitive for the gain in flood risk protection and may move issues downstream as there is no attenuation provided.

10.1.7 Diversion from Clachan Burn upstream of village to downstream of weir

Option 3.5, a diversion channel from the Clachan Burn which would divert high flows from the channel directly upstream of the village, and return them to the river where the channel has greater capacity has been considered. The indicative route is shown in **Figure 10-1.** The length of the pipeline would be approx. 290m with a fall of 7.5m. This location was deemed to be the most suitable as it would capture flow upstream of the main properties affected and would allow the culvert to be directed along carriageway rather than private gardens.

High level hydraulic calculations were used to indicate what diameter of culvert would be required to have a flood risk benefit to Clachan. A Manning's calculation indicated the capacity of the channel at the diversion location is around $20m^3/s$ which would be exceeded at the 1 in 10 year event. A Colebrook White pipe full equation was then used to determine an appropriate pipe diameter required. Based on the existing topography and required tie in to the existing channel, a 1.6m diameter culvert would be required to provide a 1 in 100 year standard of protection from the Clachan Burn alone.

The existing topography dictates the pipe diameter required to convey the flow therefore accepting a lower standard of protection would not provide much cost saving as largely the same degree of excavation would be required to achieve a suitable gradient for gravity flow and tie in the river channel. It should also be noted that this option would not reduce flood risk from the Allt Mor.

Access would be difficult for this option, particularly upstream of the road bridge and at the caravan park due to space available. As seen in **Figure 10-2**, the depth of excavation required is also quite significant (around 3m) which would impact on costs and construction time, particularly given the large diameter of pipe required.

This option has been discounted as the technical and cost challenges around construction would outweigh the flood risk benefit achieved to Clachan.

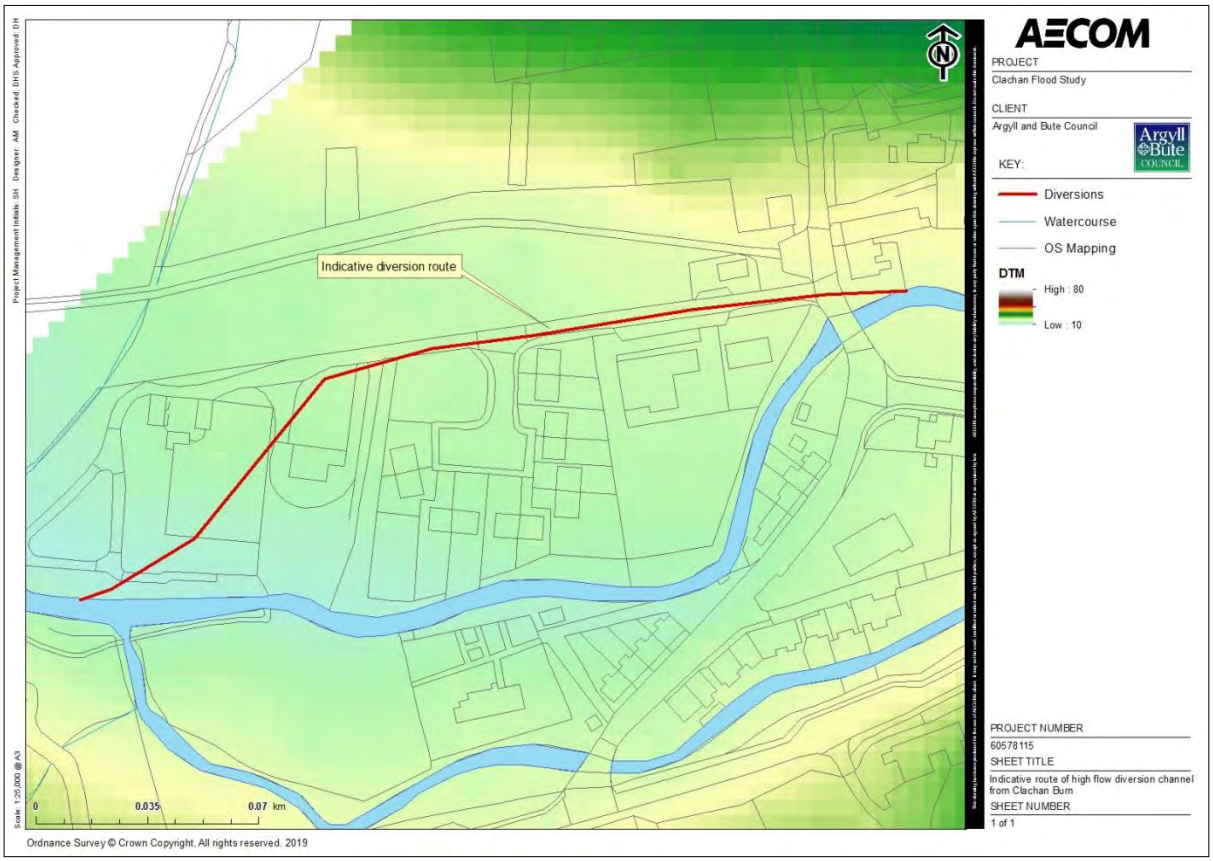

Figure 10-1 Indicative route of high flow diversion pipe from Clachan Burn

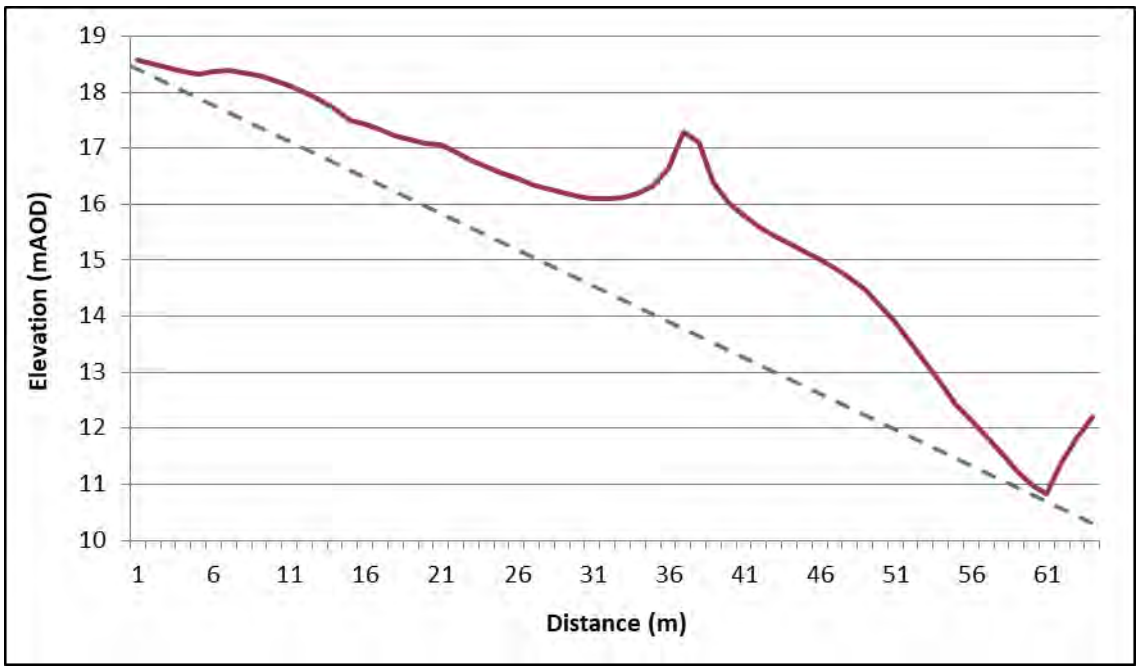

Figure 10-2 Topographic profile of indicative diversion route and possible pipeline

10.1.8 Improve conveyance of ditch and culvert at driveway

Option 3.6 has been removed but modified to be a maintenance need. It has been identified as a 'quick win' for ABC through improved maintenance and is therefore removed from the flood study.

10.1.9 Overland flow capture

Option 3.7 has been removed due to complexities in analysing where the existing drainage serves and connects. Two site walkovers and discussions with local community have not managed to ascertain where this flow is coming from. As such there is not enough technical information to assess this option fully therefore it has been discounted. Further to this, this measure is far down the catchment so it is likely other options recommended further upstream will help reduce issues from this flow path.

10.1.10 Increased storage at Loch Nan Gad

Option 3.8, storage in Loch Nan Gad has been discounted. The main reasoning is the lack of positive impact on flood risk in Clachan. Secondary to this is the construction cost and maintenance implications In addition, consulted stakeholders had reservations and these included the fact that two landowners would be affected and ABC would ultimately have to potentially buy multiple pockets of land and maintain multiple dams and outlets increasing their maintenance burden. It would also be technically challenging to gain the required storage volume and the impact of this scheme would be felt in the entire catchment above the intake.

10.1.11 Increased storage at Loch Chorra-riabhaich

Option 3.9, enhancing storage in Loch Chorra-riabhaich has been ruled out. This is mainly because of the lack of impact on flooding in Clachan Burn. The subcatchment fed by this loch is already heavily attenuated by three waterbodies therefore there is no tangible benefit in reducing this flow further.

10.1.12 Diversion from Allt Mor upstream of A83 to downstream

Option 3.10, a diversion channel from the Allt Mor Burn which would divert high flows from the channel directly upstream of the properties at the A83, and return them to the river downstream where the channel has greater capacity has been considered. The indicative route is shown in **Figure 10-3**. This location was deemed to be the most suitable as it would capture flow upstream of main properties affected and make use of available space.

As previous, high level hydraulic calculations were used to indicate the required diameter of culvert to have a flood risk benefit to Clachan. A Manning's calculation indicated the capacity of the channel at the diversion location is around $9m^3/s$ which would be exceeded at the 1 in 25 year event. A Colebrook White pipe full equation was then used to determine an appropriate pipe diameter required. Based on the existing topography and required tie in to the existing channel, a 0.75m diameter culvert would be required to provide a 1 in 100 year standard of protection from the Allt Mor alone. It should also be noted that this option would not reduce flood risk from the Clachan Burn.

The key challenges around this option are again around technical feasibility of construction. The route indicated is slightly less complex than the Clachan Burn diversion as there is more free space for a working area. The topography along the route is less extreme and excavation would be up to 2m over small sections. The length of the pipeline would be approx. 275m with a fall of 10m (**Figure 10-4**).

A key challenge would be crossing the A83. This could be challenging depending on road make-up and if there are any existing services to work around/divert. Achieving a positive benefit cost ratio is likely to be challenging with this option, given the length of the route required, particularly given the fact the option will only deal with economic damages directly from the Allt Mor. This option has been therefore been discounted on the basis that technical and cost challenges around construction would outweigh the flood risk benefit achieved to Clachan.

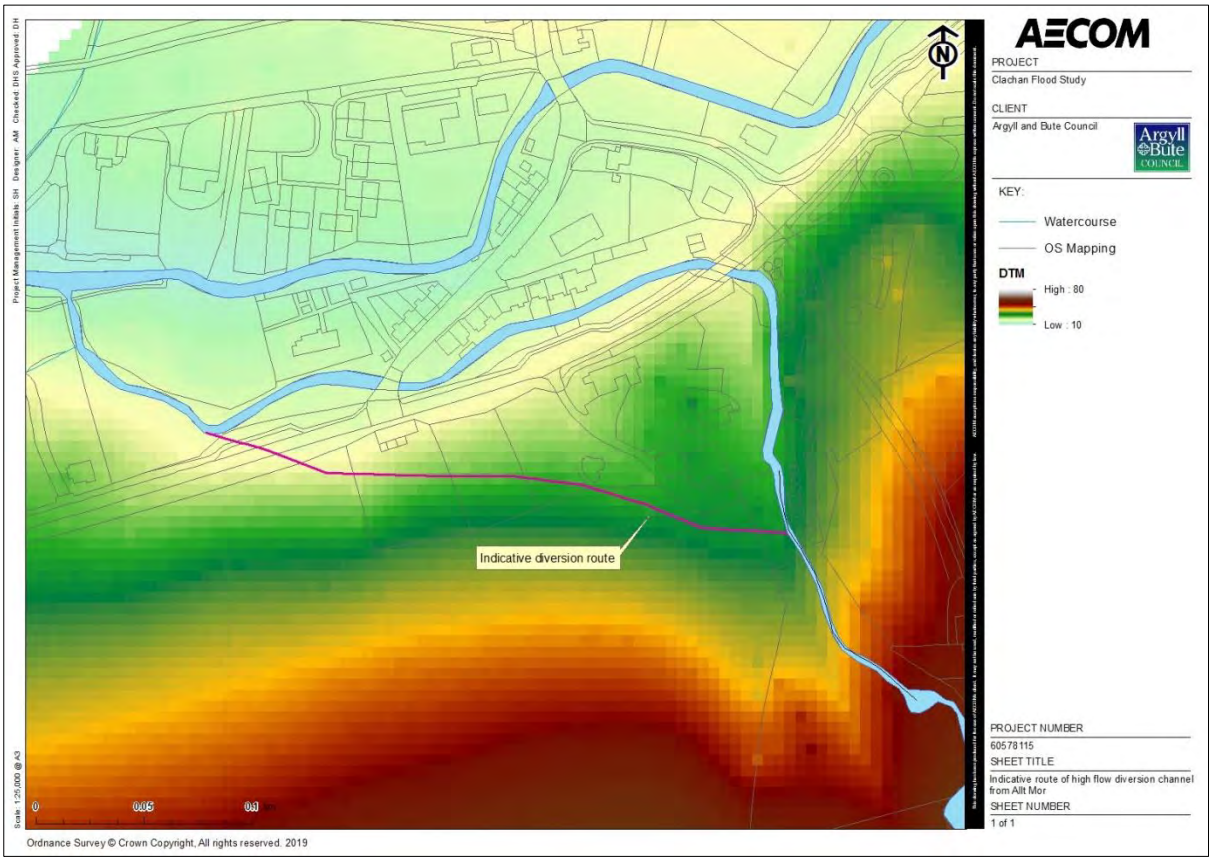

Figure 10-3 Indicative route of high flow diversion pipe from Allt Mor

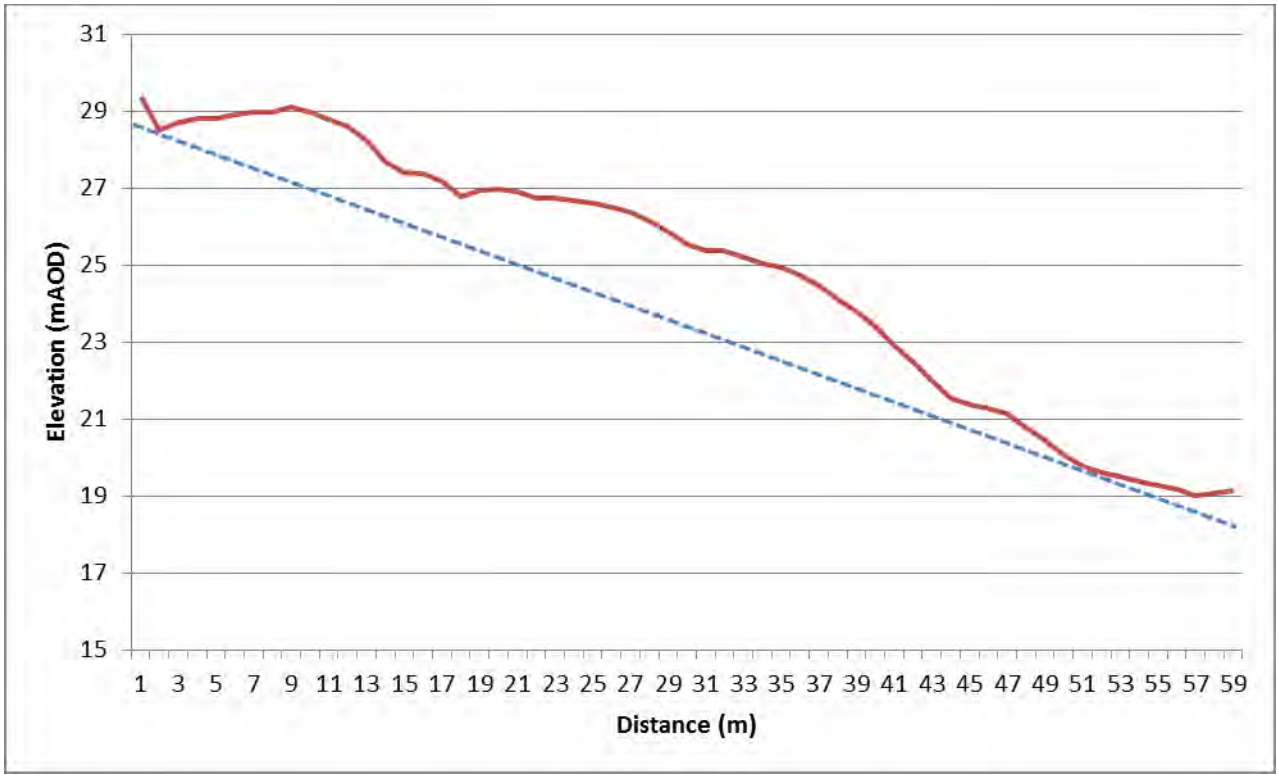

Figure 10-4 Topographic profile of indicative diversion route and possible pipeline

10.1.13 Enhance storage in Loch Ciaran

Option 4.1, enhanced storage in Loch Ciaran has been ruled out at this stage. The reasons behind this cover technical, legal and cost criteria.

From a technical perspective, the majority of the Allt Mor catchment (85%) drains through Loch Ciaran which already has a significant attenuating effect therefore there is likely to be limited opportunity to enhance this further. Downstream of the reservoir, the highest runoff contribution comes from subcatchment AM11, nearest the village (**Figure A2**) due to steep slopes feeding watercourse. Options here are likely to have more of an impact within the village.

The reservoir falls under the requirements of the Reservoirs Act (Scotland) 2011. The Act sets out the inspection and maintenance regimes required for large raised reservoirs that depend on the risk they pose to life and infrastructure. The last inspection report (2009) included measures in the interests of safety to improve the flood capacity of the reservoir, which are still outstanding. The Reservoir owner has been actively engaging with ABC throughout this study and has provided updates on planned inspection. A new inspection is due this year (2019), and the outstanding measures will need to be considered by the new inspecting engineer. If the Inspecting engineer agrees that the dam currently cannot safety pass the design flood, then works to improve the flood capacity of the reservoir will be required. The difficulty is that some options to do this will increase flows downstream, whilst others will reduce the permanent storage capacity which is unlikely to be acceptable to the owner. Possible options include:

- Permanently lower the top water level – this will increase the temporary flood storage between the spillway crest and the top of the dam. This is not likely to be acceptable to the owner as the permanent storage capacity is reduced. This is likely to reduce downstream flows for higher return periods which previously would have overtopped the dam but would now be contained and attenuated.
- Abandon the dam – again not likely to be acceptable to the owner as the permanent storage capacity is reduced. Also likely to increase flows downstream for all return period events as attenuation is lost, so will increase flooding in Clachan.
- Increase the length of spillway – doesn't affect the permanent storage capacity so likely to be acceptable to the owner but will increase flows downstream for all return period events, so will increase flooding in Clachan.
- Increase crest level of dam – increases the temporary flood storage and doesn't affect the permanent storage capacity so likely to be acceptable to the owner. Will prevent overtopping of flood events greater than the 100 year return period that are assessed to currently overtop so will reduce flood risk to Clachan.
- Make the dam able to overtop – likely not to change the current situation.
- Some combination of the above options

Because of the timing of the inspection, it's unlikely that a partnership approach tying in an option to increase attenuation in the loch for flood risk reduction purposes with the safety works required at the dam will be possible. However, it is recommended SEPA, as the national regulator for reservoirs safety liaise with the Reservoir owner to look for opportunities to consider flood risk when looking at options for Reservoir safety improvements. If any works are proposed following the inspection, planning permission will be required, and ABC should then consider including a condition that pass forward flows from the dam are not increased or if possible are reduced for flood events up to the 1 in 200+CC year return period.

From a financial viability perspective, increasing storage in the dam would require a new embankment in the order of 0.7m height and 100m length (this is based on Nextmap DTM not accurate topographic survey). This is a reasonably small embankment, however construction in this area is likely to be difficult given steep topography so access will be challenging. This is likely to have a significant impact on cost. A rough estimate of construction cost for an impounded arrangement would be in the region of £120K for a control structure and embankment based on typical Environment Agency unit costs for similar projects with consideration of uplift for difficult site access. Given the damages from the Allt Mor are in the region of £109K it is unlikely a positive benefit cost ratio would be achieved from these works.

On the basis on the technical, financial and legal feasibility criteria this option has been discounted as a formal flood mitigation measure.

10.1.14 Work with RDS developing Talatoll Plantation

Option 4.3 has been discounted largely due to legal/governance issues as well as technically limited scope to enhance the flood risk benefits of the plantation that out-with what has been proposed by FC. Modelling was carried out in Phase 2 and indicated the proposed plantation could have a positive impact on flood risk from the Allt Mor during more frequent events by slowing flows in the catchment. The long listing process was seen as an opportunity to work with the operator (RDS) and ensure best practice is adopted during creation of the scheme to maximise flood risk benefit.

Ongoing dialogue with the Forestry Commission has indicated these opportunities have already been assessed in detail by their in house hydrologists. An Environmental Impact Assessment (EIA) has been carried out which has assessed the impact on hydrology of the catchment. Within this report the design was assessed for its impact on flood risk and appropriate recommendations have been for improvements/ongoing best practise to be applied to surface water management on site and felling/restocks. There is therefore little scope in this study to make further technical recommendations to improve the design further.

Forestry Commission and RDS are aware of past flood risk issues and poor practise contributing to flooding in the village. Forestry Commission are obligated to regulate practices and have stated it is a condition of grant approval that good forestry practice is applied in line with the UK Forestry Standard, which sets out a range of legal and good forestry practice requirements. On the basis of the EIA and commitment to regulate the proposed Talatoll scheme this option has been discounted on the basis that this is out with ABC governance and there is limited technical scope to improve the scheme further.

11. Short List Options

A full options appraisal will be carried out following more detailed modelling of the short list fluvial options shown in **Table 11-1** so that options can be ranked and prioritised to find the most suitable solution considering all aspects. Short list pluvial list options in **Table 11-2** should be considered for a wider catchment approach and further investigated. Option locations can be seen in **Appendix A, Figure A3 – A8.**

Table 11-1 Short List Fluvial Options

Measure Category	Type of Measure	Measure	ID
Local Options	Property Flood Protection	Assess properties within 0.6m flood depth as optimum for PFP as a resilience rather than prevention technique.	1.2
	Self Help	This includes preparing a flood plan and flood kit, installing property flood protection, signing up to Floodline and Resilient Communities initiatives, and ensuring that properties and businesses are insured against flood damage. A Local Flood Action Group/Catchment Partnership should be established to facilitate local flood risk management.	1.4
Clachan Burn – NFM options	Wetland enhancement to south east of Balinakill	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	2.6
	Wetland enhancement & ditch blocking to north of Scotmill	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	2.7
	Riparian woodland	To increase roughness higher in catchment to create restriction and storage for flood water	2.8
	Wetland enhancement & ditch blocking to south west of Loch nan Gad	Provide storage and attenuation to reduce flows entering Clachan Burn higher in catchment	2.9
Hard engineering options	Weir modification/or removal	Weir modification/or removal	3.1
	Flood defences – embankment or wall	Flood defences along the Clachan Burn at vulnerable locations in the village	3.3
Alt Mor Options	Natural Flood Management	Tree planting and leaky barriers on tributary	4.4
	Wetland enhancement	Wetland/ storage area on right bank of Allt Mor	4.5

Table 11-2 Short List Pluvial Options

Measure Category	Type of Measure	Measure	ID
Clachan Burn – Surface Water Management NFM	Tree planting in the form of cross contour buffer strips.	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.1
	Understory planting in existing woodland	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.2
	Hedgerow planting and associated swales	To increase roughness higher in catchment to create restriction for surface water flow paths, reducing runoff reaching Clachan	2.3
	Land management measures	Farm measures to improve soil infiltration and soil water storage on agricultural land, to reduce surface runoff	2.4
	Leaky barriers on steep watercourses	Increase roughness, reduce risk of blockage and coarse sediment and reduce flooding through Clachan	2.5

12. Possible Alternative Funding Sources

The short list of options is dominated by NFM measures and relatively low cost interventions. This is driven partly by the low economic damages assessed for Clachan. In this case, it may be of value to pursue alternative funding for changes to land management throughout the catchment in order that NFM measures can be implemented. Some possible sources of funding for land managers are outlined below. Further work into the potential funding that could be accessed through this stream will be assessed later in the project is required by ABC.

12.1 Scottish Rural Development Program (SRDP)

The key purpose of the SRDP is to help achieve sustainable economic growth in Scotland's rural areas. The scheme is jointly funded by the Scottish Government and the EU. The specific priorities of the new Scottish Rural Development Programme are[9]:

- enhancing the rural economy
- supporting agricultural and forestry businesses
- protecting and improving the natural environment
- addressing the impact of climate change
- supporting rural communities

The NFM measures in this report are considered likely to meet these aims.

12.2 Ecological Focus Areas

An Ecological Focus Area is an area of land upon which agricultural practices are carried out that are beneficial for the climate and the environment. There are 6 EFA options that can be used on their own or in combination to meet your EFA commitment[10]:

- Fallow land
- Buffer strips
- Field margins
- Catch crops
- Green cover
- Nitrogen-fixing crops

A number of the potential NFM measures in this report would fall into these categories.

12.3 Agri-Environment Climate Scheme

The Agri-Environment Climate Scheme seeks to protect and enhance Scotland's natural heritage and help agricultural businesses adapt to the effects of climate change. The scheme is jointly funded by the Scottish Government and the EU. Again, planting and riparian woodland would likely meet requirements for this fund[11].

12.4 Water Environment Fund

The Water Environment Fund enables rivers to be restored by[12]:

- Repairing damaged urban rivers often in deprived areas to enhance the environment for the communities that live there. The aim of this is to create attractive and accessible green river corridors within towns and cities that can be used for active travel and recreation, improving

[9] Scottish Rural Development Programme 2014 – 2020, Information and Publicity Strategy, Scottish Rural Development Programme, April 2017
[10] https://www.sruc.ac.uk/info/120417/advisory_activities/1635/ecological_focus_areas_efas
[11] https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/
[12] https://www.sepa.org.uk/environment/water/water-environment-fund/

health and wellbeing. In addition this can help rivers contain flood waters and create new opportunities for local businesses and suitable development.

- Removing and easing barriers to migrating fish and improving vital fish stocks. The fund aims to increase the lengths of habitat accessible to native fish, helping to improve endangered populations and create new opportunities for angling, tourism and recreation, bringing economic benefits and recreational opportunities to river communities.

There may be potential to access this funding if removal of the weir is taken forward as an option. It has been identified under SEPA's River Basin Management Plan (RBMP) as presenting a barrier to fish and as a result, the status of Clachan Burn has been downgraded to "Poor". Removal of the weir could therefore potentially attract funding as an improvement to the water environment.

13. Summary and Next Steps

A long list of options was created that looked at numerous ways to mitigate flood risk within Clachan. The long list was brought before key stakeholders including ABC, FC, SNH SW, SEPA and the Clachan community. This was to identify any possible reasons for the listed options to not be feasible and identify any missed opportunities at this stage.

Input from these bodies along with desk studies to understand environmental, planning and ecological opportunities and constraints were used to inform the screening process.

Additional high level modelling was also carried out to inform the screening by investigating the potential benefit to be gained from thei option implementation. Based on this information a short list has been finalised and is listed below and in **Table 11-1**.

The following options will be taken forward to the short list:

- Property Flood Protection
- Self Help
- Wetland enhancement to south east of Balinakill
- Wetland enhancement & ditch blocking to north of Scotmill
- Riparian woodland – Clachan Burn
- Wetland enhancement & ditch blocking to south west of Loch nan Gad
- Weir modification/or removal
- Flood defences – embankment or wall
- Riparian/hillslope planting – Allt Mor
- Wetland creation – Allt Mor

Given the nature of flooding in Clachan from Allt Mor and Clachan Burn and the level of damage the type of measure remaining following screening it is unlikely one option will significantly reduce flood risk to the village. A solution in Clachan will likely take the form of low cost cumulative gains across the catchment which may not fully prevent flood risk but will reduce its impact and increase resilience.

The next phase will look to develop the short list options in more detail to enable us to cost, assess the benefit and rank these final options. Options will be grouped where appropriate to make the best use of resources and maximise benefits. Next steps are detailed below:

- Group options in consultation with ABC
- Model short listed options/group of options
- Landowner identification
- Concept design of options
- Cost options
- Damage assessment - post options
- Cost benefit analysis – including economic, environmental and social appraisals
- Produce appraisal summary tables
- Report on findings; and
- Identify preferred option(s)

Appendix A – Figures

Project Management Initials: SH Designer: AM Checked: DHS Approved: DH

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PROJECT

Clachan Flood Study

CLIENT

Argyll and Bute Council

PROJECT NUMBER

60578115

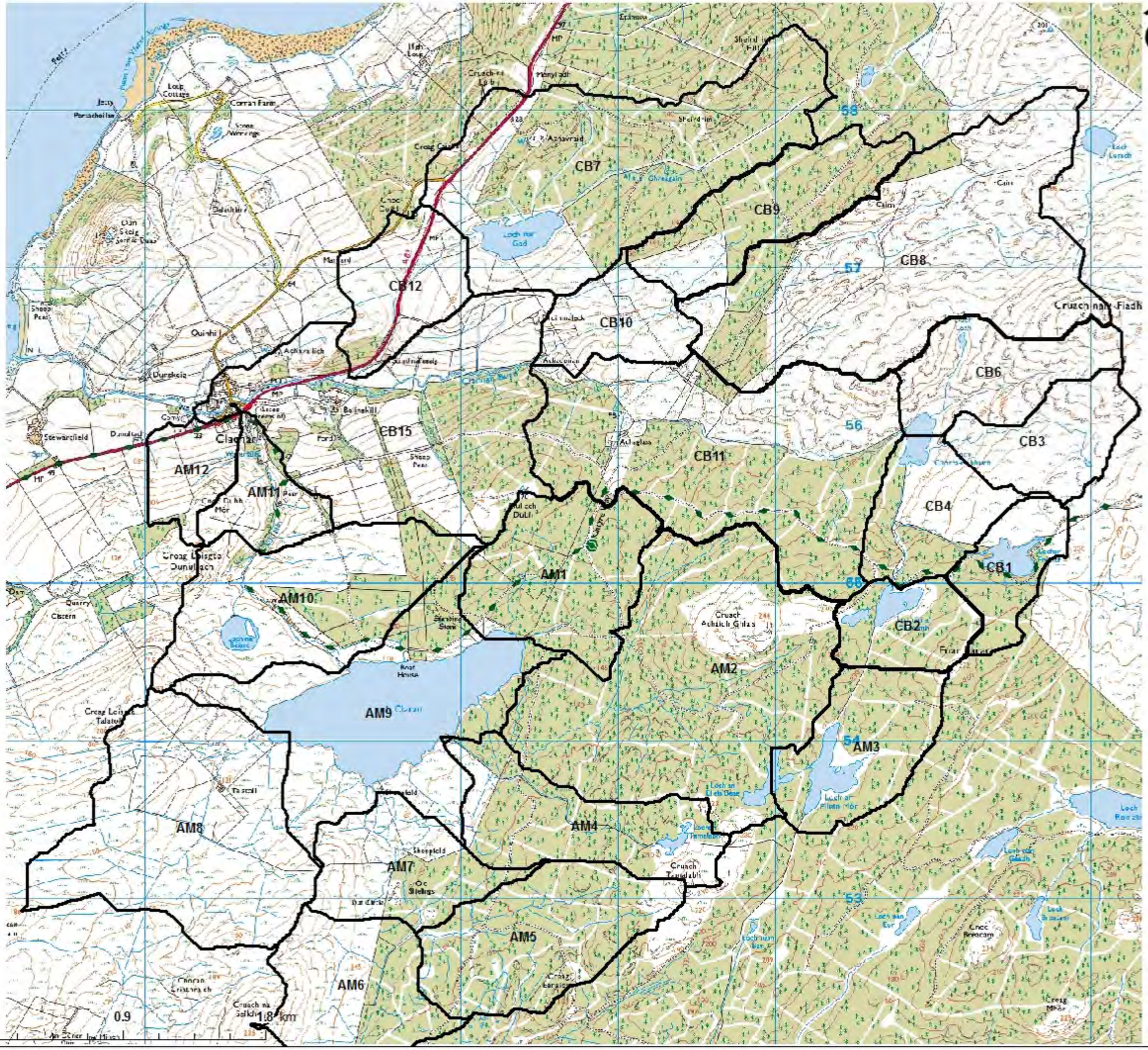
SHEET TITLE

Figure A1 Clachan Catchments

SHEET NUMBER

1 of 1

Project Management Initials: SH Designer: AM Checked: DHS Approved: DH



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PROJECT
Clachan Flood Study

CLIENT
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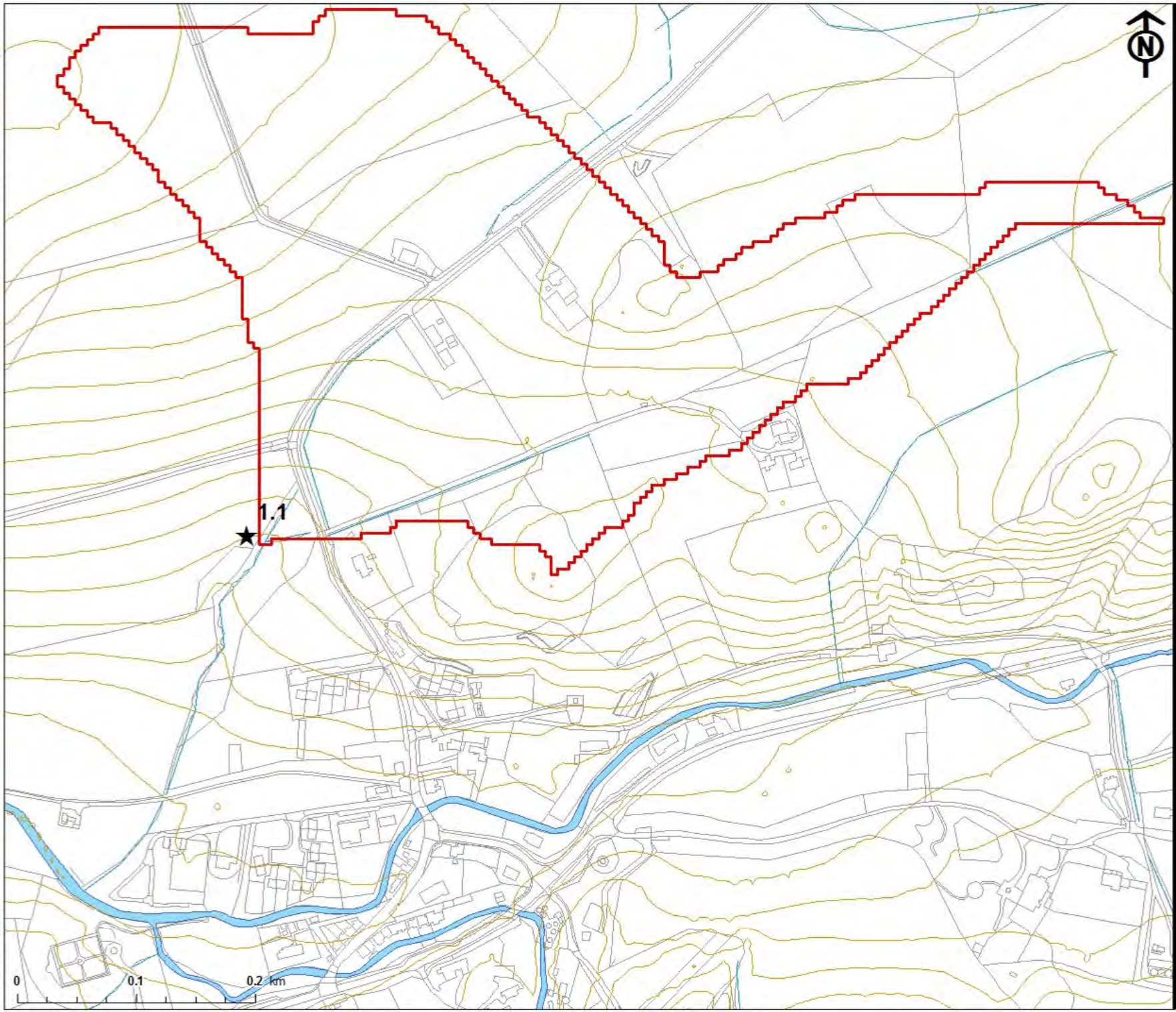
PROJECT NUMBER
60578115

SHEET TITLE
Subcatchment Map

SHEET NUMBER
1 of 1



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PROJECT

Clachan Flood Study

CLIENT

Argyll and Bute Council

KEY:

- Local Options
- Tributary Catchment Area
- 5m Contour
- Watercourse
- OS Mapping

PROJECT NUMBER

60578115

SHEET TITLE

Clachan Local Options

SHEET NUMBER

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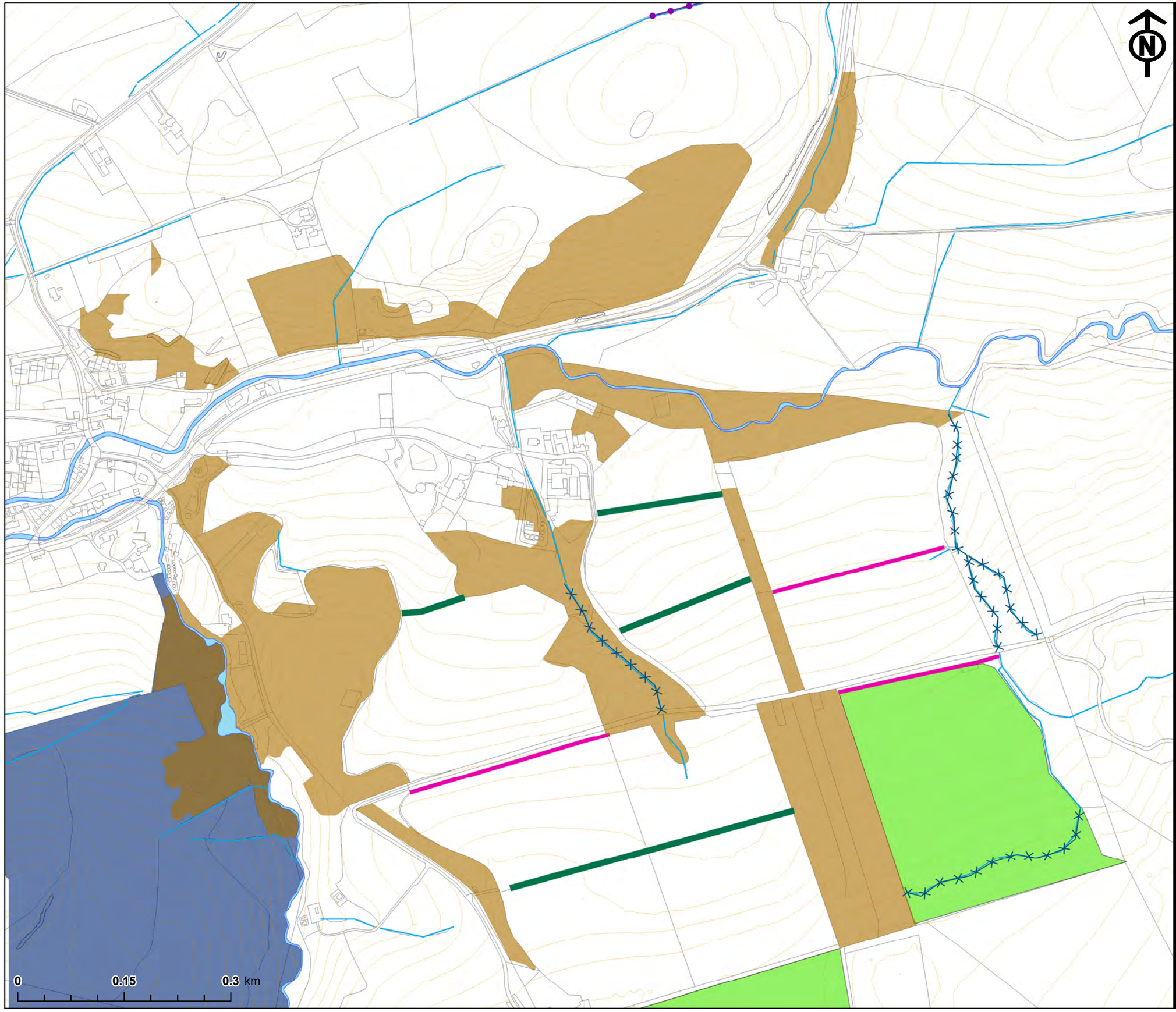

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Clachan Flood Study

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KEY:

- 2.1 Across Slope Buffers
- Ditch block
- Leaky barrier
- 2.2 Understory planting
- 2.3 Hedgerow
- Riparian/ hillslope planting
- 5m Contour
- Proposed Talatoll area
- Watercourse
- OS Mapping

PROJECT NUMBER

60578115

SHEET TITLE

Figure A4 NFM Measures - Surface Runoff

SHEET NUMBER

1 of 1

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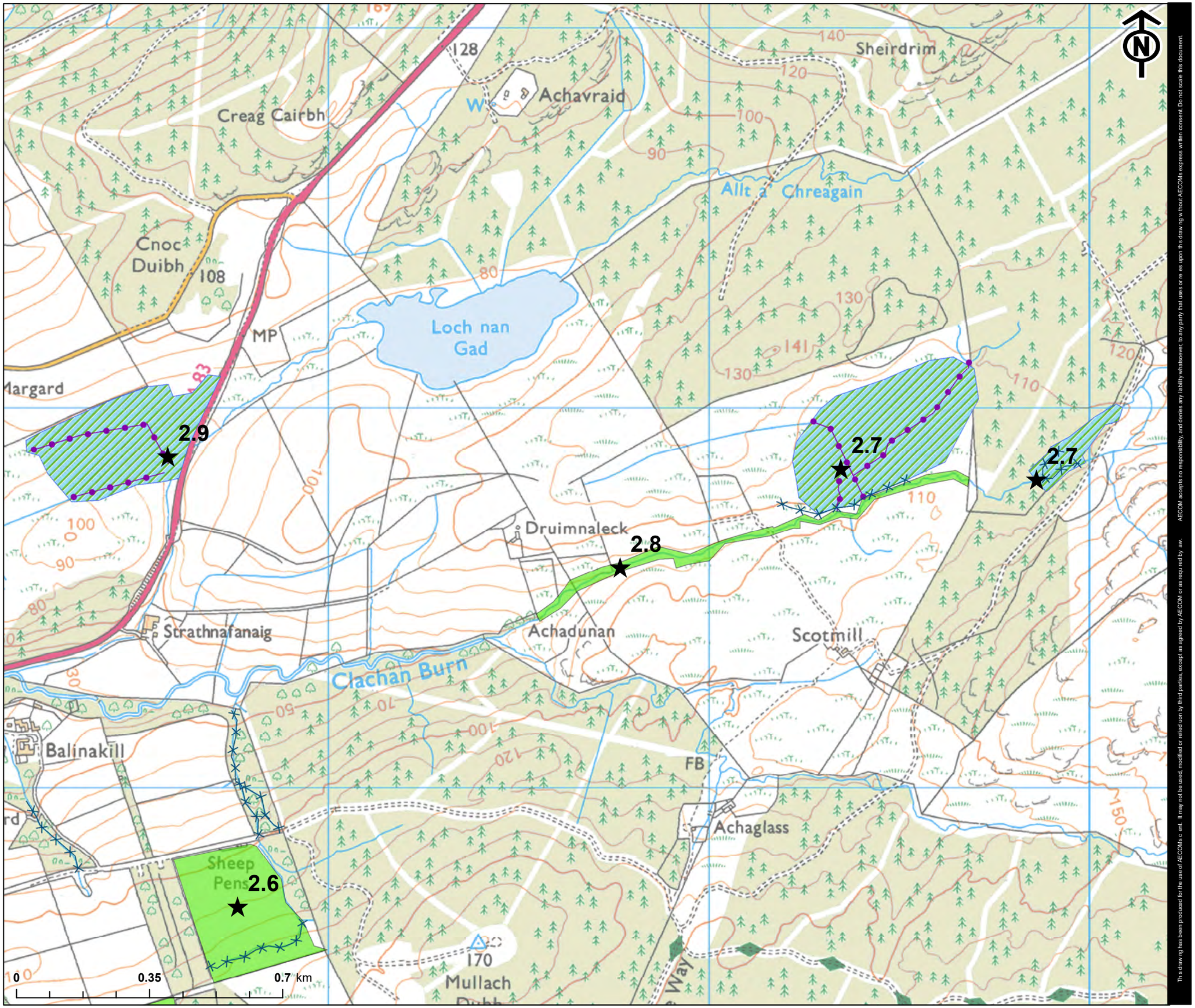

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PROJECT

Clachan Flood Study

CLIENT

Argyll and Bute Council

KEY:

- Clachan NFM Options
- Ditch block
- Leaky barrier
- Riparian/ hillslope planting
- Wetland

PROJECT NUMBER

60578115

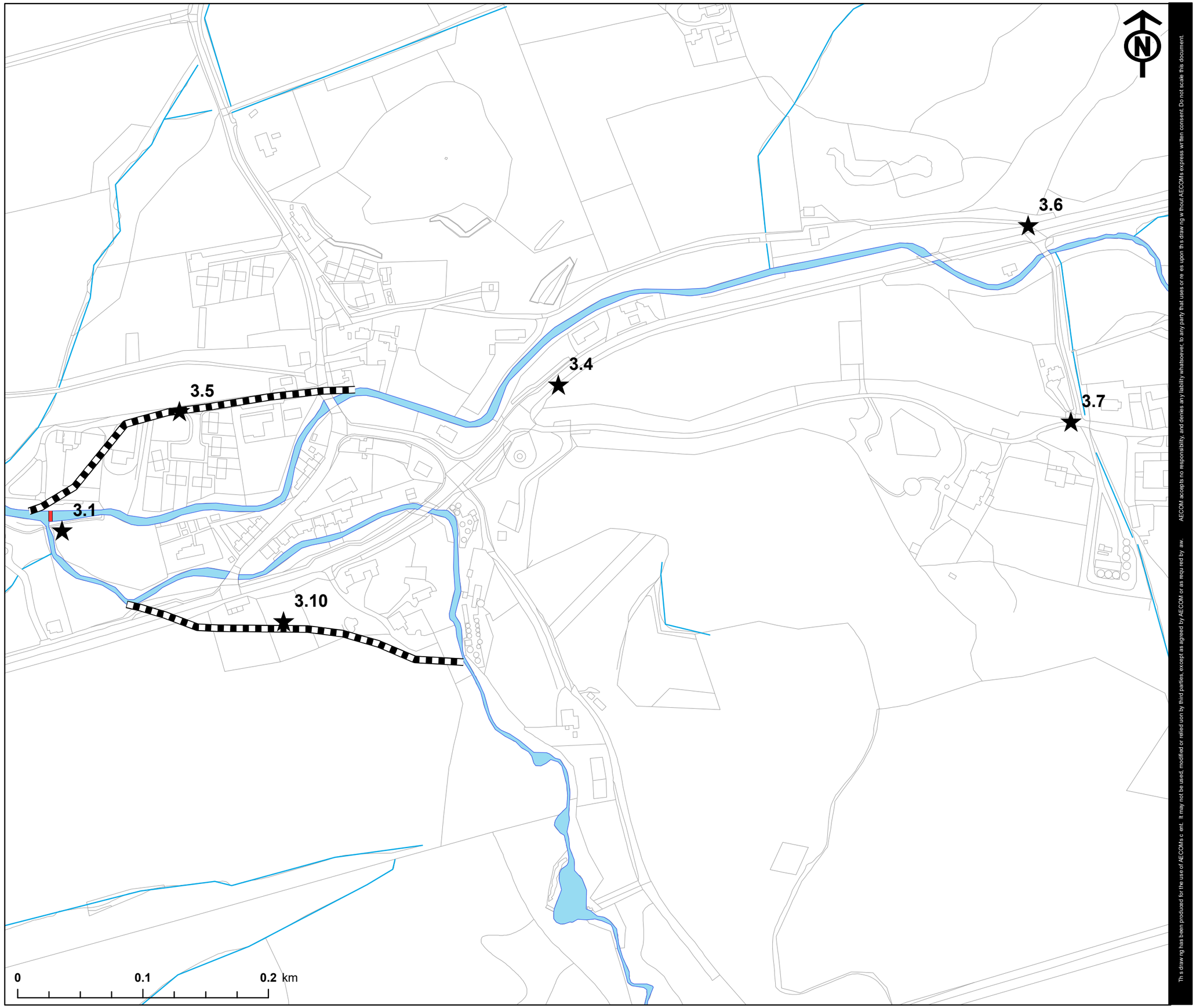
SHEET TITLE

Figure A5 Clachan Burn NFM Options

SHEET NUMBER

1 of 1

Project Management Initials: SH Designer: AM Checked: DHS Approved: DH



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PROJECT

Clachan Flood Study

CLIENT

Argyll and Bute Council

KEY:

- Engineered Options
- 3.1 Weir removal
- Diversions
- Watercourse
- OS Mapping

PROJECT NUMBER

60578115

SHEET TITLE

Figure A6 Engineered Options

SHEET NUMBER

1 of 2

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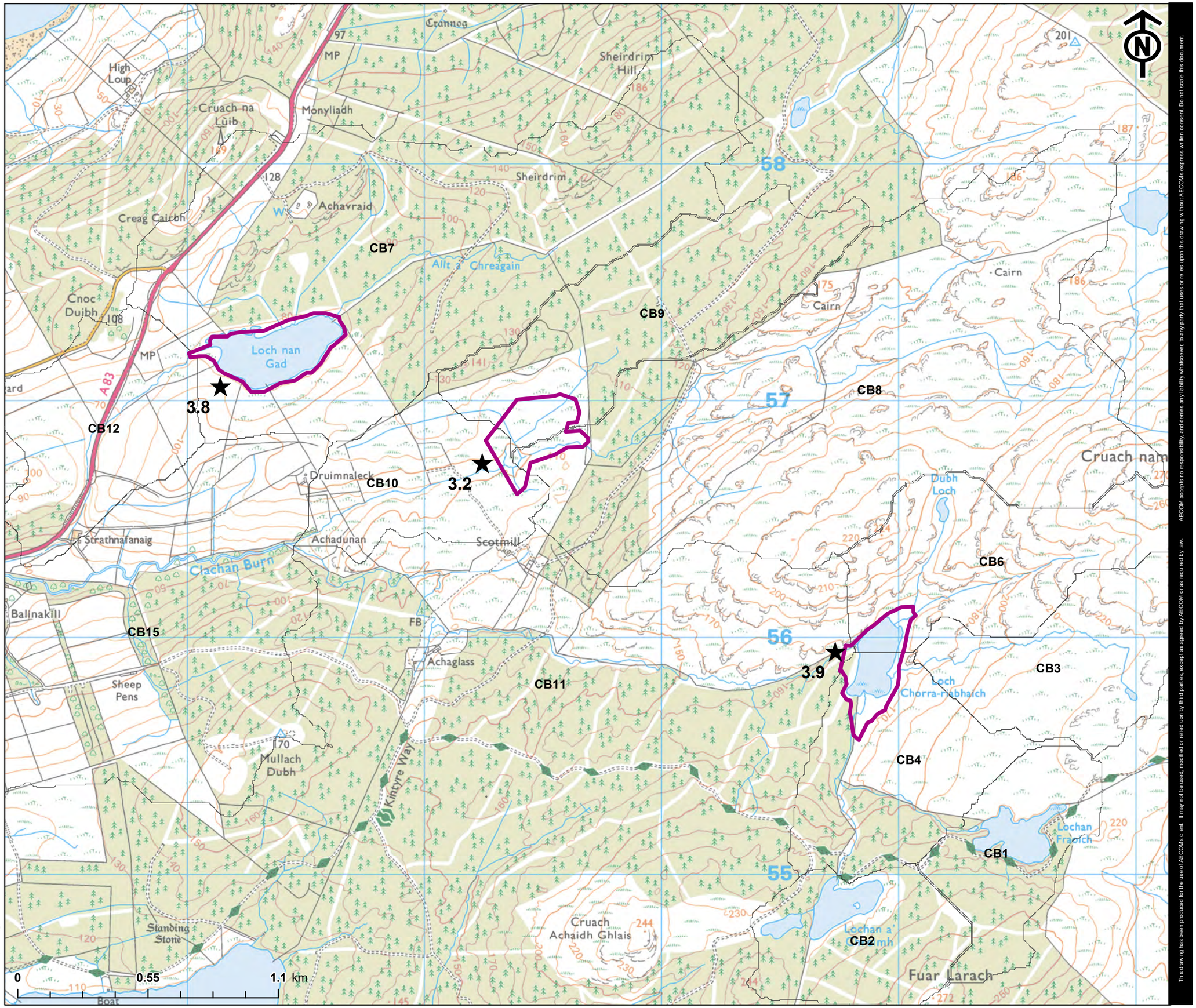

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PROJECT

Clachan Flood Study

CLIENT

Argyll and Bute Council

KEY:

- Engineered Options
- Formal Flood Storage Area
- 3.1 Weir removal
- Diversions
- Clachan subcatchments

PROJECT NUMBER

60578115

SHEET TITLE

Figure A7 Engineered Options

SHEET NUMBER

2 of 2

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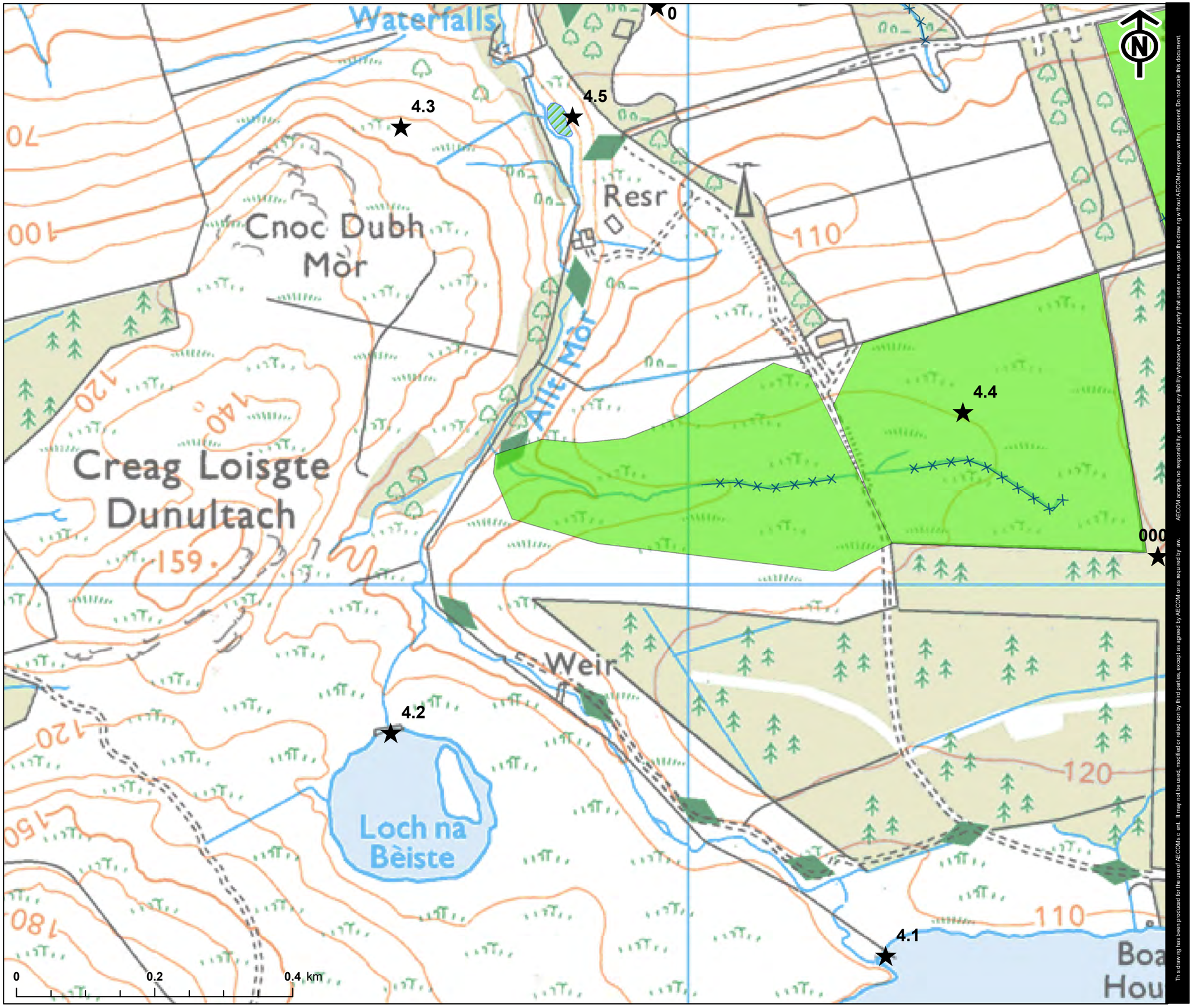

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PROJECT

Clachan Flood Study

CLIENT

Argyll and Bute Council

Argyll Bute COUNCIL

KEY:

- Allt Mor Catchment Options
- Ditch block
- Leaky barrier
- Riparian/ hillslope planting
- Wetland

PROJECT NUMBER

60578115

SHEET TITLE

Figure A8 Allt Mor Catchment Options

SHEET NUMBER

1 of 1

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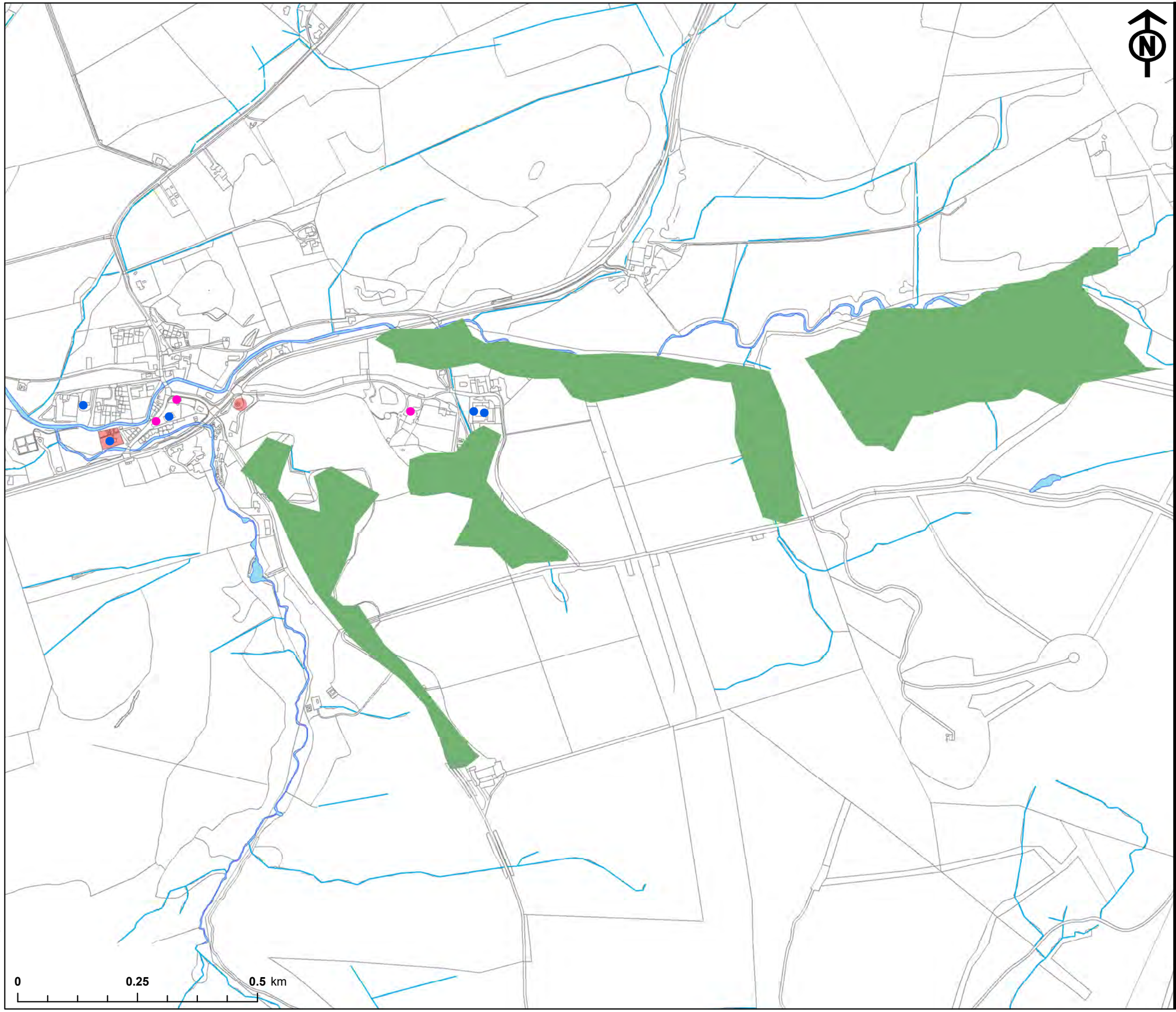

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AECOM

PROJECT

Clachan Flood Study

CLIENT

Argyll and Bute Council

KEY:

Listed Buildings by Category

- A
- B
- C

Scheduled Monuments

Ancient Woodland Inventory

Watercourse

OS Mapping

PROJECT NUMBER

60578115

SHEET TITLE

Figure A9 Environmental Contraints

SHEET NUMBER

1 of 1

Scale: 1:25,000 @ A3

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Argyll and Bute Local Development Plan 2015 App

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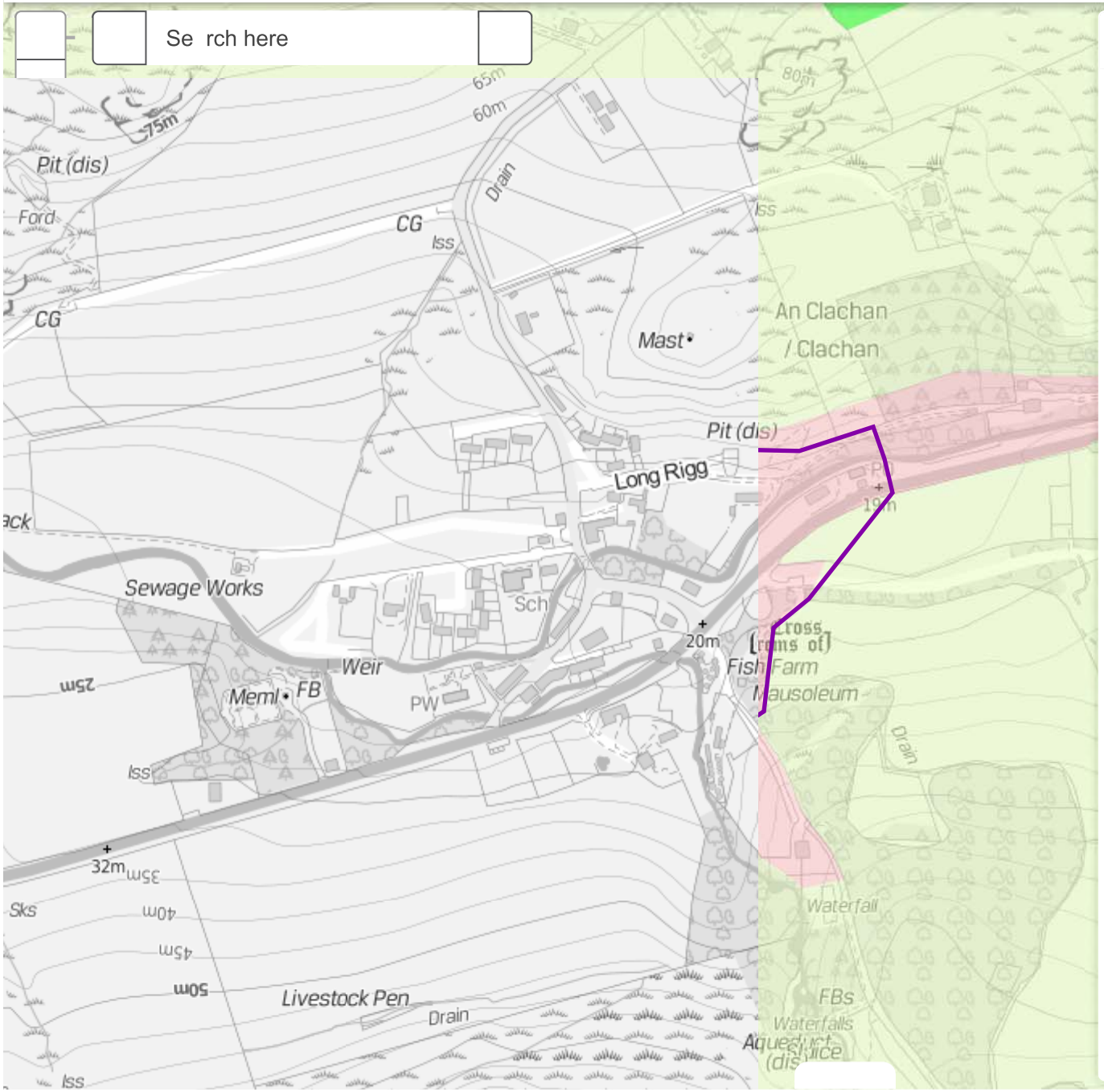

Legend -

Area for Action

Open Space Protection Area

Special Built Environment Area (SBEA)

Development Management Zones

- Countryside Zone
- Greenbelt
- Rural Opportunity Area
- Settlement Zone - Main Town
- Settlement Zone - Key Settlement
- Settlement Zone - Key Rural Settlement
- Settlement Zone - Village / Minor Settlement
- Very Sensitive Countryside -

Figure A10 Local Development Plan

Appendix B – Ecology and Environmental Preliminary Appraisal

Clachan Flood Study

Desk-based Preliminary Ecological Appraisal

Argyll and Bute Council

Project number: 60578115

22 March 2019

Quality information

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Revision history

Revision	Revision date	Details	Authorized	Name	Position

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The methodology adopted and the sources of information used by AECOM in providing its services are outlined in this Report. The work described in this Report was undertaken between 08 13 February 2019 and is based on the conditions encountered and the information available during the said period of time. The scope of this Report and the services are accordingly factually limited by these circumstances. AECOM disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to AECOM's attention after the date of the Report.

Table of contents

1. Introduction

AECOM was commissioned by Argyll and Bute Council (ABC) to undertake a Flood Study for the village of Clachan (hereafter referred to as the 'Scheme').

The Study is in the early stages of development and detailed design of works required to alleviate flooding are not yet known. Therefore, this Report refers to a general proposed scheme area (hereafter referred to as the 'Site') as defined on Figure 1. This area (central grid reference NR 764 560) encompasses an upland area of approximately 2734 ha consisting of the village of Clachan and two stream catchments (The Clachan Burn to the north and the Allt Mor Burn to the south).

The purpose of this Report is to provide a high-level, desk-based Preliminary Ecological Appraisal assessing the potential ecological risks and opportunities associated with the Scheme. The Report identifies the scope of further work that would be required to progress the project including the submission of a planning application. High-level recommendations are made on Scheme options for the avoidance or minimisation of the potential impacts of the Scheme on identified ecological features, and of potential enhancements to biodiversity and/or ecosystem services.

The approach applied when undertaking this appraisal accords with the Guidelines for Preliminary Ecological Appraisal published by the Chartered Institute of Ecology and Environmental Management (CIEEM) (CIEEM, 2017).

The purpose of the PEA was to:

- identify general habitat types present within the Scheme area and any areas immediately outside of the Scheme where there may be potential for direct or indirect effects (the "zone of influence");
- carry out an appraisal of the potential of the habitat types identified to support protected or notable species of fauna and flora; and,
- provide advice on any potential ecological constraints and opportunities, including providing recommendations for further field survey which may be required to inform the detailed design of the Scheme.

2. Wildlife legislation and planning policy

Wildlife legislation

The following wildlife legislation is potentially relevant to the proposed works:

- Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the 'Habitats Directive');
- Directive 2009/147/EC on the conservation of wild birds (the 'Birds Directive');
- Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the 'Water Framework Directive' (WFD));
- Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species ('Invasive Alien Species Regulation');
- Conservation (Natural Habitats, &c.) Regulations 1994 (as amended in Scotland) (the 'Habitats Regulations');
- Wildlife & Countryside Act 1981 (as amended in Scotland) ('WCA');
- Nature Conservation (Scotland) Act 2004 (as amended);
- Wildlife & Natural Environment (Scotland) Act 2011 (as amended) ('WANE Act');
- Protection of Badgers Act 1992 (as amended in Scotland); and,
- Conservation of Salmon (Scotland) Regulations 2016 ('Salmon Regulations').

The above legislation has been considered when planning and undertaking this PEA using the methods described in Section 3, when identifying potential constraints to the Scheme, and when making recommendations for further survey, design options and mitigation, as discussed in Section 5. Compliance with legislation may require the attainment of relevant protected species licences prior to the implementation of the Scheme.

Further information on the requirements of the above legislation is provided as Appendix A.

National planning policy

Scottish Planning Policy (SPP) 2014 recognises the environment as a national asset offering opportunities for enjoyment, recreation and sustainable economic activity. In summary, the policy principles most relevant to nature conservation state that the planning system should:

- facilitate positive change while maintaining / enhancing distinctive landscape character;
- conserve and enhance protected sites and species, maintaining healthy ecosystems and the natural processes which provide important services to communities;
- protect and improve the water environment and soil;
- protect and enhance ancient woodland, hedgerows and trees with high ecology/landscape value; and,
- seek biodiversity benefits from new development where possible.

SPP also sets out the biodiversity duty of public bodies and the legislative requirements for protected sites and species.

It is also Scottish Government policy to treat Wetlands of International Importance (Ramsar sites) in the same way as Natura 2000 sites (Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)), and to treat candidate, potential or proposed Natura 2000 / Ramsar sites, as well as areas identified as compensation sites for adverse effects on these designations, as if they were fully designated.

Local planning policy

Relevant local planning policies for ABC are included in the Argyll and Bute Local Development Plan (LDP), adopted March 2015. This LDP includes the following policies relevant to nature conservation:

- Policy LDP STRAT 1 – Sustainable Development: states that in preparation of new development proposals, developers should seek to conserve and enhance the natural and built environment and avoid significant adverse impacts on biodiversity, natural and built heritage resources. They should also avoid having significant adverse impacts on land, air and water environment;
- Policy LDP 3 – Supporting the Protection, Conservation and Enhancement of our Environment: in all development management zones, Argyll and Bute Council will assess applications for planning permission with the aim of protecting, conserving and, where possible, enhancing the built, human and natural environment. There is extensive supporting guidance detailing the mechanism of this policy delivery;
- Policy LDP 5 – Supporting the Sustainable Growth of Our Economy: this policy in part aims to help deliver sustainable growth through focussing on regeneration activity and promoting environmental enhancement; and,
- Policy LDP 10 – Maximising our Resources and Reducing Our Consumption: ABC will support development proposals which seek to maximise resources and reduce consumption where they accord with (amongst others) minimising impact on the water environment, minimising impact on biodiversity and the natural environment, avoiding the loss of trees and woodland and avoiding the disturbance of carbon rich soils.

ABC has also produced a technical note for planners and developers to provide guidance and ensure that development meets the requirement to address and protect biodiversity in the planning and development process.

The Argyll and Bute Biodiversity Action Plan (BAP) (2010 to 2015) contributes to the biodiversity conservation aims, objectives and actions described at a national level and to the delivery of a number of other strategies and plans relevant to the biodiversity of the Council area. Specifically it details six ecosystem works programmes to be delivered by the plan and lists habitats and species selected for action. Habitats selected for action that may be relevant to the Development include upland oak *Quercus* woodland, lowland mixed deciduous woodland, rivers and blanket bog. Priority species for conservation action include Greenland white-fronted goose *Anser albifrons* ssp. *flavirostris,* black grouse *Tetrao tetrix,* osprey *Pandion haliatetus,* red squirrel *Scurius vulgaris,* otter *Lutra lutra* and soprano pipistrelle *Pipistrellus pygmaeus*. The 2010 to 2015 BAP has not yet been superseded but is currently being re-drafted.

The above planning policy has been considered when assessing potential ecological constraints and opportunities identified by the desk study and when assessing requirements for further survey, design options and ecological mitigation, as described in Section 5.

3. Methods

This PEA was a purely desk-based exercise and no field survey was carried out to inform the assessment.

A stratified approach was taken during the desk study, based on the likely zone of influence of the various options for the Scheme on different ecological features and the maximum distances typically considered by statutory consultees. Accordingly, the desk study sought to identify:

- any international nature conservation designations within 10 km of the Site
- other statutory nature conservations designations within 2 km of the Site;
- local non-statutory nature conservation designations within 1 km of the Site; and,
- protected / notable habitats and species within 2 km of the Site.

Combined, these areas are referred to as the 'Desk Study Area'. Statutory designations further afield were also considered if impacts were possible, such as on water-related features of interest via connecting watercourses, or if the features of interest included mobile species for which Scottish Natural Heritage (SNH) require wider search distances (such as geese).

Greenland white-fronted goose Anser albifrons ssp. flavirostris is known to utilise the Kintyre area, to the south of Lochgilphead, during the non-breeding season. To define the Desk Study Area in relation to this species, its local range was examined. In a report commissioned by SNH, Pendlebury et al (2011) identified that the core foraging range of Greenland white-fronted geese in Kintyre is between 5 – 8 km from roost sites. It was therefore considered reasonable to adopt a 10 km Desk Study Area in relation to SPAs designated for this species.

The desk study was carried out using the data sources detailed in Table 1. For the purposes of this PEA protected and notable habitats and species included:

- all species listed on Schedules 2 and 4 of the Habitats Regulations;
- all species listed on Schedules 1, 5 and 8 of the WCA;
- all species of birds listed on Annex I of the Birds Directive;
- all qualifying features of European designated sites within 10 km of the Site;
- species and habitats considered of principal importance for nature conservation in Scotland through inclusion on the Scottish Biodiversity List (SBL);
- priority habitats and key species in the Argyll and Bute BAP;
- species that are Nationally Rare, Nationally Scarce or listed in national or local Red Data Lists;
- bird species on the Red List of Birds of Conservation Concern (BoCC, Eaton *et al,* 2015); and,
- invasive non-native species of UK concern, such as those identified on Schedule 9 of the WCA (although this no longer legally applies in Scotland) and those considered species of EU concern under the EU Invasive Alien Species Regulation.

Table 1. Desk study data sources

Data source	Accessed	Data obtained
Argyll and Bute Council website	08/02/2019	• LDP policies relevant to nature conservation. • Biodiversity Action Plan information. • Local non-statutory nature conservation designations within 1 km of the Site.
Google	08/02/2019	• Aerial imagery and Streetview
NBN Atlas Scotland (commercially-available records only)	13/02/2019	• Biological records.
Ordnance Survey (OS) 1:25,000 maps and aerial photography	08/02/2019	• Habitats and connectivity relevant to interpretation of planning policy and potential protected / notable species constraints.
Scotland Environment webpage	13/02/2019	• Habitat Map of Scotland dataset

Scottish Environment Protection Agency (SEPA) River Basin Management Plan (RBMP) http://gis.sepa.org.uk/rbmp/	13/02/2019	• Status of waterbodies / watercourses.
SNH Natural Spaces webpage	08/02/2019	• Dataset for Ancient Woodland in Scotland.
SNH SiteLink webpage	08/02/2019	• International statutory designations within 10 km. • Other statutory designations within 2 km.

Limitations

3.1 The Site could not be examined in detail or fully using aerial and Google Street View imagery and it is likely that some features could not be seen.

3.2 Google Street View Imagery was from 2015 and aerial imagery is from an unknown date. It is possible that habitats / conditions at the Site have changed since these photos were taken.

3.3 Desk study information is dependent on records having been submitted for the area of interest. As such, a lack of records for particular habitats or species does not necessarily mean they are absent from the area of interest. Similarly, the presence of records for particular habitats and species does not automatically mean they still occur within the area of interest or are relevant.

3.4 Given the high level of detail required from this report, and the uncertainty surrounding the final design of the scheme, sources of notable species data was restricted to that which was commercially and freely available on the NBN Atlas Scotland website. As such, data directly from Lorn Biological Records Centre, or otherwise available at cost, was not accessed.

4. Results

Nature conservation designations

Statutory designations

Table 2 details the statutory nature conservation designations of sites identified by the desk study, based on the method given in Section 3 of this Report. The designations are listed in descending order, with those closest to the Site listed first. The locations of all designated sites described in Table 2 are illustrated on Figures 2, 3 and 4.

Table 2. Sites with statutory designations for nature conservation

Designation	Reason(s) for designation	Relationship to the Site
Kintyre Goose Roosts SPA and Ramsar site	Internationally important wintering population of Greenland white-fronted goose. This site is also underpinned by two Sites of Special Scientific Interest, Kintyre Goose Lochs and Rhunahaorine Point, described below.	This SPA is a multi-part site, of which three parts are within the Desk Study Area. The closest of these is Loch Garasdale, 380 m south of the Site, separated by moorland and rough hill grazing. Loch an Fhraoich is located 4.8 km south of the Site with intervening habitat of conifer plantation and moorland and rough hill grazing. Rhunahaorine Point is located 5.1 km south-west of the Site and separated by mixed grazing, conifer plantation, moorland and a small area of broadleaved woodland. The SPA citation states that two main populations use the SPA, one of which uses Loch Garasdale, Loch an Fhraoich and Rhunahaorine Point, and feeds on agricultural land surrounding these.
Kintyre Goose Lochs SSSI	Designated for supporting an internationally important wintering population of Greenland white-fronted goose.	A multi-part site of which one part is present within the Desk Study Area. This is Loch Garasdale, 380 m south of the Site.
Sound of Gigha Proposed SPA (pSPA)	Selected to provide protection to important wintering grounds used for feeding, moulting and roosting by non-breeding great-northern diver *Gavia immer*, common eider *Somateria mollissima* and red-breasted merganser *Mergus serrator*.	Approximately 1.2 km west on the coast of the Kintyre Peninsula. Intervening land use is lowland grazing, broadleaved woodland and small areas of residential development. This designation is still proposed and is not a finalised SPA. However, it is Scottish Government policy to treat pSPAs as if they were fully designated. Please note that pSPA boundaries may be subject to change prior to classification.
Inner Hebrides and the Minches SAC	Considered to be the one of the best areas in the United Kingdom for harbour porpoise *Phocoena phocoena.*	This large marine SAC is located 1.4 km west of the Site.
Tarbert Woods SAC	The primary reason for the designation of this site is the presence of western acidic oak woodland with holly *Ilex aquifolium* and hard fern *Blechnum* spp. The site comprises coastal strips of fragmented broad-leaved woodland with good stands of old sessile oak woods *Quercus petraea*, which are important for oceanic bryophyte communities.	This SAC is a multi-part site, of which seven parts across three areas are within the Desk Study Area. The nearest of these is a fragmented area approximately 1.97 km north of the Site, on the opposite bank of West Loch Tarbert. A second collection of fragmented parts is present 7.1 km north of the Site, at the head of West Loch Tarbert, on the opposite bank. An additional area is present 8.7 km north-east, separated from the Site mainly by conifer plantation and moorland.
Ardpatrick and Dunmore Woods SSSI	Designated for the presence of upland oak woodland which is of long-established origin and has a strong oceanic influence. Species present include oak, downy birch *Betula pubescens*, rowan *Sorbus aucuparia*, hazel *Corylus avellana*, holly and cherry *Prunus* sp. and a rich assemblage of lower plants. This site also contains notified features of geological interest.	A small segment of this site is present within the Desk Study Area. It is present 1.97 km north-west of the Site and overlapped by Tarbert Woods SAC, and is separated by West Loch Tarbert and broadleaved woodland and conifer plantation.

Designation	Reason(s) for designation	Relationship to the Site
Rhunahaorine Point SSSI	Designated due to the presence of notified features including non-breeding Greenland white-fronted goose, breeding little tern *Sterna albifrons* and shingle.	Located 4.5 km south-west of the Site and partially overlapping Kintyre Goose Roosts SPA.
Loch Sween Marine Protected Area (MPA)	Designated due to the presence of the following protected features: • burrowed mud; • maerl beds; • native oysters; and, • sublittoral mud and mixed sediment communities	Located 16.4 km north of the Site and separated by the Sound of Jura.

Non-statutory designations

Local Nature Conservation Sites

Three Local Nature Conservation Sites (LNCS) are located within 1 km of the Site. The locations of these were found on the Argyll and Bute Local Development Plan 2015 Interactive Map, although no other information regarding the reason(s) for their designation could be found. The locations of all three sites are shown on Figure 3.

Both Loch Ciaran LNCS and the Loch an Eilein Group LNCS are found within the Site and appear similar in character to Loch Garasdale SPA and SSSI and other lochs in the surrounding area. Given this, these sites are considered to have the potential to support wintering Greenland white-fronted goose.

West Loch Tarbert LNCS is located 821 m north of the Site, and largely overlaps the Sound of Gigha pSPA.

Ancient Woodland

Three main areas of woodland that appear on the Ancient Woodland Inventory are present within the Desk Study Area.

One area containing four parts is located within the Site and comprises ancient and long-established woodland associated with the village of Clachan. However, the easternmost part of this, comprising ancient woodland of semi-natural origin, appears to have been vastly reduced in size to make way for conifer plantation, which was felled at the time aerial photographs were taken.

Another area of ancient woodland is located 200 m north of the Site, on the banks of West Loch Tarbert, west of the A83.

An additional small area of ancient woodland is present 780 m north of the Site, east of the A83.

Habitats

The following assessment of the habitats likely to be present on Site is based on a review of available aerial images only, and no verification has been carried out through field survey.

The Site appears to be predominantly upland, comprising mostly moorland and conifer plantation, and covers two catchments – the Clachan Burn catchment in the north and Allt Mor catchment in the south, as shown on Figure 1. The Allt Mor joins the Clachan Burn in the village and enters the sea 900 m west of this, approximately 1.2 km south of the mouth of West Loch Tarbert.

Clachan Burn Catchment

The Clachan Burn catchment appears to encompass a large area of rough hill grazing with patches of heather *Calluna vulgaris* and grassland in the centre and to the east, including the highest point Cruach nam Fiadh, 270 m above sea level. Two main areas of conifer plantation are present, in the south and south-east, and in the north-west, which appears from aerial imagery to be at varying stages of growth and felling and are crossed by several access roads. An additional narrow strip of plantation is present between the two. In the south-east of the catchment, the Habitat Map of Scotland lists a small area as “Coniferous woodland” as opposed to “Highly artificial coniferous plantations“, suggesting that certain areas may be more semi-natural in character.

Four small lochs are present within the catchment. Lochan Fraoich, Lochan a' Chreimh and Loch Chorra-riabhaich occur adjacent and within conifer plantation to the south-east, and Loch nan Gad, is located adjacent to conifer plantation in the north-west. A few smaller areas of standing water are spread throughout the catchment.

To the west, the land is lower and more improved fields are present, as well as numerous houses. Areas of broadleaved woodland, including that which is on the Ancient Woodland Inventory, are present along the Clachan Burn and in the wider area. The Clachan Burn passes under the A83 and flows parallel to the road for a short distance before entering Clachan village, where the bank vegetation continues to be broadleaved woodland, with the apparent inclusion of some invasive non-native species, potentially including rhododendron *Rhododendron* sp. The Clachan Burn is met by the Allt Mor within Clachan village and a weir is present on the Clachan Burn immediately upstream of this confluence.

The most recent assessment by SEPA for the River Basin Management Plan (2017) suggests that the overall quality of the Clachan Burn was Poor. In previous years, the watercourse received 'Good' status (2010 – 2016). It appears that the only factor contributing to the 2017 Poor status is "Fish barrier". This may be related to the weir structure described above. Assessments of macroinvertebrates received a 'Good' overall rating and a 'Pass' was awarded for the pollution category.

The Habitat Map of Scotland suggests that blanket bog is present to the north-east of this catchment.

Allt Mor Catchment

Loch Ciaran, an oligotrophic loch, is situated near the centre of the Allt Mor catchment (see Figure 1), with a group of smaller lochs, the Loch an Eilein group, located to the east. The upper Allt Mor, as well as other small watercourses, link the Loch an Eilean group and surrounding land to Loch Ciaran, from which the Allt Mor continues. A further small loch, Loch na Beiste, is also present to the west of Loch Ciaran, from which a tributary meets the Allt Mor. The majority of habitat to the north and east of this catchment, including the area surrounding the Loch an Eilein group, is conifer plantation which, as in the Clachan catchment, is at varying stages of growth and criss-crossed by access roads.

The south-west and west of the Allt Mor catchment appears to be used for rough hill grazing, with a mix of grassland and heather. This habitat is continued in fragmented patches between areas of conifer plantation and extends to the highest point, Cruach A'chaidh Ghlais, which is 244 m above sea level.

A derelict farmhouse is present to the south-west of Loch Ciaran and the adjacent fields appear to have more of an improved character.

To the north-west, in the lower reaches of the Allt Mor catchment, the burn is lined with broadleaved trees and strips of ancient woodland are present. Surrounding land use comprises more improved fields with some areas of gorse *Ulex europaeus* scrub. At the northwestern extent of the Allt Mor catchment, the Allt Mor crosses under the A83 and takes on a more artificial character, with man-made banks and ornamental bank vegetation. Shortly after this it meets the Clachan Burn.

The section of the Allt Mor between Loch Ciaran and the confluence with Clachan Burn received an overall 'Poor' status in the SEPA River Basin Management Plan. Again, the main factor contributing to this was impassability to fish for the year 2017 only. In all previous years the rating for this part of the watercourse had been 'Good'. This could be due to the installation of a micro hydro power scheme which covers a significant proportion of the burns length between Loch na Bieste and the A83 (Argyll and Bute Council Planning, application approved 2011), or potentially due to the presence of a small dam and offtake structure at approx. NGR NR 76743 55764, along with the natural waterfalls in this area. Upstream of Loch Ciaran, the watercourse received a 'High' overall status for years 2012 to 2017, with all parameters receiving 'High' ratings.

Protected and notable species

A list of protected and/or notable species for which records were returned by the NBN Atlas Scotland, along with source accreditation, is provided in Appendix 2.

Plants

Shaded wooded ravine habitat is present on the Allt Mor between Loch Ciaran and Clachan village. This is potentially suitable for Killarney fern *Trichomanes speciosum*, a species listed on Annex II of the Habitats Directive and the SBL. The Site lies within the known range of this species.

Mammals

Badger

The lower slopes of the Site appear to be suitable for badger *Meles meles*, with the sloping areas potentially offering opportunities for sett building and the improved field and broadleaved woodland likely providing foraging habitat.

No records of badger were returned by the NBN Atlas Scotland.

Bats

Strips of broadleaved woodland on the lower slopes likely provide commuting and foraging routes for bats, as do the edges of conifer plantation. Conifer plantation throughout the Site is likely to offer only limited opportunities for roosting bats, however, broadleaved woodland especially that consisting of mature trees has greater potential to provide roosting opportunities. Furthermore, several buildings within the Site, for example Balinakill Country House, cottages within the village and the derelict farmhouse west of Loch Ciaran, are may have potential to support roosting bats. However, these could not be assessed fully from aerial imagery or Google Streetview.

No records of bats were returned by the NBN Atlas Scotland.

Otter

The wooded lower reaches of the Clachan Burn and Allt Mor likely offer opportunities for otter resting sites and for foraging and commuting. Furthermore, several lochs on Site, including Loch Ciaran and Lochan Fraoich, are advertised for brown trout *Salmo trutta* fishing and so are likely to provide a feeding resource for otter.

No records of otter were returned by the NBN Atlas Scotland.

Pine marten and red squirrel

Suitable habitat for pine marten *Martes martes* and red squirrel is present on Site, both within the conifer plantation and the broadleaved woodland on the lower slopes.

The NBN Atlas Scotland returned two recent records of red squirrel from 2010 and 2012, both north of the Site, near the A83.

Water vole

Habitat for water vole *Arvicola amphibius* on Site is likely to be mostly suboptimal, with the majority of watercourses fast flowing or heavily shaded by woodland. There is some potential for the species to occur in ditches around the lochs on Site, and in the higher reaches of the burns if they are found to be sufficiently slow flowing.

No records of water vole were returned by the NBN Atlas Scotland.

Wildcat

The mosaic of woodland, moorland and rough grazing offers suitable habitat for hunting and sheltering wildcat *Felis silvestris*. The Site is located within the southern extent of the wildcats known range (Harris & Yalden, 2008); however it is not located near any of the Scottish Wildcat Action Priority Areas as listed on the Scottish Wildcat Action website.

Although suitable habitat does exist within the Site, the presence of human habitation has been shown to reduce wildcat activity, with Klar *et al* (2008) demonstrating displacement of 200 m around single houses and 900 m around settlements. The presence of the village of Clachan and other frequent farms and dwellings therefore reduces the likelihood of wildcat presence.

The NBN Atlas Scotland returned a single record of wildcat from 1985 from Ronachan, 1.2 km west of the Site. The Scottish Wildcat Action website provided a single record of a hybrid cat from Cour, approximately 5 km east of the Site, although no date was attached to this.

Marine mammals

The coastal area surrounding the mouth of the Clachan Burn appears suitable for both common seal *Phoca vitulina* and grey seal *Halichoerus grypus*.

The nearest Designated Haul-out Sites for grey and common seals are located south-east of the Site, on the east coast of the peninsula, 17 km an 27 km away (Marine Scotland).

The NBN Atlas Scotland returned three records of common seal. The most recent record, from 2016, was of 53 individuals at Eilean Traighe, a group of small rocky islands associated with the opposite bank of West Loch Tarbert. A record was also returned from Ronachan Point, approximately 1 km west of the Site.

Birds

Based on aerial imagery, the lochs on Site appear similar in habitat composition to those of the nearby Kintyre Goose Roosts SPA and Kintyre Goose Lochs SSSI. Therefore it is possible that they are used by Greenland white-fronted goose at times.

The Site is located within the known breeding range of red-throated diver *Gavia stellata*, and the lochs present may offer suitable breeding habitat. The NBN Atlas Scotland returned a single record of red-throated diver from May 2006, however precision of this record was only to 1 km and it is unknown if this was of breeding.

Lochs such as Loch Ciaran also offer suitable hunting grounds for osprey, and surrounding conifer plantation likely provides suitable nesting sites.

Conifer plantation also offers suitable habitat for common crossbill *Loxia curvirostra.*

Woodland habitats and farm buildings on Site offer nesting opportunities for barn owl *Tyto alba*, for which the NBN Atlas Scotland returned twelve records from 2003 – 2006.

A large area of the Site is covered by moorland with patches of heather. This in combination with the woodland edges associated with the conifer plantation offers potentially suitable habitat for hen harrier *Circus cyaneus* and black grouse. The NBN Atlas Scotland returned two records of black grouse, all from a 1 km grid square overlapping a large proportion of the Site and from 2008, 2006 and 2005.

The combination of farmland and nearby coastal habitats offers nesting and foraging opportunities for species such as curlew *Numenius arquata*, lapwing *Vanellus vanellus* and redshank *Tringa totanus*.

The NBN Atlas Scotland returned eleven records of curlew, four records of redshank and a single record of lapwing, the most recent of which for all species was 2006.

Habitats throughout the Site offer suitable foraging and nesting opportunities for a range of common bird species.

Reptiles and amphibians

The mosaic of moorland, woodland and heathland habitats on Site are suitable for reptile species including adder *Vipera berus*.

Numerous bodies of standing water are present throughout the Site with the potential to support amphibian species. However, several of the larger lochs support resident brown trout populations, reducing the suitability. The Amphibian and Reptile Group UK (ArgUK) suggests that the location is “unsuitable” for great crested newt *Triturus cristatus*; however the JNCC website suggests that the species has been recorded elsewhere on the Kintyre Peninsula.

No records of reptile or amphibian species were returned by the NBN Atlas Scotland.

Fish

It is likely that barriers referred to in the SEPA River Basin Management Plan assessment are the weirs within Clachan village, although OS mapping also suggests that natural waterfalls are present on the Allt Mor between Clachan village and Loch Ciaran, and it is possible that a culvert may be present under the A83. Furthermore, a micro hydro scheme was approved for the Allt Mor in 2011 and it is possible this could negatively influence fish passage on this watercourse (if built). Previous ‘Good’ ratings of the Allt Mor watercourse for fish passage suggest the ‘Poor’ rating in 2017 was caused by variation in water levels during the fish migration period in this

year. No assessment of the suitability of spawning habitat for Atlantic salmon *Salmo salar* and sea trout could be made from Google Streetview and aerial photography, although it appears there is the potential for the species to spawn in the lower section of the Clachan Burn. Waterbodies including Loch Ciaran are advertised as supporting resident brown trout and it is likely that these occur throughout both the Clachan Burn and Allt Mor. There is the potential for depositions of sediment to be present offering habitat for lamprey species; however this could not be assessed from aerial photography.

No records of freshwater fish species were returned by the NBN Atlas Scotland.

Invertebrates

Butterflies

Habitats throughout the Site have the potential to support rare and common butterfly species. For example, the damp grassland and heathland present are suitable for species such as small pearl-bordered fritillary *Boloria selene* and marsh fritillary *Euphydryus aurinia*, both listed on Schedule 5 of the Wildlife and Countryside act and the Scottish Biodiversity List.

Freshwater invertebrates

Records of ten species of dragonfly and damselfly were returned by the NBN Atlas Scotland from the lochs on Site, nine of which were recorded at Loch nan Gad. Many of these species are tolerant of the acid conditions that are likely to occur in lochs surrounded by heathland and conifer plantation. The large number of species indicates an unpolluted waterbody.

The NBN Atlas Scotland returned data from freshwater invertebrate surveys undertaken across three sites on the Clachan Burn by SEPA in 2005 and 2006. A range of invertebrates were found including numerous species of aquatic beetle, stonefly, caddisfly, true-fly and freshwater snail; this biodiversity indicates good water quality.

Clean and fast flowing river habitat with fine gravel or sand has the potential to support freshwater pearl mussel *Margaritifera margaritifera*, and may be present within the Study Area. This species requires an Atlantic salmon or brown trout host to complete its lifecycle, thus its presence may be constrained by a lack of access to fish. Furthermore, the Site is outside the known range of the species, which is not recorded as occurring on the Kintyre Peninsula (Skinner et al., 2003).

Marine invertebrates

The coastal area 1 km to the west of the Site has the potential to support numerous common marine species. For example, the NBN Atlas Scotland returned records of several polychaete worms, anemones, starfish, crabs and mollusc species.

Lichen

The NBN Atlas Scotland returned records of 48 lichen species from a single survey in 2004. All records were from the coastal area at Dun Skeig. One lichen species recorded was *Lobaria pulmonaria*, a Scottish Biodiversity List species and protected by the Wildlife and Countryside Act (Schedule 8). Habitat for this species, including broadleaved trees and mossy rocks, is likely to be present throughout the Site. Due to the remoteness of the Site, air quality is likely to be good and this could promote the occurrence of a range of lichen species.

No bryophyte records were found on the NBN Atlas Scotland, however particular broadleaved woodland habitat in this geographical location is known to support notable bryophyte (moss and liverwort) communities. The Allt Mor and Clachan Burn are both included in the SNH commissioned project 'Bryological assessment for hydroelectric schemes[1] in the West Highlands' (Averis *et al*, 2012). Both are categorised as potentially important but not surveyed.

Invasive non-native species

Sika deer *Cervus nippon*, are known to be present on the Kintyre Peninsula and may be present in the wooded areas on Site.

Given the proximity to the village of Clachan, there is the potential for invasive non-native plants to occur. Rhododhendron could be seen from Google Streetview within the village growing on the bank of the Clachan

[1] Although this assessment related specifically to hydro-electric schemes, flood schemes have the potential to result in changes in hydrology and therefore similar impacts.

Burn, and it is possible that other invasive non-native plants such as Japanese knotweed *Reynoutria japonica*, as well as escaped garden species, will be present.

5. Ecological constraints and recommendations

Approach to the identification of ecological constraints

Relevant ecological features that may represent constraints to the Scheme, or that provide opportunities to deliver ecological enhancement in accordance with planning policy, are identified in Section 4 of this Report.

Scottish Planning Policy and local planning policy (summarised in Section 2 of this Report) specify requirements for the protection of features of importance for biodiversity, and requirements for the protection of sites of conservation importance. Planning policy is a material consideration when determining planning applications.

Compliance with planning policy requires that the proposed works considers and engages the following mitigation hierarchy where there is potential for impacts on relevant ecological receptors:

1. avoid features where possible;
2. minimise impact by design, method of working or other measures; and,
3. compensate for significant residual impacts, for example by providing suitable habitats.

This hierarchy requires the highest level to be applied where possible. The rationale for the proposed mitigation and/or compensation should be provided with planning applications, including sufficient detail to show that these measures are feasible and would be provided.

The likelihood of the relevant ecological features constraining the proposed works has been assessed with reference to the scale described in Table 3. The higher the importance of the ecological receptor for the conservation of biodiversity at national and local scales, the more likely it is to be a material consideration during determination of the planning application for the proposed works.

In pursuance of the objective within Scottish Planning Policy of providing biodiversity benefits where possible, consideration should be given (where appropriate) to scope for enhancement as part of the proposed works. This should represent biodiversity gain over and above that achieved through mitigation and compensation. Enhancement could be achieved on and/or off the Site.

Table 3. Scale of constraint to development

Likelihood	Definition
High	An actual or potential constraint that is subject to relevant legal protection and is likely to be a material consideration in determining the planning application (e.g. statutory nature conservation designations and European/nationally protected species). Further survey likely to be required (as detailed in this report) to support a planning application.
Medium	An actual or potential constraint that is covered by national or local planning policy and, depending on the level of the potential impact as a result of the proposed works, may be a material consideration in determining the planning application. Further survey may be required (as detailed in this report) to support a planning application.
Low	Unlikely to be a constraint to works or require further survey prior to submission of a planning application. Mitigation is likely to be covered under Construction Environmental Management Plan (CEMP) or precautionary working method statement (e.g. generic requirements for the management of nesting bird risks).

Constraints and recommendations: designations

Statutory designations

Kintyre Goose Roosts SPA and Ramsar site, Kintyre Goose Lochs SSSI and Rhunahaorine Point SSSI

The sole qualifying interest of the Kintyre Goose Roosts SPA and Ramsar site and notified feature of Kintyre Goose Lochs SSSI are over-wintering Greenland white-fronted goose. This is also a notifying feature of Rhunahaorine Point SSSI, along with breeding little tern and shingle. The three parts of the SPA within the relevant search distances are Loch Garasdale (444 m from Site) and Loch an Fhraoich (4.8 km from Site), both of which are overlapped by the Kintyre Goose Lochs SSSI, and Rhunahaorine Point (6 km from Site), overlapped by the Rhunahaorine Point SSSI.

Any land utilised by the qualifying species for which a SPA is designated, even if not within the defined SPA boundary, has potential to be 'functionally linked' to the designation and must be taken into account when assessing potential impacts upon it. European sites and their qualifying features are of great ecological importance and are strictly protected under the Habitats Regulations (see legislation section above).

It is noted in the SPA citation that Greenland white-fronted goose roosts exist on the Kintyre Peninsula out with the defined SPA area. However, although functionally linked to the SPA, they are used only sporadically and by smaller numbers of geese than is considered to be nationally important. Non-designated potentially suitable roosting and foraging habitat (not noted in the SPA citation) is present within the Site in the form of lochs and improved agricultural land around Clachan village, and connectivity between the SPA / Ramsar site and SSSIs and the Site is possible, with Loch Ciaran only 2.3 km from Loch Garasdale. Therefore, habitat which may be used by foraging geese (and therefore may be functionally-linked to the SPA) does occur within the Site.

Such habitat may be affected both during the construction and operational phases of the Scheme. If a significant area of improved grassland habitat in this area will be lost to the Scheme (even temporarily during flood events), or significant disturbance is possible during construction, it is considered possible that there may be a Likely Significant Effect (LSE) on the SPA qualifying feature. To assess if such a LSE is possible, a Habitats Regulations Appraisal (HRA) Screening exercise will be required to assess whether the proposed works may have a significant adverse effect on the SPA or its qualifying feature. It is therefore recommended that an HRA Screening assessment is carried out in relation to the proposed Scheme. SNH should be involved throughout the Screening process and approached for any relevant data they may hold. Depending on the data available (from SNH and other sources), there may be a requirement for wintering bird surveys to be carried out to collect data on the use of the Sites by Greenland white-fronted geese.

Given the above, the Kintyre Goose Roosts SPA (and associated Kintyre Goose Lochs SSSI) is considered to pose a **Medium** constraint to the Scheme.

Suitable beach habitat for breeding little tern, an additional notified feature of Rhunahaorine Point SSSI, is present at the mouth of the Clachan Burn in Dunskeig Bay. However, given the distance to the Site, it is unlikely that nesting terns will be subject to any disturbance as a result of construction. Shingle, another notified feature of Rhunahaorine Point SSSI, is unlikely to be affected by works given the distances involved.

Rhunahaorine Point SSSI is considered to pose **No** constraint to the Scheme.

Sound of Gigha pSPA

It is Scottish Government policy to treat pSPAs as if they were fully designated sites and the Sound of Gigha pSPA should be considered as thus. Proposed marine SPAs were scheduled for final submission to Government in February 2018, however no formal full designation has yet been announced. This site follows the coast of the Kintyre Peninsula approximately 1 km to the west of the Site. The habitats on Site are unsuitable for the species for which the pSPA qualifies (wintering great-northern diver, eider and red-breasted merganser).

As such, the Sound of Gigha pSPA is considered to be of **No** constraint to the Scheme and is not considered further.

Inner Hebrides and the Minches SAC

This site, solely designated due to the presence of harbour porpoise, extends to the coast of the Kintyre Peninsula approximately 1 km to the west of the Site.

Any potential waterborne pollution as a result of the Scheme should be prevented through the implementation of standard pollution prevention measures, and any pollution event is likely to be fully mitigated by the significant dilution effects of the intervening waterbody. Thus, Inner Hebrides and the Minches SAC is considered to present **No** constraint to the Scheme.

Tarbert Woods SAC and Ardpatrick and Dunmore Woods SSSI

Tarbert Woods SAC is designated due to the presence of old sessile oak *Quercus petraea* woods. Given the degree of separation from the Site, with two areas being on the opposite bank of West Loch Tarbert, and a third 8.7 km north east, separated from the Site by conifer plantation and moorland, no effects on the SAC are anticipated as a result of the Scheme. Ardpatrick and Dunmore Woods SSSI is designated for similar reasons and is located on the opposite bank of West Loch Tarbert, concurrent with the SAC.

Tarbert Woods SAC and Ardpatrick and Dunmore Woods SSSI are therefore considered to be present **No** constraint to the Scheme.

Loch Sween MPA

Loch Sween MPA is over 16 km to the north-east of the Site, and is directly connected to the Clachan Burn via the coast. Given the distances involved, any pollution events are unlikely to be of a significant scale to affect this designation. As well as dilution effects there will be strict pollution prevention measures in place during construction of the Scheme to avoid such pollution events occurring in the first place. Under the legislation by which MPAs are protected (the Marine (Scotland) Act), Scottish Ministers must be notified by a public authority if “the exercise of any of the authority’s functions, or an activity that the authority intends to carry out, will significantly hinder the conservation objectives of a MPA – unless guidance has been given previously”.

The MPA is considered to pose **No** constraint to the Scheme and it is not considered necessary that such consultation under the Marine (Scotland) Act takes place.

Non statutory designations

Local Nature Conservation Sites

Three Local Nature Conservation Sites are present within the Desk Study Area, two within the Site itself and West Loch Tarbert LNCS located approximately 1 km to the north west of the Site. Details regarding the conservation value of these sites could not be found and although LNCS do not receive any specific legal protection, they have been highlighted as important to local nature conservation / biodiversity. As mentioned previously, Loch Ciaran and the Loch an Eilein group have the potential to support red-throated diver, Greenland white-fronted goose, brown trout and numerous invertebrate and amphibian species; all LNCS have the potential to support otter.

There is potential for connectivity to exist between the Scheme and these sites. If LNCS may be affected by works, further survey may be required to assess if it hosts notable habitats or species (likely to be the case, by virtue of their designation), and mitigation relating to these may be required. LNCS are considered to be a **Medium** constraint to the Scheme.

Ancient Woodland

Only a small area of ancient woodland exists within the Site, directly adjacent to Clachan village and surrounding residences. Ancient woodland is relatively uncommon within this part of the Kintyre Peninsula and therefore potentially provides valuable habitat for a range of species. National planning policy states that ancient woodland should be protected and enhanced (along with other native and long-established woodlands with high nature conservation value). If woodland habitat is likely to be affected by works (during construction or operation) either directly or indirectly (i.e. via pollution via watercourses) further survey is recommended to collect data on woodland types present.

Ancient woodland is considered to pose a **Low** constraint to the Scheme.

Constraints and recommendations: habitats

Blanket bog was identified from the Habitat Map of Scotland as being present in the north-east of the Site. This habitat is listed on Annex I of the Habitats Directive and is therefore protected from actions that will jeopardise its favourable conservation status. There is also a presumption against developments that will adversely affect this habitat. Furthermore, the habitat is listed on the Scottish Biodiversity List and Argyll and Bute Biodiversity Action Plan.

Rivers and streams on Site qualify as SBL habitats by fitting the criteria for headwaters, and potentially for the presence of Atlantic salmon. As mentioned above, both the Clachan Burn and Allt Mor have good water quality but receive a Poor overall status on the SEPA River Basin Management Water Environment Hub only due to barriers for fish migration.

Conifer plantation covers the majority of the Site and appears to comprise dense and uniform stands of an exotic conifer species, with limited ecological value. There is the potential for areas of the plantation to comprise Scots pine *Pinus sylvestris*, which would be of higher value.

Lochs on Site have the potential to qualify as Oligotrophic and Dystrophic Lakes, an SBL habitat. Although ecologically valuable, this is a common habitat type across this part of Scotland.

Broadleaved woodland, including that on the AWI is present on Site. Much of this is present as riparian vegetation and therefore has the potential to be affected by the Scheme.

Additional farmland and moorland habitats are likely to be of some ecological value; however this could not be assessed from aerial imagery.

Other habitats which are not notable are likely to be present on. These habitats may support notable species, although they have limited ecological value themselves.

Habitats could not be fully assessed using aerial imagery, however it is considered likely that notable habitats are present on Site. It is recommended that where habitats may be affected by the Scheme, a Phase 1 habitat survey is carried out to identify the habitat types present. It may also be necessary to carry out NVC survey in areas of particularly diverse vegetation or where there may be GWDTE (a SEPA requirement). Where river / stream habitat may be affected, appropriate aquatic habitat surveys (such as River Habitat Survey (RHS)) may be required.

If notable habitats are affected by the Scheme, following biodiversity best practice these should be remediated / replaced like-for-like. Notable habitats therefore pose a **Medium** constraint to the Scheme.

Constraints and recommendations: species

Plants

Habitat suitable for Killarney fern, a species protected under Annex II of the Habitats Directive and listed on the SBL, is present on Site. If works are to impact this habitat, it is suggested that survey for Killarney fern is carried out.

Killarney fern is deemed to pose a **Medium** constraint to the proposed works.

Mammals

Badger

Suitable habitat for badger is present on Site. Badger are specially protected by the Protection of Badgers Act, thus survey for this species should take place if works will affect suitable habitat. If badger refuges are present and may be disturbed / destroyed during works, mitigation (including obtaining licences from SNH) will be required.

Badger is considered to be a **Medium** level constraint to the Scheme.

Bats

Bats are European Protected Species and receive strict legal protection under the WCA. Suitable habitat and roosting opportunities for bats are present across the Site. If trees or buildings are to be impacted by the final design of the Scheme (during construction or operation) they should be subject to assessment of their suitability to roosting bats. Depending on the feature, further assessment may be required and this could take several forms. Surveys could include further ground-based investigations using an endoscope, survey of the features at height (using a ladder or climbing techniques) and/or dusk emergence / dawn re-entry surveys during the bat activity season. Activity surveys would also be beneficial in investigating the use of habitat present. A suitable survey programme should be devised and surveys should follow the guidelines published by the Bat

Conservation Trust (BCT) in Collins (2016). If bat roosts are found to be present and may be disturbed / destroyed during works, mitigation (including obtaining licences from SNH) will be required.

Therefore bat species have the potential to pose a **Medium** level constraint to the Scheme.

Otter

Streams and waterbodies across the Site are suitable for otter and it is considered likely that the species is present. Otter are strictly protected under the Habitats Regulations (i.e. they are EPS).

If otter refuges are present and may be disturbed / destroyed during works, mitigation (including obtaining licences from SNH) will be required. Given their protection and close association of this species and the Scheme with watercourses, otter has the potential to present a **High** level constraint to the Scheme.

Pine marten and red squirrel

Suitable woodland habitat is available for both pine marten and red squirrel throughout the Site. Both species are protected under the WCA, and if the Scheme involves disturbing suitable habitat, it would be necessary to conduct surveys for both species.

If pine marten / squirrel refuges are present and may be disturbed / destroyed during works, mitigation (including obtaining licences from SNH) will be required. These species are considered likely to be present and may present a **Medium** level constraint to the Scheme.

Water vole

Some suitable habitat is present on Site for water vole. Water vole burrows are protected by the WCA, thus it is suggested that surveys for the species are undertaken if suitable habitat will be disturbed.

If water vole refuges are present and may be disturbed / destroyed during works, mitigation (including obtaining licences from SNH) will be required. Given their protection and close association of this species and the Scheme with watercourses, water vole is considered to present a **Medium** level constraint to the Scheme.

Wildcat

The mosaic of habitats required by wildcat is present in the wider area, and the Site is within the known range of the species (although proximity of the Scheme to human habitation reduces their potential to be present). Wildcat are EPS and it is therefore recommended that wildcat surveys be undertaken if suitable habitat for this species will be disturbed.

If wild cat refuges are present and may be disturbed / destroyed during works, mitigation (including obtaining licences from SNH) will be required. Wildcat is therefore considered to present a **Medium** level constraint to the Scheme.

Marine mammals

No suitable habitat is available on Site for marine mammals and designated seal haul-out sites are located at least 17 km away on the opposite side of the Kintyre Peninsula from the mouth of the Clachan Burn. Therefore marine mammals pose **No** constraint to the Scheme.

Birds

Habitats assessed as potentially present may support populations of specially protected bird species. These may include barn owl, common crossbill, hen harrier, osprey and red-throated diver (Schedule 1 (WCA) species); black grouse (SBL and LBAP) and waders such as curlew (SBL, LBAP and BoCC red list). Greenland white-fronted goose (qualifying interest of the nearby SPA) may also be seasonally present within the Scheme area.

Given the above, the Scheme may affect notable bird species and specific bird surveys may be required, notable bird species therefore represent a **Medium** constraint to the Scheme.

There is potential for common breeding bird species to be present throughout the Site, assemblages of which may be important locally and require specific mitigation. If suitable habitat for such assemblages of breeding birds will be affected, it is recommended that a programme of breeding bird surveys be undertaken to identify the species present and any mitigation required, Furthermore, active nests of all wild birds are protected under the WCA, this should be noted during preparations for pre-construction or construction works.

Common breeding birds are considered to be a **Medium** level constraint to the Scheme.

Reptiles and amphibians

Habitat potentially suitable for adder is present on Site. All native reptiles are protected from intentional or reckless killing or injury under the WCA, and adder is an SBL species

If suitable habitat for notable reptile species may be affected by the Scheme, further survey and mitigation may be required. Notable reptiles present a **Low** level constraint to the Scheme.

Habitat potentially suitable for great crested newt (EPS) is present on Site, and given the nature of the Scheme there is higher risk of impacts upon the aquatic environment (on which this species depends). It is therefore recommended that Habitat Suitability Index (HSI) surveys of all waterbodies within 250 m of the Scheme are carried out. If waterbodies are found to be suitable for great crested newt, and may be affected by works, further surveys potentially consisting of eDNA analysis and subsequent trapping and torching may be required to investigate their presence and inform mitigation requirements. If great crested newt are present and may be disturbed / habitats destroyed during works, mitigation (including obtaining licences from SNH) will be required.

Other notable amphibians may be present (e.g. common toad, an SBL species), however such species are common and widespread and their presence is only likely to require standard mitigation measures to avoid direct harm.

Therefore notable amphibians (including great crested newt) have the potential to be a **Medium** level constraint to the Scheme.

Fish

Both watercourses were assessed as having “Poor” accessibility to fish in 2017, however this is inconsistent with previous years and watercourses still appear to offer suitable habitat for brown trout throughout and Atlantic salmon and sea trout in the lower reaches of the Clachan Burn.

It is recommended that the local fisheries group is consulted to investigate the potential presence of notable fish species, to understand the local fisheries ecology such as timings of runs / spawning periods, and in regards to barriers to fish migration present in 2017.

As the Scheme is inherently associated with watercourses, the works could have adverse effects on fish or other aquatic features (if found to be present), either directly or indirectly and during construction or operation.

If notable fish species or their habitats may be affected by the Scheme, further survey will be required.

Given the close association of both fish species and the Scheme with watercourses, fish are considered a **Medium** level constraint to the Scheme.

Invertebrates

Given the habitats likely to be present, there is the potential for notable butterfly and dragonfly species to occur on Site. Notable macrophytic invertebrates may also be present within both freshwater and marine habitats.

If terrestrial or aquatic habitats will be affected by the Scheme, invertebrate surveys are recommended. These may inform appropriate detailed design of the Scheme, or inform habitat mitigation recommendations.

Notable invertebrates are considered to pose a **Low** level constraint to the Scheme.

Lichens and bryophytes

Notable lichen species were recorded near to the Site, and it is known that notable species / assemblages of lichens and bryophytes exist within the general Scheme area. Certain bryophyte species are closely associated with watercourses and highly dependent on specific micro-habitats and can be affected by minor changes in inundation / splashing / humidity). Such species, if present within the Scheme area, may be significantly affected by any changes to watercourses and associated hydrology. The Allt Mor and Clachan Burn are included in the SNH commissioned project ‘Bryological assessment for hydroelectric schemes in the West Highlands’ (Averis *et al*, 2012). Both were categorised as potentially important but not surveyed. Consequently the assessment recommends that targeted bryological surveys are required regarding hydro-electric schemes on these watercourses.

If the Scheme affects habitats with the potential to host notable lichen / bryophyte communities, further survey (or consultation regarding survey requirements) for these species is recommended. Results of these surveys may inform the detailed design of the Scheme, or inform mitigation requirements. Therefore, notable species / assemblages of lichens and bryophytes are considered to pose a **Low** level constraint to the Scheme.

Invasive non-native species

Sika deer are non-native to the UK and as such (under the WANE Act) it is an offence to release this species or allow it to escape from captivity – such actions are not relevant to the Scheme and as such this species is not considered further.

Rhododendron is listed on Schedule 9 of the WCA (although this no longer applies in Scotland) and is therefore considered a potentially high impact species. It is also possible that other invasive non-native plant species are present.

It is an offence under the Wildlife and Natural Environment Act (Scotland) Act 2011 (as amended) to plant, or otherwise cause to grow, any plant in the wild at a location outside its native range. There are therefore considered to be two primary risks regarding the Scheme and invasive non-native species: the potential movement of invasive plant material during construction (i.e. a direct effect), and effects associated with the nature of the Scheme which will involve amendments to watercourses, culverts and discharge locations which could facilitate new movement / increased movement of such species indirectly.

With regard to non-native species, if charged with committing an offence, it is a defence against prosecution to prove that all reasonable steps were taken and all due diligence exercised in attempting to avoid committing the offence. Therefore, to demonstrate due diligence and avoid the accidental spread of the non-native species, they should be subject to specific survey (where possible) at an appropriate time of the year, and encompassed within a Biosecurity Management Plan (BMP). This document will record the known locations of relevant species (both terrestrial and aquatic), assess the risk they pose to the project (once a detailed design is chosen) and set out proportionate measures to be implemented to control these risks. Construction and operational risks should be considered. Careful consideration of species-specific management is also required as all non-native species have differing methods and timings of dispersal. Where possible, works should aim to avoid invasive non-native species (plus a suitable buffer) entirely and appropriate biosecurity (cleaning of machinery etc.) must be described in the BMP and fully employed. The BMP must be strictly adhered to and inform all stages of the work proposed, including preliminary tasks such as ground investigation.

Non-native invasive plant species are deemed to pose a **Medium** constraint to Scheme.

6. Summary

Several ecological features may be present on Site, as described in this Report. If present, notable ecological features may to pose constraints to the Scheme and these have been discussed in Section 5 and are summarised in Table 6, below. Where potential constraints have been identified, high-level recommendations for further ecological survey work and possible requirements for mitigation have been provided. Features discussed above and assessed as being likely to pose no constraint to the Scheme are not included in Table 6.

Table 6. Summary appraisal of ecological constraints and recommended further action

Receptor	Scale of constraint	Further action, including surveys and potential mitigation	Primary driver	When is action likely to be required		
				To inform design	Before planning application	Pre-construction onwards
Kintyre Goose Roosts SPA (and Ramsar, plus Kintyre Goose Loch SSSI	Medium	HRA Screening in consultation with SNH. Further field work potentially required.	Legislation	✓	✓	
LNCS	Medium	If affected further survey for notable habitats / species and consequent mitigation may be required.	Planning policy	✓	✓	
Ancient Woodland	Low	Avoid ancient woodland removal (and removal of other woodland with high nature conservation value). Further survey to identify ancient woodland areas which may be affected. If removed mitigation is not possible.	Planning policy	✓	✓	
Notable habitats	Medium	Avoid adversely affecting notable habitats such as streams, woodland and blanket bog. Survey will be required to assess if notable habitats are present within the Scheme area. If notable habitats are adversely affected, these must be remediated / replaced.	Legislation	✓	✓	
Broad leaved woodland	Medium	Minimise woodland and tree removal.	Planning policy	✓	✓	
Killarney fern	Medium	Survey of suitable habitat within zone of influence of Scheme. If found, take steps to maintain favourable conservation status.	Legislation	✓	✓	
Badger	Medium	Survey of suitable habitat within zone of influence of Scheme. If refuges are located within disturbance distance mitigation / licensing will be required.	Legislation	✓	✓	✓
Bat species	Medium	Survey of suitable habitat within zone of influence of Scheme for roost suitability and activity. If structures/trees suitable as roosts are located within disturbance distance, further survey will be required alongside potential mitigation / licensing.	Legislation		✓	✓
Otter	High	Survey of suitable habitat within zone of influence of Scheme. If refuges are located within disturbance distance mitigation / licensing will be required.	Legislation	✓	✓	✓
Pine marten and red squirrel	Medium	Survey of suitable habitat within zone of influence of Scheme. If refuges are located within disturbance distance mitigation / licensing will be required.	Legislation	✓	✓	✓
Watervole	Medium	Survey of suitable habitat within zone of influence of Scheme.	Legislation	✓	✓	✓

Receptor	Scale of constraint	Further action, including surveys and potential mitigation	Primary driver	When is action likely to be required		
				To inform design	Before planning application	Pre-construction onwards
		If refuges are located within disturbance distance mitigation / licensing will be required				
Wildcat	Medium	Survey of suitable habitat within zone of influence of Scheme. If refuges are located within disturbance distance mitigation / licensing will be required	Legislation	✓	✓	
Notable bird species	Medium	Species specific survey if relevant habitats will be affected. Implementation of specific mitigation.	Legislation	✓	✓	✓
Common breeding birds	Medium	Although not notable, assemblages of common bird species may be affected. Survey may be required depending on habitat affected. Mitigation to avoid offences regarding disturbance / obstruction / destruction of active bird nests.	Legislation			✓
Notable reptiles	Low	Survey / mitigation if suitable retile habitat will be affected.	Legislation	✓	✓	✓
Notable amphibians (including great crested newt)	Medium	HSI surveys required for waterbodies within 250 m of the Scheme. If waterbodies are found to be suitable, and likely to be affected by the Scheme, further surveys to investigate the presence / absence of this species may be required. If great crested newt are located within disturbance distance mitigation / licensing will be required. Standard mitigation required for common amphibians.	Legislation	✓	✓	✓
Fish	Medium	Consultation with local fisheries trusts to investigate presence of notable species, local ecology and barriers to fish migration. Survey of suitable habitat within zone of influence of Scheme. Implementation of specific mitigation.	Legislation	✓	✓	✓
Notable invertebrates	Low	Survey for terrestrial / aquatic invertebrates if suitable habitat will be affected. Implementation of specific mitigation if required.	Legislation / Planning policy	✓	✓	✓
Notable lichens and bryophytes	Low	If suitable habitat for these species will be affected, consultation / further survey required. If significant assemblages present, specific mitigation to be implemented.	Planning policy	✓	✓	✓
Invasive non-native species	Medium	Dedicated survey for terrestrial and aquatic species within Scheme area. If present (highly likely) production of a Biosecurity Management Plan (BMP) to be strictly adhered to.	Legislation		✓	✓

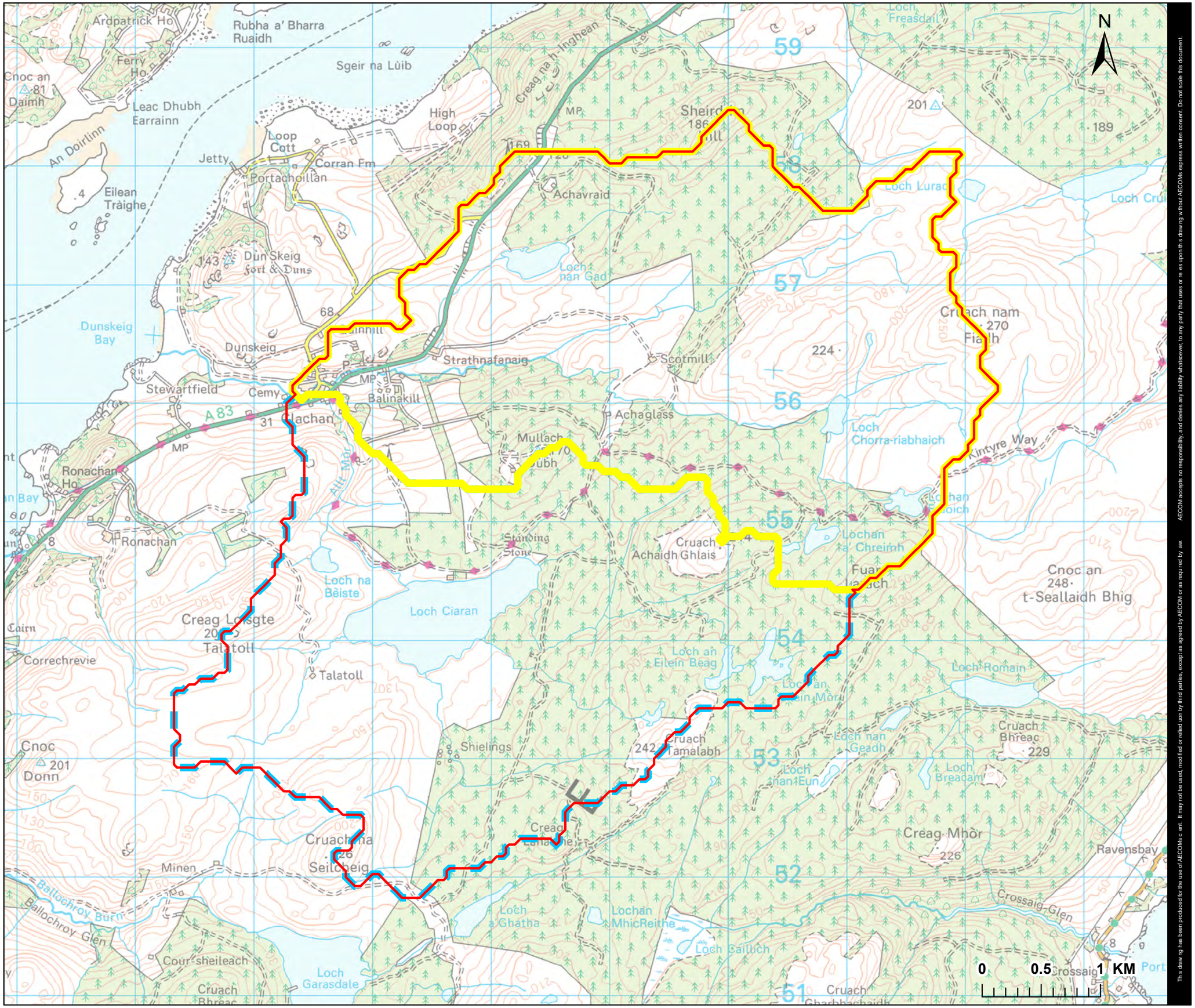
7. Enhancement

National planning policy outlines that the planning system should seek biodiversity benefits from new development where possible. The proposed Scheme could incorporate a number of ecological enhancement measures and this concept should be built-in to the Scheme from an early stage and refined as the Scheme progresses. Suggestions for potential enhancement measure are outlined below:

- The burns within the Scheme area may have a number of modifications such as culverts which may affect the presence of protected and notable species. Removing obstacles to migration (for both fish and mammals such as otter) and improving the immediate riparian habitat to improve connectivity could constitute significant ecological enhancement as part of the scheme.
- Vegetation planting upstream to attenuate and store water flow before it reaches the flood risk area could increase ecologically valuable habitat and could constitute significant ecological enhancement. Areas of proposed planting would have to be carefully selected to ensure a net gain in biodiversity is achieved, and that the natural function of ecologically valuable habitats is maintained (including land which may be functional to specially protected sites as noted above).
- If non-native species are found to be present these will need to be managed, most likely through the production of an Invasive Species Biosecurity Management Plan (BMP). If such plans are required these would constitute an ecological benefit in themselves by cataloguing the species present and avoiding the further spread of such species. There is potential to widen the ecological benefit of such plans by increasing their scope to the entire catchment(s) (which in this area is not particularly large). A catchment-wide approach will have far-reaching ecological benefit and may help to address the risk of invasive-non-native species spreading back into the Scheme area in the future.

8. Figures

Project Management Initials: SH Designer: JD Checked: SM Approved: TM



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AECOM

PROJECT

Clachan Flood Scheme

CLIENT

Argyll and Bute Council

KEY:

- Site boundary
- Allt Mor catchment
- Clachan Burn catchment

PROJECT NUMBER

60578115

SHEET TITLE

Figure 1 - Site overview

SHEET NUMBER

1 of 1

Scale: 1:30,000 @ A3

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Project Management Initials: SH Designer: JD Checked: SM Approved: TM

Inner Hebrides and the Minches SAC

Tarbert Woods SAC

Tarbert Woods SAC

Sound of Gigha pSPA

Kintyre Goose Roosts SPA and Ramsar

N

0 2.5 5 KM

Scale: 1:100,000 @ A3

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PROJECT

Clachan Flood Scheme

CLIENT

Argyll and Bute Council

KEY:

- Site boundary
- 10 km buffer
- Special Protection Area
- Special Area of Conservation
- Wetland of International Importance (Ramsar site)

PROJECT NUMBER

60578115

SHEET TITLE

Figure 2 - Internationally designated sites

SHEET NUMBER

1 of 1

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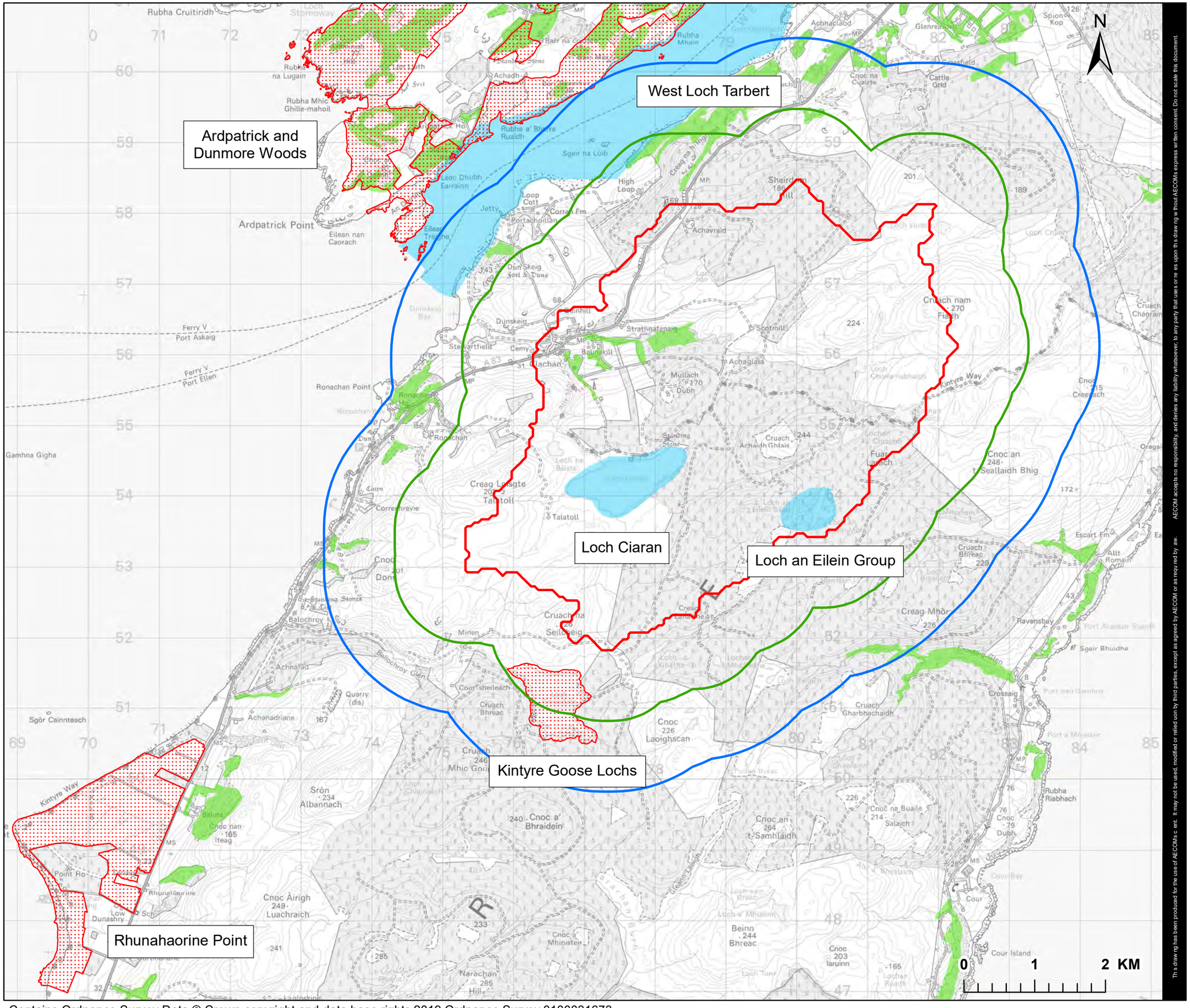

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PROJECT

Clachan Flood Scheme

CLIENT

Argyll and Bute Council

KEY:

- Site boundary
- 1 km buffer
- 2 km buffer
- Site of Special Scientific Interest
- Ancient woodland
- Local Nature Conservation Site

PROJECT NUMBER

60578115

SHEET TITLE

Figure 3 - Nationally designated sites

SHEET NUMBER

1 of 1

Project Management Initials: SH Designer: JD Checked: SM Approved: TM

Loch Sween

N

0 5 10 KM

Scale: 1:200,000 @ A3

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PROJECT

Clachan Flood Scheme

CLIENT

Argyll and Bute Council

KEY:

- Site boundary
- 20 km buffer
- Marine Protected Area

PROJECT NUMBER

60578115

SHEET TITLE

Figure 4 - Marine Protected Areas

SHEET NUMBER

1 of 1

9. References

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Skinner, A., Young, M. & Hastie, L. (2003). *Ecology of the Freshwater Pearl Mussel*. Conserving Natura 2000 Rivers Ecology Series No. 2 English Nature, Peterborough.

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Scottish Wildcat Action website: http://www.scottishwildcataction.org/how-you-can-help

Appendix A Legislation and Planning Policy

This Appendix provides only a summary of relevant legislation and policy, covering only the most relevant aspects.

Conservation (Natural Habitats, &c.) Regulations 1994 (as amended in Scotland)

These Regulations ('the Habitats Regulations') implement *Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora* (the 'Habitats Directive'), designating and protecting European Protected Species (EPS) and Natura 2000 sites. The latter comprise Special Protection Areas (SPAs) for birds, and Special Areas of Conservation (SACs) for other taxa and habitats. For EPS (including all bats, otter *Lutra lutra*, great crested newt *Triturus cristatus* and natterjack toad *Bufo calamita*) it is an offence to:

- Deliberately or recklessly kill, injure or take an EPS (or its eggs where applicable);
- Deliberately or recklessly disturb an EPS at a place of shelter, or elsewhere if this could impair its ability to breed or affect its local distribution; or,
- Damage, destroy or obstruct access to an EPS place of shelter (whether occupied or not).

Places of shelter include all bat roosts, otter holts and laying-up areas, and great crested newt foraging/hibernation habitat up to 500m from breeding ponds where connective habitat exists.

Actions which would be EPS offences can be licensed, if a) the reason is one of the specified purposes in Regulation 44(2), b) there is no satisfactory alternative, and c) the 'favourable conservation status' of the species is not compromised. Developments affecting Natura 2000 sites must be subject to a Habitats Regulations Appraisal (HRA), and site integrity must be maintained.

Wildlife & Countryside Act 1981 (as amended in Scotland) (WCA)
Nature Conservation (Scotland) Act 2004 (as amended)
Wildlife & Natural Environment (Scotland) Act 2011 (as amended) (WANE Act)

These Acts work together to protect birds and certain animals and plants, regulate non-native species, protect Sites of Special Scientific Interest (SSSIs) and place a duty on public bodies to further the conservation of biodiversity. The WCA implements *Directive 2009/147/EC on the conservation of wild birds* (the 'Birds Directive') and the *Convention on the Conservation of European Wildlife and Natural Habitats* (Bern Convention). For Schedule 5 animals (e.g. red squirrel *Sciurus vulgaris*, water vole *Arvicola amphibius*, pine marten *Martes martes* and wildcat *Felis sylvestris*) it is an offence to intentionally or recklessly (or knowingly cause or permit another person to):

- Kill, injure or take the animal (not currently applicable to water vole in Scotland);
- Damage, destroy or obstruct access to the animal's places of shelter; or,
- Disturb the animal whilst at a place of shelter.

Common reptiles are protected from intentional or reckless killing and injury.

For birds it is an offence to intentionally or recklessly:

- Kill, injure or take any wild bird or its eggs;
- Take, damage, destroy or interfere with the nest of any wild bird whilst in use or being built (or at any time for eagles), or obstruct/prevent any wild bird from using its nest; or,
- Disturb Schedule 1 birds at or near an active nest or lek, or their dependent young (or harass eagles, hen harrier or red kite at any time).

Actions which would be offences regarding wild birds cannot be licensed for development purposes. Some actions which would be offences affecting Schedule 5 species can be licensed for development purposes if there is a) significant social, economic or environmental benefit and b) no satisfactory alternative. Developments affecting SSSIs are generally only allowed if there are reasons of national importance and site integrity will be

maintained. Under the WANE Act it is an offence in Scotland to spread any non-native species in the wild (not only those on Schedule 9 of the WCA).

Protection of Badgers Act 1992 (as amended in Scotland)

It is an offence to: wilfully kill, injure or take a badger; intentionally or recklessly damage, destroy or obstruct a badger sett; or disturb a badger in a sett (or allow someone to do these things). A sett is any structure or place with signs of current use by badger. Some actions which would be offences can be licensed, but direct removal or killing of badgers cannot be licensed for development purposes.

EU Directive 2000/60/EC Water Framework Directive (WFD)

The WFD requires that water catchments are managed so that waterbodies and watercourses meet required standards. A consequence is that SEPA normally require developers to identify groundwater-dependent terrestrial ecosystems (GWDTEs) within 100m of roads/trenches or 250m of substantial constructions, and to avoid degradation of GWDTEs and surface waters. If avoidance is not possible, SEPA will require mitigation to minimise impacts, and may request planning conditions to guarantee it.

Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species ('Invasive Alien Species Regulation')

This lists invasive non-native species of EU concern and sets out requirements for their management. EU regulations are applicable to member states without implementation through national legislation.

Conservation of Salmon (Scotland) Regulations 2016 ('Salmon Regulations').

These Regulations require the conservation status of salmon populations on catchments supporting them to be assessed yearly, and the numbers of salmon that may be killed (if any) to be determined. They also state that conservation plans may be agreed for conservation and management of salmon.

Scottish Planning Policy (SPP) 2014

SPP recognises the environment as a national asset offering opportunities for enjoyment, recreation and sustainable economic activity. In summary, the policy principles most relevant to nature conservation state that the planning system should:

- facilitate positive change while maintaining and enhancing distinctive landscape character;
- conserve and enhance protected sites and species, maintaining healthy ecosystems and natural processes which provide important services to communities;
- protect and improve the water environment and soil;
- protect and enhance ancient woodland, hedgerows and trees with high ecology/landscape value; and,
- seek biodiversity benefits from new development where possible.

SPP also sets out the biodiversity duty of public bodies and legislative requirements for protected sites and species. Note also that it is government policy to treat Ramsar sites in the same way as Natura 2000 sites (SACs and SPAs), and to treat candidate, potential or proposed Natura 2000 / Ramsar sites, and areas identified as compensation sites for adverse effects on these designations, as if they are fully designated.

Appendix B Protected and notable species records from within 2 km

Table B1. Notable Species Records within 2 km as accessed through NBN Atlas Scotland website

Type	Species	Scientific name	Legislation	Data source
Mammal	Otter	*Lutra lutra*	EPS, WCA Sch5, SBL, LBAP	Biological Records Centre
Mammal	Red squirrel	*Sciurus vulgaris*	WCA Sch5, SBL, LBAP	Scottish Wildlife Trust
Mammal	Wildcat	*Felis silvestris*	WCA Sch5, SBL, LBAP	Biological Records Centre
Mammal	Common seal	*Phoca vitulina*	Marine Scotland Act Part 6, SBL	Argyll Biological Records Centre
Bird	Barn owl	*Tyto alba*	WCA Sch1, SBL	Royal Society for the Protection of Birds (RSPB)
Bird	Black grouse	*Tetrao tetrix*	Red BoCC, SBL, LBAP	RSPB
Bird	Bullfinch	*Pyrrhula pyrrhula*	Amber BoCC, SBL, LBAP	RSPB
Bird	Curlew	*Numenius arquata*	Red BoCC, SBL, LBAP	RSPB
Bird	Dunnock	*Prunella modularis*	Amber BoCC	RSPB
Bird	Grasshopper warbler	*Locustella naevia*	Red BoCC, SBL, LBAP	RSPB
Bird	Lapwing	*Vanellus vanellus*	Red BoCC, SBL, LBAP	RSPB
Bird	House sparrow	*Passer domesticus*	Red BoCC, SBL	RSPB
Bird	Lesser redpoll	*Acanthis cabaret*	Red BoCC, SBL	RSPB
Bird	Redshank	*Tringa totanus*	Amber BoCC, LBAP	RSPB
Bird	Red-throated diver	*Gavia stellata*	WCA Sch1, SBL, LBAP	RSPB
Bird	Reed bunting	*Emberiza schoeniclus*	Amber BoCC, SBL, LBAP	RSPB
Bird	Snipe	*Gallinago gallinago*	Amber BoCC	RSPB
Bird	Song thrush	*Turdus philomelos*	Red BoCC, SBL	RSPB
Bird	Spotted flycatcher	*Muscicapa striata*	Red BoCC, SBL, LBAP	RSPB
Bird	Starling	*Sturnus vulgaris*	Red BoCC	RSPB
Bird	Tree pipit	*Anthus trivialis*	Red BoCC, SBL	RSPB
Bird	Twite	*Linaria flavirostris*	Red BoCC, LBAP	RSPB
Bird	Whinchat	*Saxicola rubetra*	Red BoCC	RSPB
Bird	Wood warbler	*Phylloscopus sibilatrix*	Red BoCC, SBL	RSPB
Bird	Yellowhammer	*Emberiza citrinella*	Red BoCC, SBL, LBAP	RSPB
Lichen		*Arthonia graphidicola*	Nationally scarce, SBL	British Lichen Society (BLS)
Lichen		*Arthonia stellaris*	Nationally scarce	BLS
Lichen		*Arthopyrenia carneobrunneola*	Nationally scarce, SBL	BLS
Lichen		*Crutarndina petractoides*	SBL	BLS
Lichen		*Eopyrenula grandicula*	Nationally scarce, SBL	BLS
Lichen		*Lecanora albella*	Nationally scarce, SBL	BLS
Lichen	Lungwort lichen	*Lobaria pulmonaria*	WCA Sch8, SBL	BLS
Lichen		*Opegrapha thelotrematis*	Nationally scarce, SBL	BLS
Lichen		*Arthopyrenia cerasi*	Nationally scarce	BLS

Type	Species	Scientific name	Legislation	Data source
Lichen		*Abrothallus microspermus*	Nationally scarce	BLS
Lichen		*Pyrenula laevigata*	Nationally scarce, SBL	BLS
Lichen		*Arthonia arthonioides*	Nationally scarce	BLS
Lichen		*Pyrenula occidentalis*	SBL	BLS
Lichen		*Sticta limbata*	SBL	BLS
Lichen		*Sticta sylvatica*	SBL	BLS

Nationally scarce refers to species occurring in 16 – 100 hectads in Great Britain.

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Appendix C – Baseline Damage Assessment

Clachan Flood Study

Baseline Economic, Social and Environmental Impact Assessment- Technical Report

Project number: 60578115

October 2019

Quality information

Prepared by	Checked by	Verified by	Approved by
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Revision History

Revision	Revision date	Details	Authorized by	Position
1	April 2019	Draft for client comment	DHS	Principal Hydrologist
2	October 2019	Final	DHS	Principal Hydrologist

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Figures

Tables

1. Introduction

1.1 Background

AECOM is working to explore options for managing flood risk within Clachan on behalf of Argyll and Bute Council (ABC). An understanding of expected flooding impacts under the baseline scenario is required to enable screening of options and support further option development. This study concerns the fluvial flood risk within Clachan.

The aims of this assessment are to:

1. identify the areas of highest economic impacts and any points where there is a disproportional change in economic impacts relative to the change in probability (to determine where interventions should be focussed);
2. quantify the economic impacts of flooding expected over the appraisal period (to inform the scale of intervention that should be considered); and
3. provide a basis for identifying the potential benefits and impacts of any proposed options

This assessment covers economic, social and environmental impacts of flooding under the baseline scenario. It is not an Environmental Impact Assessment associated with any Flood Protection Scheme or other development. This document should be read in conjunction with the baseline modelling report[1] and preliminary ecological appraisal[2].

[1] Phase 2 Report - Baseline Conditions, AECOM.
[2] Preliminary Ecological Appraisal Report Clachan, AECOM.

1.2 Study Area

The study area is shown in **Figure 1** below.

Clachan is a small village in North Kintyre in the west of Scotland. In the 2011 census Clachan had a recorded population of 87.

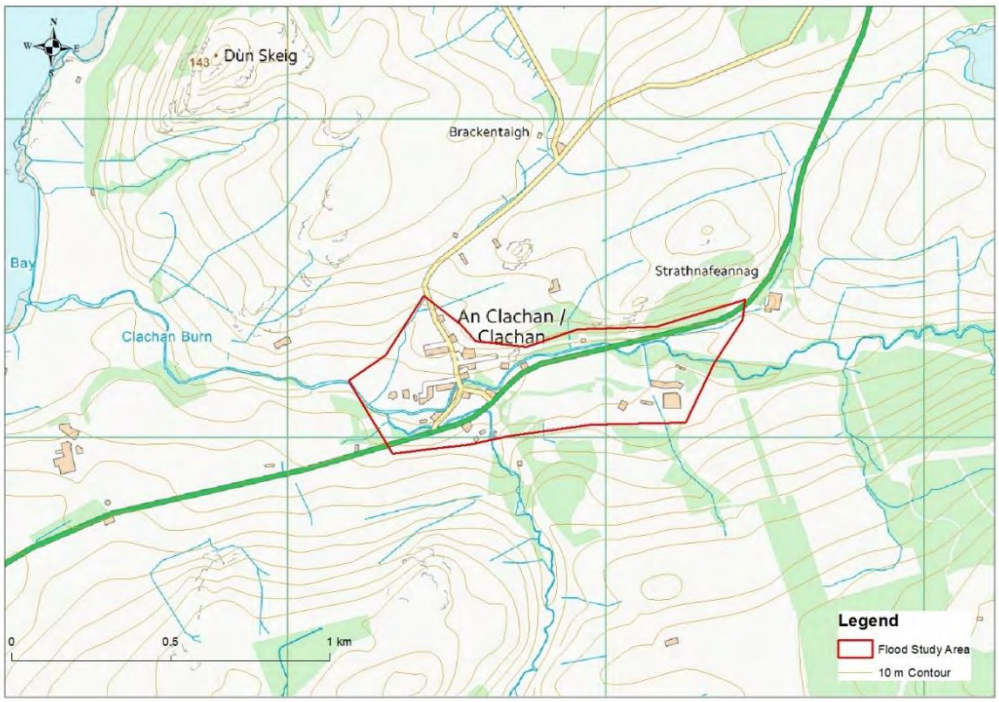

Figure 1. Study area

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2. Methodology

2.1 General

2.1.1 Available Information

The following data sources were used for this assessment.

Table 1. Available data

Data name	Source	Data description
SEPA receptor datasets (properties)	ABC	GIS dataset of assets within the study area, 2011 data
Google Streetview and aerial imagery	Google	-
OS MasterMap	ABC	Ordnance Survey vector mapping
OS 50k mapping	AECOM	Ordnance Survey 1:50,000 scale raster mapping
Spot Level Survey	ABC	Spot Level Survey of terrain
Threshold level survey	ABC	Threshold level survey of vulnerable property thresholds and ground levels

2.1.2 Legislation and Guidance

Flood risk management is governed by the Flood Risk Management (Scotland) 2009 Act. The Scottish Government has produced a guidance document describing the responsibilities of SEPA, local authorities and Scottish Water under the Act[3]. The document states that responsible authorities should “act with a view to reducing overall flood risk” (probability and consequence) in a sustainable way. ABC has included the development of a flood study for Clachan in its Local Flood Risk Management Plan.

The process for developing flood study appraisals is outlined in Scottish Government appraisal guidance[4].This covers the economic, environmental and social aspects to be considered when promoting schemes under the Act. The Environment Agency has produced similar guidance[5] for England and Wales and is also a useful reference document. The assessment process used here follows the Scottish Government guidance and, as such, will be compatible with the aims of the Act.

Whilst the Scottish Government guidance covers the main principles of the assessment set out below, the Multi-Coloured Manual (MCM)[6] and Multi-Coloured Handbook (MCH)[7] cover the detailed procedure and standard data used for the assessment.

2.1.3 Proportionate Approach

The Scottish Government guidance requires that the level of detail in the assessment is proportionate to the stage of appraisal and the level of detail needed to differentiate between options. For low-cost flood risk management options, a full-scale assessment may not be justified.

[3] Scottish Government, 2011. Delivering Sustainable Flood Risk Management. Edinburgh: Scottish Government
[4] Scottish Government, 2016. Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities. Edinburgh: Scottish Government.
[5] Environment Agency, 2010. Flood and Coastal Erosion Risk Management Appraisal Guidance Appraisal Guidance. Bristol: Environment Agency
[6] Penning-Rowsell et al. (2013). Flood and Coastal Erosion Risk Management. A Manual for Economic Appraisal. Oxon: Routledge.
[7] Penning-Rowsell et al. (2017). Flood and Coastal Erosion Risk Management. A Handbook for Economic Appraisal. [Online] London: Middlesex University

2.1.4 Scenarios

The appraisal process requires consideration of the following scenarios:

- 'Do Nothing': walk away and cease all maintenance, repairs and similar activities. This may not be an acceptable option for Local Authorities due to their statutory obligations under the Act. In this case, the 'do minimum' option should be considered as the baseline.
- 'Do Minimum': this involves maintaining the existing situation. This can include general maintenance, repairs and watercourse clearance. The costs of the 'do minimum' option can be significant in areas with a high maintenance burden
- At a later stage of this project - 'Do Something': this involves the provision and maintenance of a flood risk management option. This includes both structural and non-structural measures.

2.1.5 Valuation of Costs and Benefits

All values should be in economic terms rather than financial:

- Financial takes situation from an individual's point of view whereas economic looks at the impact on the nation as a whole, noting that one person's loss can be another's gain. If, for example, a 10-year old TV is lost in a flood the financial cost would be the cost of replacing it with an equivalent new TV, whereas the economic cost would be the value of a 10-year old TV.
- VAT and other indirect taxes are included in financial costs, whereas they are not included in the economic case as they are simply transfers of money within the economy.

All benefits and costs over the entire life of the scheme require to be brought to a present value (PV). The current discount rates specified in the HM Treasury Green Book are 3.5% for years 0-30, 3% for years 31-75 and 2.5% thereafter. An appraisal period of 100 years is used to ensure all costs and benefits can be compared in an equitable manner. The choice of a 100 year period reflects the typical design life of the longest-lasting scheme elements. Some elements, such as mechanical and electrical components, may have a shorter lifespan and would therefore need to be replaced during the appraisal period.

Any historical valuations or costs are brought to a present-day value using an appropriate index. For example, historical property sales are converted to a current valuation using the House Price Index (HPI). Depth-damage data is brought to a present value using the Consumer Price Index (CPI).

2.1.6 Return Periods

The choice of return periods is an important factor in the assessment of damages. The aim of selecting return periods is to reasonably represent the "true" loss-probability curve (that is the loss-probability curve that would be generated if an infinite number of events were modelled). Higher-frequency events contribute the greatest proportion of damages, and it is therefore vital that there is good resolution of data for the lower return periods. A range of return periods were included in this assessment, ranging from more frequent flood events (2-year return period) up to low frequency flood events (1000-year return period). This provides a good representation of the loss-probability curve.

2.1.7 Capping of Damages and Write-offs

2.1.7.1 General Guidance

Scottish Government guidance (as for the other guidance referred to in this report) states that economic property losses should not exceed the current capital value of the property. Where damages exceed the market value, a cap is applied. Capping values should be the regional risk-free values of the property in question (i.e. the value of the property if there was no flood risk).

The MCM states that properties should be written off where the flood frequency exceeds, on average, once every three years. Since the modelling did not include the 3 year return period, a property was considered to be written off if the flood frequency was once every 2 years. Properties were written off at the cap values described below.

2.1.7.2 Residential Property

The MCM states that the risk-free regional (i.e. Scottish) average value should be used for capping residential property damages. For this assessment, residential property valuations were obtained from Registers of Scotland. It should be noted that this dataset is highly likely to include properties at risk of flooding; however the presence of a large number of additional properties should moderate their impact. Static caravans were capped at the average value for replacing a second hand static caravan home as outlined in the MCM.

Table 2. Residential property values, Q3 2018

Property Type	Scotland Average (RoS)	Comment
Detached	£263,541	
Semi-detached	£168,221	
Terraced	£145,962	
Flat	£143,303	
Bungalow*	No data	£200,000 was used as an approximate valuation
Static Caravan	£17,500	

**Data for bungalows is not specifically included by RoS; presumably bungalows are classified in terms of whether they are detached, semi-detached etc.*

2.1.7.3 Non-Residential Property

For non-residential properties, the MCH recommends rateable values are multiplied by 10 to derive approximate valuations. More detailed valuations can be estimated by multiplying the rateable values by (100 / rental yield).

Rateable values were obtained from the Scottish Assessors Association website (www.saa.gov.uk). Yields were obtained from CBRE. Where rateable values were not available via the Scottish Assessors Association an average rateable value was applied. There is likely to be some uncertainty associated with these estimates, but this is considered to be a proportionate approach at this stage.

Yield data is reported as a Scottish average and broken down by sector. The “all property” yield was used for all non-residential properties in this study. This is similar to the values reported in the MCH. Where the influence of this valuation is significant site surveys can be carried out to improve confidence. It should be noted that there are fluctuations in rates both in time and location; 7% is considered to be representative of recent years.

Table 3. Property yields, 2017

Sector	Yield (2017)
All property	7%
Offices	8.6%
Industrial	8.4%
Retail	4%

Source: CBRE Scotland Market view Q3 2017

2.1.7.4 Other Property / Infrastructure

The MCH does not set out procedures to follow for capping non-property damages such as utilities. The Scottish Government guidance suggests that the maximum economic benefit should be limited to the cost of reconstructing the asset to avoid the flood risk (e.g. by raising or relocating). The cost should be depreciated to allow for the age of the existing asset. The guidance notes that the cost of raising or relocating these types of assets is likely to be extremely high and rarely less than the expected damages.

2.1.8 Climate Change

Climate change is expected to increase the incidence of severe weather events. Scottish Government guidance on the Act[8] encourages the development of flood risk management solutions that are adaptable to future changes in the climate. The Scottish Government appraisal guidance recommends the use of judgement and up to date evidence to estimate the impacts of climate change on flood risk.

For this study, the application of climate change to economic assessments is a separate assessment to that applied during modelling. Modelling focuses on the increased extents and depths during a climate change scenario. The economic application of climate change focuses on increased frequency of flooding and the impact that has on the flood damages likely to occur.

An assessment of the vulnerability of Scottish river catchments to climate change was published by the CEH in 2011[9] based on UKCP09 data. Some of the results are summarised by SEPA in their 2016 flood modelling guidance for responsible authorities. Three periods are covered by the UKCP09: the 2020s (2010-2039), the 2050s (2040-2069) and the 2080s (2070-2099). There are also three emissions scenarios (low, medium and high) and, due to the probabilistic nature of climate change modelling, there is a range of possible change factors depending on the confidence interval for each emissions scenario. For example, for the 2050s medium emissions scenario, there is a 50% chance that the change in flood peak will exceed 26% in Argyll. The CEH research also indicated that the change factors vary with the magnitude of the flood.

It is clear that there is significant uncertainty in estimating the impact of climate change on future flood risk. For the purposes of this assessment, the medium emissions scenario, 50th percentile, was used. This is expected to give a middle value of climate change. Sensitivity testing was used to better understand the influence of this decision.

Table 4. % change in peak flow for medium emissions scenario, 50th percentile, for Argyll

Period	Peak river flow change factor
2020s	14%
2050s	26%
2080s	37%

Source: Kay et al. (2011).

The effect of climate change was incorporated into the assessment by increasing the frequency of damages over the 100-year appraisal period. The change in frequency was determined by the change factors noted above.

2.1.9 Existing Property-Level Flood Mitigation Measures

No information relating to existing property-level measures was made available by ABC and no measures were observed during AECOM's site visits to the area. No property-level flood mitigation measures were therefore included in this study.

[8] Scottish Government, 2011. Delivering Sustainable Flood Risk Management. Edinburgh: Scottish Government

[9] Kay, Crooks, Davies & Reynard (2011). An Assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change. Wallingford: CEH.

2.2 Overview of Appraisal Approach

The table below sets out the approach used for each component. A more detailed description of the proposed approach taken for selected receptors is included below.

Table 5. Summary of Damage Assessment Components

Receptor	Damage assessment approach
Economic impacts	
Residential properties	Included. Properties classified by type, age and regional social grading
Non-residential properties	Included. Properties classified by MCM code.
Vehicles	Included. Based on number of properties at risk (detailed information on number of vehicles within the study area is not readily available).
Evacuation	Included. Evacuation costs based on property type and flood depth (detailed local data is not readily available)
Distributional impacts	Included. Based on 2011 census data for Clachan
Indirect impacts on non-residential properties	Applied as basic 3% uplift to direct damages
Local authority, emergency and recovery costs	Included. Uplift factor from MCM data.
Infrastructure	
Electricity and gas	Described
Water and waste water	Described
Telecommunications	n/a – no vulnerable infrastructure present within study area
Schools	Described
Hospitals	n/a – none at risk of flooding within study area
Transport	
Road disruption	Described
Rail disruption	n/a – no infrastructure present within study area
Agriculture	n/a – none present within study area
Social impacts	
Risk to life	Quantified based on flood hazard, number of properties and likelihood
Health	Monetised based on standard of protection provided.
Social vulnerability	Described
Recreation, community and way of life	Described
Environmental impacts	
Water environment	Described
Biodiversity, flora and fauna	Described
Air and soil	Described
Climatic factors	Described
Landscape	Described
Cultural heritage	Described

2.3 Economic Impacts

2.3.1 Residential and Non-Residential Properties

The property dataset was created using PVA data provided by ABC, a number of alterations were made to better represent the area. Additional fields were added to contain data for this assessment:

- **Flood cells**. The study area was divided into smaller zones that flood independently. This allows for the spatial distribution of damages to be understood and flood mitigation measures to be optimised to target those areas most at risk.
- **MCM code**. The basis of MCM codes was OS mapping, Google StreetView and survey photos. Residential properties were categorised based on type and age. Non-residential properties were categorised based on their MCM category.
- **Floor areas**. These are only required for non-residential properties and were derived using OS mapping.
- **Floor levels**. Surveyed floor levels were applied.
- **Flood levels**. Flood levels for properties were extracted from the hydraulic model based on the maximum water level within the property boundary.

Depth-damage data was taken from the MCH for the relevant flood duration (short), water types (storm) and warning (none). For residential property, the depth-damage data for individual social classes were aggregated into a single weighted average.

A static caravan site is located to the west of Clachan. Guidance from the MCM handbook was used assess these properties. Average rates for static homes were applied based on the number of caravan plots observed. It is not proportionate to undertake a detailed site-specific assessment. Should options be considered in detail for the caravan park further site surveys may be required.

2.3.2 Distributional Impacts Analysis

Distributional impacts analysis reflects how reducing flood risk affects individuals depending on their socio-economic group. The principle is that an extra pound is worth more to a person who has a lower income than someone who has a higher income. Distributional impacts require to be applied where necessary and practical.

In the case of Clachan, there is a relatively high proportion of residents in approximated social grade C and DE compared to the national average. There is therefore a strong case for the inclusion of distributional impacts analysis and there is sufficient data available. The applied uplift factors are shown in the table below.

Table 6. Census data and distributional impacts analysis factors

	Number of people	AB	C1	C2	DE
Census data	87	10%	16%	46%	28%
Weighted factor	-	0.74	1.12	1.22	1.64
				Total weighted factor	1.27

Source: http://www.scotlandscensus.gov.uk/

2.3.3 Infrastructure and Transport – General

There are three types of losses associated with infrastructure: direct damages; wider economic impacts and wider less tangible impacts. The direct damages to all buildings affected are calculated within the non-residential property section. Additional losses and direct damages for infrastructure not associated with properties will be explored here. Categories identified in the MCM are: electricity and gas; water and waste water; telecommunications; schools; hospitals; roads; and rail.

The MCM states that assessments should be proportional to the impact of flooding on the asset and the significance of the asset. Although it may be *feasible* to assess the potential losses to a number of assets it may not be *cost-effective or necessary* to do so. The 5 step prioritisation process was followed for all identified infrastructure.

1. Identify those assets at risk of flooding
2. Determine the likelihood of flooding assets
3. Determine the criticality of the assets to flooding
4. Utilise a risk matrix for prioritisation (**Table 7**)
5. Assess the impact of resistance and resilience

Table 7. Risk Matrix

Impact	**Significant**	Medium Risk	High Risk	Very High Risk
	Moderate	Low Risk	Medium Risk	High Risk
	Low	Negligible Risk	Low Risk	Medium Risk
		Very low	**Low**	**Medium/High**
		Likelihood		

2.3.4 Electricity and Gas

No substations were included in the asset database used for this assessment. It is therefore considered that the impact of flooding on the electricity network is small. Therefore, no further investigation / quantification was warranted.

Low likelihood, low impact. Overall risk: low.

2.3.5 Water and Wastewater

A sewage works is located to the west of Clachan. At this stage of the study, only direct damages to the building were quantified. Further investigation is possible at future stages of the study, if options to prevent flood risk to the sewage works are considered.

Medium likelihood, moderate impact. Overall risk: High Risk.

2.3.6 Telecommunications

No telephone exchanges were included in the asset database used for this assessment. No further investigation was therefore warranted.

Overall risk: n/a

2.3.7 Schools

There is one school located with Clachan and it is located with the area at risk of flooding. At this stage of the study, only direct damages to the building were quantified. Further investigation is possible at future stages of the study, particularly if there are records of the school being disrupted as a result of flooding.

Low likelihood, moderate impact. Overall risk: medium.

2.3.8 Hospitals

There is no medical practice located with Clachan and therefore no further investigation was required.

Overall risk: n/a

2.3.9 Road Disruption

Several roads within the study area are at risk of flooding. The key factors for estimating traffic disruption costs include flood duration, the number of roads likely to be impacted and the importance of those roads affected (i.e. whether a flood causes a significant knock-on effect to other parts of the network).

Of particular note is the A83 which is the main road for Clachan and the through road for the Kintyre Peninsula. Due to the importance of this road locally further investigation is required.

Medium / high likelihood, moderate impact. Overall risk: high risk.

2.3.10 Rail disruption

There are no railways in the study area.

Overall risk: n/a

2.3.11 Agriculture

Although there are areas of agriculture just outside the edge of Clachan, these are not the focus of this study.

Overall risk: n/a

2.4 Social Impacts

2.4.1 Risk to Life

The hazard associated with flooding is based on the depth and velocity of water. This, paired with the probability of flooding, can be used to assess the risk to life. Whilst it is possible to monetise this risk, at this stage of the study it was considered appropriate to describe the risk based on hazard, probability and key properties affected.

2.4.2 Health

Flooding can have a wide range of impacts on health including stress and anxiety associated with flooding, physical health effects from contact with flood water and worry about future flooding. This is an area of active research and there is uncertainty associated with any methods used to quantify these impacts. The Scottish Government appraisal guidance refers to a 2004 Defra study[10]. This has since been superseded with research from 2012[11], which was used for this assessment.

2.4.3 Social Vulnerability

The effects of flooding will be felt differently by different people depending on a range of factors (e.g. age, health, income, home ownership) – this is known as social vulnerability. Flood disadvantage is the combination of social vulnerability and flood risk. The Scottish Government has produced maps showing the flood disadvantage across Scotland. These were used for this study to describe the social vulnerability to flooding in Clachan.

2.4.4 Recreation, Community and Way of Life

Similar to health, flooding can have wide-ranging effects on the local community by disrupting recreational opportunities (e.g. football grounds, sports centres), causing flood damages to community facilities (e.g. town halls, libraries) and affecting day-to-day life (e.g. employment and

[10] Defra (2004). Flood and coastal defence appraisal guidance. Supplementary note to operating authorities. Revisions to economic appraisal on: reflecting socio-economic equity in appraisal and appraisal of human-related intangible impacts of flooding. Defra: London.
[11] Ramsbottom et al. (2012). Climate change risk assessment for the floods and coastal erosion sector. Defra: London. Discussion also in Frontier Economics (2013). The economics of climate resilience: appraising interventions to diminish the mental health effects of flooding – a case study of Hull. Frontier Economics Ltd: London.

shopping). There is insufficient evidence available to allow such impacts to be readily monetised and in any case the impact is not likely to be significant for Clachan. These impacts will therefore be assessed based on a description of impacts.

2.5 Environmental Impacts

The Scottish Government appraisal guidance describes the key categories against which flooding impacts can be assessed as follows (although other methods, such as ecosystem services, are also possible):

- Water environment
- Biodiversity, flora and fauna
- Air and soil
- Climatic factors
- Landscape
- Cultural heritage

It is understood that there are currently no pressing environmental issues associated with flooding at the site. The primary requirements for environmental appraisal are therefore to identify opportunities for environmental enhancement and assess environmental impacts associated with any flood mitigation options (thus allowing for impacts to be mitigated). For this appraisal, the environmental impacts are described unless there is an indication that impacts will be significant (in which case a formal Environmental Impact Assessment may be required).

3. Results

3.1 Baseline Monetised Damages

The number of properties affected by flooding during a 'do nothing' scenario in the study area are shown in **Table 8**. The corresponding damages are shown in **Table 9**. These results do not include the impact of capping or write-offs, as those factors only get taken into account when damages are discounted over the appraisal period.

Table 8. Number of properties affected by flooding in the study area

		Return period (years)								
Scenario	**Property Type**	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**200+CC**	**1000**
Present Day	Residential	0	6	7	9	10	11	15	34	40
	Non-Residential (NRP)	0	2	3	5	5	5	6	10	13
Total no. of properties affected by flooding		0	8	10	14	15	16	21	44	53

* Damages for residential properties start to be accrued when the water is within 300mm of the floor level as water enters the sub-floor area.

Table 9. Baseline monetised flood damages by present day return period

		Return period (years)							
Category		**2**	**5**	**10**	**20**	**50**	**100**	**200**	**1000**
Residential	Direct	£0	£4,178	£5,659	£6,955	£9,653	£14,976	£31,801	£481,773
	Vehicles	£0	£0	£0	£0	£0	£2,882	£11,528	£77,816
	Indirect	£0	£0	£0	£0	£832	£2,555	£4,972	£78,335
	DIA	£0	£1,129	£1,529	£1,879	£2,607	£4,045	£8,590	£130,134
	Subtotal	**£0**	**£5,307**	**£7,187**	**£8,834**	**£13,092**	**£24,459**	**£56,891**	**£768,058**
NRP	Direct	£5,476	£19,736	£27,389	£44,298	£58,270	£73,141	£91,262	£336,871
	Indirect	£164	£592	£822	£1,329	£1,748	£2,194	£2,738	£10,106
	Subtotal	**£5,641**	**£20,328**	**£28,210**	**£45,627**	**£60,018**	**£75,336**	**£94,000**	**£346,977**
Other	Emergency	£586	£2,559	£3,536	£5,484	£7,268	£9,429	£13,168	£87,595
	Health	£0	£0	£0	£0	£1,013	£3,039	£5,065	£32,417
	Subtotal	**£586**	**£2,559**	**£3,536**	**£5,484**	**£8,281**	**£12,468**	**£18,233**	**£120,012**
Total		**£6,227**	**£28,193**	**£38,934**	**£59,945**	**£81,391**	**£112,262**	**£169,124**	**£1,235,046**

Average Annual Damage (AAD) is the expected value of damages within a typical year: $\sum$*Damages x Probability.* AAD is shown below calculated from current value damages and probability; and for future probability for the climate change horizons. Due to the frequency of flooding, one property was considered to be written off (and were not included in the AAD total). The increased frequency of flooding with climate change means that the ADD does not increase linearly. **Table 10** shows the AAD for the assessed climate change scenarios.

Table 10. Baseline average annual damages

Category		Annual Average Damage			
		Current	2020s	2050s	2080s
Residential	£3,468	£6,216	£7,457	£9,846	£6,890
	£307	£674	£856	£1,233	£789
	£298	£649	£820	£1,166	£798
	£937	£1,679	£2,014	£2,660	£1,861
	£5,010	**£9,218**	**£11,148**	**£14,905**	**£10,339**
NRP	£11,606	£18,134	£5,614	£7,384	£7,282
	£348	£544	£168	£222	£218
	£11,954	**£18,678**	**£5,783**	**£7,605**	**£7,500**
Other	£844	£1,364	£732	£965	£794
	£158	£352	£445	£631	£335
	£1,002	£1,716	£1,177	£1,596	£1,129
Total		**£17,967**	**£29,611**	**£18,108**	**£24,106**

Present Value Damage (PVD) represents the damages expected to be accumulated over the appraisal period (100 years). The total damages accrued are also “discounted” to a Present Value (see **Section 2.1.5**). PVD is derived from the sum of all probability damages accrued, capped and discounted: ∑ (Damages x Probability) capped x discount rate. Where required, properties were written off in the year that the flood frequency is expected to exceed once every three years, with a discount factor applied where necessary.

The study area was split into ‘flood cells’ – areas which flood from the same location(s) and which could potentially be protected independently. This allows for further investigations to focus on those areas which are most affected. A plan showing the location of the flood cells is included in **Appendix A.1**. **Table 11** shows the present value damage by type while **Table 13** shows the present value damage (PVD) for each flood cell. **Table 12** presents a summary of the present value damage, both with and without climate change.

Table 11. Baseline present value damages by type

Category		PVD	PVD CC
Residential	Direct	£103,399	£196,497
	Vehicles	£9,151	£16,120
	Indirect	£8,890	£16,132
	DIA	£27,930	£43,623
	Subtotal	£149,369	£272,372
NRP	Direct	£134,801	£187,646
	Indirect	£2,115	£1,129
	Subtotal	£136,916	£188,776
Other	Emergency	£25,487	£40,101
	Health	£4,711	£7,590
	Subtotal	£30,199	£47,691
Total		**£316,484**	**£508,838**

Table 12. Summary Present Value Damage

Totals	Total PVD	Total PVD (CC)
Clachan	**£320 K**	**£510 K**

Table 13. Baseline present value damages by cell

Flood cell	Residential	Non-residential	Other	Total	Proportion of total
1	£117,631	£74,195	£64,233	£256,060	50.32%
2	£19,845	£102,814	£20,254	£142,913	28.09%
3	£59,021	£10,637	£40,207	£109,866	21.59%
4	£0	£0	£0	£0	0.00%
Total	**£196,497**	**£187,646**	**£124,695**	**£508,838**	100.00%

3.2 Baseline Non-Monetised Damages

3.2.1 Economic - Road Disruption

The A83 is the main road through Clachan and provides access to the rest of the Kintyre peninsula. The road is at risk of flooding from the 2-year event. During more extreme events this could result in road closures.

There are two aspects of damages to roads which can be accounted for: direct damage to road infrastructure and losses due to road traffic disruption.

Direct damages to road infrastructure vary depending on the type and scale of the damage, the type of road and the location of the required repair. Estimates are available from the MCM of unit costs for resurfacing roads from £15/m² for quiet roads to £50/m² for busier roads. Direct damages can occur if flooding causes lasting damage to the road. However, for flooding to cause lasting damage water would have to remain on the road for long periods of time (the MCM considers a long period of time to be 'days' rather than hours) or high velocities would have to be present. This is found not to be the case in Clachan and therefore direct damages have not been assessed at this stage of the study. Should the options considered be found to provide significant benefits to the road infrastructure, further assessment may be warranted.

The MCM provides framework to value traffic disruption. This is based on additional distance required when diverting.

- A83 – potentially closed during a 10-year return period event or greater. Diversion via B842 which is single tracked with passing places in parts. This route would add a minimum of 45 minutes to journey times to the south of the Kintyre peninsula and vice versa.

As discussed previously, this is not considered a significant enough delay to require an economic assessment of delays.

Property damages can be affected by the waves caused by vehicles being driven along flooded roads. This impact has not been included in the numerical model and therefore has not been quantified in the assessment, however it could lead to further justification for road closures.

3.2.2 Social – Risk to Life

Due to the shallow and localised nature of flooding, the flood hazards are generally not significant. The locations of maximum hazard are similar to the roads at risk of flooding. No detailed analysis was carried out. Flood hazard ratings were estimated using the equation *hazard = d x (v + 0.5)*. The following table summarises maximum flood hazards.

Table 14. Flood hazard

Return period (years)	Maximum flood hazard	Hazard description	Affected locations
50	0.3 (Low)	**Caution** – flood zone with shallow flowing water or deep standing water	A83, petrol station
100	0.9 (Moderate)	**Dangerous for some** (i.e. children) – flood zone with deep or fast flowing water	A83, petrol station

Return period (years)	Maximum flood hazard	Hazard description	Affected locations
200	1.1 (Moderate)	**Dangerous for some** (i.e. children) – flood zone with deep or fast flowing water	A83, petrol station

In addition to the locations identified in **Table 13**, any watercourses are likely to be a Moderate hazard or greater during a flood event.

3.2.3 Social – Social Vulnerability

The key local assets at risk of flooding are the through road A83, petrol station and residential homes. The risk of flooding in Clachan therefore impacts the flood disadvantage of Clachan and the surrounding area.

3.2.4 Social – Recreation, Community and Way of Life

The following is a list of community features that are affected by flooding to provide an indication of the range of social impacts of flooding. For the avoidance of doubt, this is not a site-specific flood risk assessment for each of the features noted.

It should be noted that as Clachan is a small village and flooding impacts the village centre, flooding would seriously impact the recreation, community and way of life for the majority of residents.

Table 15. Community features at risk of flooding

Feature	Onset of flooding (indicative return period in years)
Petrol Station and post office	2
Town Hall	50
Church	200+CC (equivalent to a 625-return period)
Primary School	1000

3.2.5 Environmental

Separate ecological assessments[12]. have been carried out in order to identify constraints and opportunities relevant to the development of a FPS. A summary of key issues in terms of flooding impacts is provided here.

Water environment

The Clachan Burn and the Allt Mor tributary have an overall water status of 'Poor' from 2007 to 2017. The Poor status is due to its ecological status; in particular fish. Therefore, the current level of flood risk is not considered to be affecting the water environment. The increased frequency of flooding could increase the likelihood of pollutants entering the natural environment.

Biodiversity, flora and fauna

The presence of a range of species, including protected species, should be expected within the study area. Further detail can be found in the Clachan Flood Study Preliminary Ecological Appraisal.

The current level of flood risk is not considered to be affecting biodiversity, flora and fauna however there are always opportunities for environmental enhancement as part of any flood mitigation proposals.

Air and soil

The current level of flood risk is not considered to be affecting air and soil.

[12] Preliminary Ecological Appraisal Report Clachan, AECOM.

Climatic factors

Flooding leads to greenhouse gas emissions through the following:

- Emissions during the flood response (vehicle movements, pumping etc.)
- Emissions embedded in replacement goods
- Emissions embedded in repair materials
- Emissions associated with additional energy use to dry out properties following a flood

Cultural heritage

Clachan is home to a number of Listed Buildings, two areas of scheduled monuments, the Clachan Churchyard, Cross, Cross Slabs & Tombstones and Ballinakill House cross. Some of these are directly affected by flooding. It is possible that repeated flooding would discourage investment in maintaining these properties and lead to an overall degradation of the area. This does not appear to be an issue at present.

Landscape

The current level of flood risk is not considered to be affecting the local landscape other than those issues discussed under cultural heritage.

3.3 Sensitivity Analysis

3.3.1 Single Large Damage Sources

The damage assessment is dependent on a large number of variables, each with its own level of reliability. Sensitivity testing is used to improve understanding of the potential variation of the damage values, and the influence this could have on the overall study outcome.

The total damages are distributed amongst 53 properties, both residential (40) and non-residential (13). Around 42% of property damages are associated with non-residential properties. There is a relatively even spread of damages across the properties, with one property contributing the highest percentage of 14%, which is the petrol station. It is not unusual to have one property contributing to the overall property damages when the dataset of total properties is so small. Site surveys for the petrol station maybe required during option development. The remaining damages are evenly spread among properties therefore total damages would not be sensitive to uncertainty in the assumptions for any one property (such as property type, age or floor level). Instead, damages will be sensitive to any inherent uncertainty in the general MCM methodology such as climate change and translating model results into flood levels within properties.

Closer inspection of many of the highest contributors shows that the high proportion of damages is justified as many of the buildings and surrounding areas have experienced flooding in the past. Where possible many of the highest contributing properties have been sense checked to ensure the results are appropriate.

3.3.2 Modelling Tolerance

There are always uncertainties when quantifying physical processes using mathematical models, and economic damages are sensitive to these uncertainties. As such, many of the uncertainties highlighted within the modelling report continue to apply to this assessment. As discussed within the modelling report the approach is based on best practice and best available research/data and is therefore acceptable. Sensitivity testing has been carried out and is detailed in the baseline modelling report to understand potential changes to model results due to different parameters. For details on potential sensitivity to changes in model results see the following section on flood depths.

3.3.3 Flood Depths within Properties

Flood depths are based on the difference between modelled water levels and the property floor level. The majority of floor levels within Clachan have been surveyed and should therefore have a high

degree of accuracy. Floor levels for some of the properties were estimated based on adjacent surveyed properties. Both levels have some level inherent uncertainty based on the methods used to derive them. A flood depth increases of just 100mm would increase total PV flood damages from £510K to £660K; an increase of 30%. Although in flood level terms 100mm is a large increase, there is more uncertainty in model results and an error of 100mm is possible. It is expected, however, that model results are broadly representative of actual flood events. Methods follow best practice using the best available data, so there is little scope for increasing confidence further.

3.3.4 Future Flood Risk

The increase in future flood risk associated with climate change was included in this assessment. There is significant uncertainty in the effects of climate change. If there was no change in flood frequency, then total PV flood damages would be £320K, a reduction of £190K (38%).

3.3.5 Capping and Write Offs

Depending on the frequency of flooding, damages for some properties are required to be capped; and some properties were even considered to be written off within a study. For Clachan there is a reasonable degree of confidence in both the residential property valuations and non-residential property valuations, which used standard methods. However, there is less confidence in the properties that had no rateable value data and therefore had an averaged value applied. This is in line with the recommendations made by Chatterton[13], but reduces confidence in the results.

Overall within Clachan there is very little occurrence of capping and write off and therefore effects the overall results very little.

3.3.6 Summary

Uncertainty is an inherent factor in economic damages assessments, given the process involves layering together different datasets with their own individual uncertainties and simplifying assumptions across areas. MCM guidance recommends the use of sensitivity analysis to be aware of these uncertainties. The chosen method is in line with best practice and industry standard approaches which aim to provide a managed, efficient and proportional method to economic damages assessment.

The sensitivity analyses have shown there to be some uncertainty in flood damages for example the reliance on the modelling results and the climate change scenario. There is therefore a degree uncertainty in flood depths for this study. This is typical of a study of this kind.

The damages presented here are based on a best estimate of each of the variables; however, the potential for variation in the total damages (both positive and negative) needs to be borne in mind in any decision-making. As shown in the sensitivity analysis above, variations of +/- 25% would not be unexpected.

[13] Chatterton (2016). National receptor dataset: property codes with prefix “9”. Published by Flood Hazard Research Centre, Middlesex University.

4. Conclusions

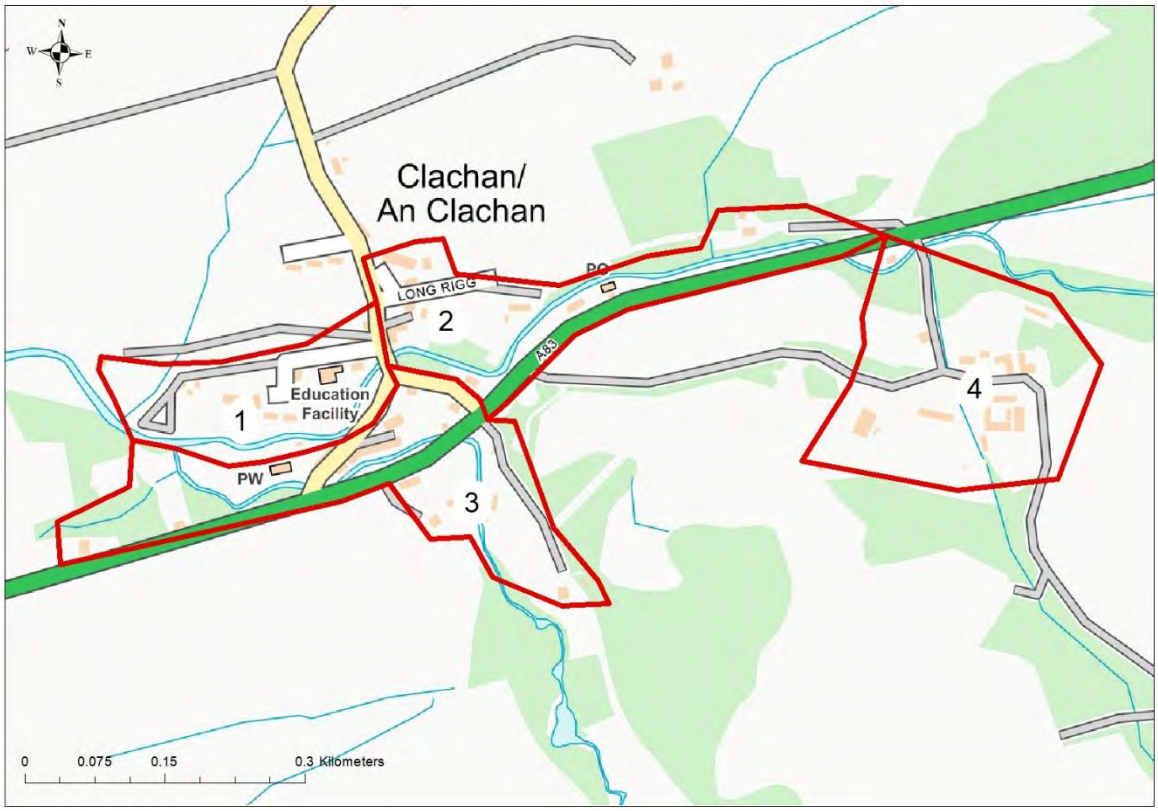
This assessment of economic, social and environmental impacts of flooding was carried out in accordance with Scottish Government guidance, using data from the Multi-Coloured Manual and other sources. Impacts covered the next 100 years if no intervention takes place to reduce the risk of flooding. This is a baseline scenario against which options can be evaluated.

The flooding impacts assessed in this report are broadly in line with the impacts experienced during historical flood events; the greatest impacts are located in those areas that have flooded most frequently in recent years. A total of 53 properties are expected to be flooded during a 1000-year return period flood event; 40 residential and 13 non-residential. The total monetised damages associated with a 1000-year event were estimated to be around £1.2M. Key non-monetised impacts include flooding of roads and associated disruption, risk to life, damage to key community assets and impacts on key employers. The frequency of such an event is expected to increase as a result of climate change.

The present value of monetised flood damages over the next 100 years was estimated to be £510K; this includes annual average damages of around £17k and the value of properties written off due to the high frequency of flooding in the future. The damages presented here are based on a best estimate of each of the variables; however the potential for variation in the total damages (both positive and negative) needs to be borne in mind in any decision-making. The aforementioned non-monetised impacts should also be taken into account as part of any appraisals and decision-making.

The findings from this assessment will be used in the in the decision-making process for selecting a preferred scheme option for Clachan.

Appendix A .1 – Flood Cells



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