Oban Flood Study
Report 1A: Main Report

December 2019

Oban Flood Study
Report 1A: Main Report

Client:	Argyll & Bute Council
Document number:	8533
Project number:	170506
Status:	FINAL
Author:	Eleanor Morrison
Reviewer:	Dr Iain Struthers
Date of issue:	10 December 2019
Filename:	Report 1A Oban Flood Study_Main Report_Final_December2019

Glasgow	Aberdeen	Inverness	Edinburgh
Craighall Business Park 8 Eagle Street Glasgow G4 9XA 0141 341 5040 info@envirocentre.co.uk www.envirocentre.co.uk	Banchory Business Centre Burn O'Bennie Road Banchory AB31 5ZU 01330 826 596	Alder House Cradlehall Business Park Inverness IV2 5GH 01463 794 212	1st Floor Sirius Building The Clocktower Estate South Gyle Crescent Edinburgh EH12 9LB 0131 370 4071

EXECUTIVE SUMMARY

Oban experiences significant flooding, with recent notable flooding events in 2014 and 2018 causing widespread damage and disruption to the community. The town is a regionally significant hub for transport, tourism and local services and has significant reach in providing services to a wider rural community. It has been ranked 5 out of 168 Potentially Vulnerable Areas (PVA) requiring a flood study at a national level, and ranked 1 out of 9 and prioritised for flood risk reduction by Argyll and Bute Council.

This Flood Study has assessed flood risk associated with three interacting sources: coastal, river and surface water. A comprehensive understanding of flooding dynamics has been developed through the various technical assessments and consultation with the local community and other stakeholders.

The town is centred around Oban Bay in the Firth of Lorn, where parts of the seafront are at risk from extreme tides and wave overtopping. The tidally-influenced Black Lynn Burn flows through the commercial centre of the town at Lochavullin, a low-lying area which was historically a tidal loch. This area has flooded significantly on multiple occasions in recent years, despite being protected by flood embankments and having a pumped drainage system designed to evacuate excess surface water accumulating in the area.

Rainfall along this exposed western coastline is relatively high, at 1,680mm per year. Storm water quickly accumulates over the steep slopes in the catchment, overwhelming ageing drainage networks and causing surface water flooding issues distributed throughout the urban area. This drainage flooding has been modelled by Scottish Water, which reveals that, apart from Lochavullin, most of the surface water flooding predicted is relatively shallow and focused on roads and open spaces.

Hydrological and hydraulic modelling has been used to quantify current flood risk for events with return periods ranging between 1 in 2 and 1 in 1000 years, resulting in the generation of interactive maps of flooding extents and depths. Current climate change predictions for Oban indicate that greater extremes are likely to be experienced in future. By 2100 it is predicted that there will be more intense rainfall, with river flows increasing by up to 56% and extreme tidal levels rising by approximately 0.8m for a 1 in 200 year event. Model scenario testing shows that these changes will be most critical where fluvial and tidal floodwaters combine, particularly in Lochavullin, where 1 in 200 year flood levels are predicted to rise by over 0.5 m by the year 2100.

In the absence of new capital flood management investment, present value damages totalling **£31.2 million** are estimated over the 100 year economic appraisal period. Most of this is associated with the Black Lynn network (£17.9 million) and coastal flooding (£10.3 million). Property damages associated with surface water flooding are low relative to fluvial and coasting flooding (£3.0 million).

Flatter ground is at a premium in this rugged landscape, and historically development has been focussed on floodplain areas, right up to the riverbank in places. Not only does this exacerbate flood risk, but also limits the available space for flood mitigation measures. A strategic approach has been identified to achieve optimum flood risk reduction for Oban in the most cost-effective and sustainable way.

Following identification, screening and prioritisation of flood management options, recommended measures for implementation combine traditional flood defences with more sustainable options such as upstream flood storage, alleviation of hydraulic bottlenecks and natural flood management. Short-listed options have been conceptually designed and costed to enable economic appraisal, ensuring that benefits (in terms of reduction in flood damages) outweigh costs over the lifetime of any flood scheme. This is a necessary requirement for prioritisation and funding support from the Scottish Government, which are primary aims of this study.

If successful, Scottish Government funding will contribute up to 80% of the capital cost of the recommended flood scheme, with the remaining element funded by Argyll and Bute Council. Operational and maintenance

costs over the operational life of the scheme will be met by the Council, possibly with contributions from other stakeholders.

The core elements of the recommended flood scheme on the Black Lynn include upstream flood storage areas at Lon Mor and Mossfield, capacity improvements to the Miller Road culvert and Market Street Bridge, and flood defences on the Black Lynn in Lochavullin. Together, these are estimated to have a lifetime cost of £8.2 million (capital and operational costs over a 100-year financial period, including a 60% optimism bias as required for this type of study).

The proposed fluvial measures would combine to reduce estimated flood damages by 77% over the next 100 years, achieving a property-related flood damage reduction of £13.8 million and potential additional benefits (in terms of traffic, local economy and health impacts) in the region of £9.6 million. With a benefit-cost ratio in excess of 1.68, or 2.84 including additional benefits, it is anticipated that this will be sufficient to justify 80% government funding for the proposed scheme.

Following an iterative process of scenario testing, design and costing, it was determined that the economic case for building direct shoreline defences is marginal under current climate conditions, but will strengthen over time as tidal levels continue to rise into the future. Over the short to medium term, targeted coastal Property Level Protection is more justifiable, particularly if combined with improved flood warning and emergency planning. Reliability should also be optimised through expert specification and use of automatic rather than manual floodgates. The estimated cost of the targeted costal PLP is £407,000 over 25 years, bringing about a reduction in flood damages of 809,000 over that period. With a BCR of 1.99, this is considered the most economically viable coastal defence option at the current time.

The core measures recommended for the formal flood scheme do not include significant investment in the surface water drainage network, as this is not adequately justified in economic terms. A longer-term strategy of improved maintenance regimes and targeted upgrades has been prepared, in the form of a Surface Water Management Plan, which can be implemented separately by Argyll and Bute Council in partnership with Scottish Water.

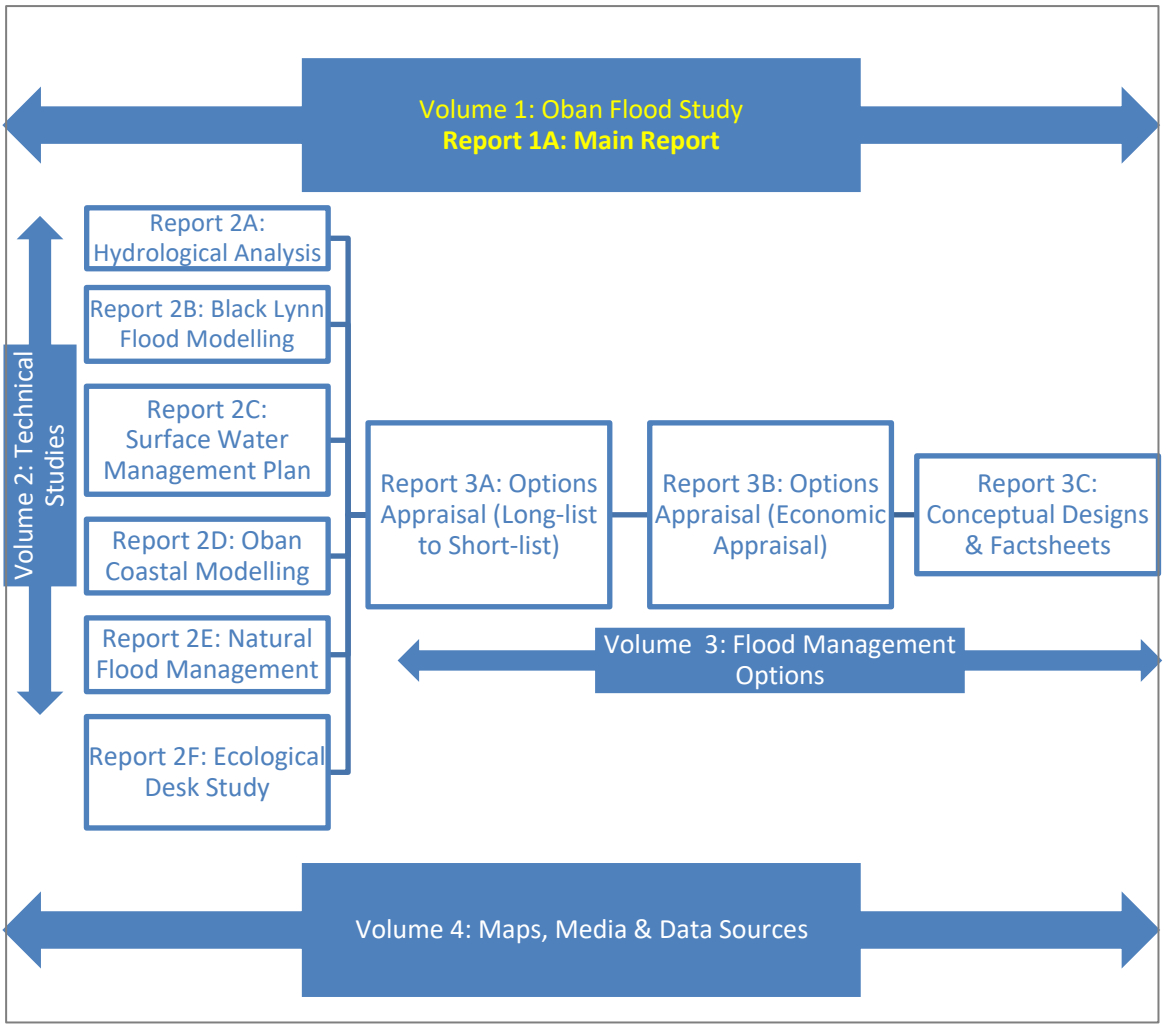
The recommended scheme would not be capable of entirely resolving flood risks in Oban. Options capable of achieving a higher level of flood protection were determined through economic appraisal not to be cost-beneficial at this point in time. As flood risk is anticipated to increase over time due to climate change, the economic justification for flood management investment will continue to improve with time, such that certain management options may become cost-effective in the future. As such, it is recommended that the Council continue to investigate the viability of medium- and long-term options, including sustainable drainage network improvements, natural flood management and adjustments to local development plan policies, beyond the completion of this study.

Emphasis is placed on increasing community awareness, adaptation and resilience. Property level protection measures offer a cost-effective means to protect individual properties, in line with the legal principle that property owners are primarily responsible for their own flood defence. Channel and drainage maintenance are key responsibilities of Argyll and Bute Council and Scottish Water, who are obliged to work in partnership to manage surface water flood risk. Flood monitoring, alerts and emergency planning would also go some way to limiting the disruption and damage caused by storm events.

A flood management strategy combining short and long term measures has been prepared to reduce the frequency and magnitude of flooding where possible, and otherwise to minimise the consequences of flooding when it does occur. This includes a shift towards a more sustainable local development planning strategy for Oban.

OBAN FLOOD STUDY REPORT MAP

The context of the current report within the wider Oban Flood Study is highlighted in yellow as shown below.



Contents

Executive Summary i
Oban Flood Study Report Map iii
1. Introduction 1
1.1 Context 1
1.2 Terms of Reference 1
1.3 Aims and Objectives 1
1.4 Limitations and Assumptions 2
1.5 Report Usage 2
2. Legislation and Policy Context 3
2.1 Responsibilities for Flooding 3
2.2 Legislation and Policy Context 4
3. Local Context 6
3.1 Study Area 6
3.2 Oban and its People 7
4. Approach 0
4.1 Guiding Principles 0
4.2 Flood Management Process 0
4.3 Methodology 1
4.4 Consultation 4
5. Catchment Characterisation 8
5.1 Climate 8
5.2 Geology, Hydrogeology and Soils 8
5.3 Topography 9
5.4 Land Use 9
5.5 Historic Development 9
5.6 Watercourses and Catchments 10
5.7 Morphology 13
5.8 Drainage 15
5.9 Coast 15
5.10 Pressures 16
6. Flood History 18
7. Flood Risk 21
7.1 Definitions 21
7.2 Flood Risk Assessment 22
7.3 Flood Risk Interactions 22
7.4 Flooding Hotspots 24
7.5 Climate Change Impacts 27
7.6 Economic Impacts of Flooding 27
8. Flood Risk Management 29
8.1 Strategy 29
8.2 Prioritisation 29
8.3 Short-term Priorities 33
8.4 Long-Term Adaptation Measures 36
9. Next Steps 38
9.1 Forward Strategy 38
9.2 Future Design Refinement 38
9.3 Potential Additional Funding Sources 38
9.4 Possible Future Opportunities 39
10. Conclusions 40

Appendices

A Legislative Context
B Catchment Characterisation Maps
C Flood History

Figures

Figure 2.1 Key Roles and Responsibilities for Flooding in Scotland 3
Figure 2.2 Flood Risk Management Funding Cycles 4
Figure 3.1 Study Area (pink boundary) and Main Watercourses (blue lines) 6
Figure 4.1 Adaptive Management Approach for Flood Management 0
Figure 4.2 Study Methodology 1
Figure 5.1 Study Area Catchments 11
Figure 5.2 Stream Power 13
Figure 5.3 Oban Bay towards North Pier, including the Black Lynn Outfall 15
Figure 7.1 Simplified Flood Risk Matrix 21
Figure 7.2 Locations of Observed Flooding 24
Figure 8.1 Oban Flood Risk Management Strategy 30
Figure 8.2 Strategic Phasing Concept 32

Tables

Table 4.1 Public Consultations 6
Table 4.2 Other Stakeholders 7
Table 5.1 Watercourse Descriptions 12
Table 5.2 Oban Pressures 16
Table 6.1 Major Flooding Events 19
Table 7.1 Lifetime Chance of Experiencing Various Return Period Flood Events 21
Table 7.2 Example of Land Uses in Oban 22
Table 7.3 Examples of Interacting Flood Sources in Oban 23
Table 7.5 Key Flooding Hotspots 25
Table 7.4 Climate Change Allowances for Rainfall, Sea Level and River Flow in Oban for the 2100 Scenario 27
Table 7.6 Comparison of Predicted Property Numbers Affected by Flooding Between Current Day and 2100 .. 28
Table 8.1 Key Considerations in the Prioritisation of Flood Management Measures 31

1. INTRODUCTION

1.1 Context

Oban is the second largest settlement in Argyll and Bute and represents an important fishing and transport hub centred around Oban Bay in the Firth of Lorn. The town is identified as subject to flood risk and classified as a Potentially Vulnerable Area (PVA) in terms of flood risk, with a priority for investment in a flood study ranked 5 out of 168 on a national basis and 1 out of 9 within Argyll and Bute.

Flooding is not a new problem here, but over more recent decades flood risk has been exacerbated in line with increased urban development. Flooding of homes and businesses, most notably in 2014 and 2018, has caused great damage, disruption and distress to the community. The challenge of managing flood risk in Oban is set to increase in light of future climate change predictions.

Argyll and Bute Council (herein referred to as the Council) commissioned EnviroCentre Ltd. to produce a Flood Study to develop a clear understanding of the problem. Technical studies have been produced focusing on river, coastal and surface water flood risk. These have led to the identification of a wide range of flood management measures which have been appraised to create a short-list of priority actions. These form the basis of a competitive funding application to the Scottish Government for financial support.

Further recommendations are also made for measures which can be undertaken by the Council, the local community and other key stakeholders. Community involvement, sustainability, adaptability and resilience are key themes in the recommended flood management strategy for Oban.

1.2 Terms of Reference

This report has been prepared as part of the Oban Flood Study commissioned by Argyll and Bute Council to provide an overview of the study (Volume 1). It has been produced in conjunction with a suite of supporting technical reports (*Volume 2*), together with options appraisal and conceptual design of flood management measures (*Volume 3*). These reports make reference to maps, media and flood mapping presented in *Volume 4: Maps, Media and Data Sources*.

1.3 Aims and Objectives

The main aims of the study were established in Argyll and Bute's Local Flood Risk Management Plan of 2016 and can be summarised as follows:

Assess flood risk from the Black Lynn Burn, including tidal effects;
Assess flood risk from coastal flooding in Oban Bay;
Produce a Surface Water Management Plan which sets objectives for the management of surface water flood risk, using available information and network modelling results from Scottish Water;
Identify a 'long-list' of options for flood management, including direct defences, Natural Flood Management, reservoir storage, property level protection and individual property relocation for residual risk;
Carry out benefit cost appraisal to determine the most suitable option or suite of options, requiring economic assessment of flood damages together with conceptual design and costing of short-listed flood management options.

From the outset, the study has put emphasis on community and stakeholder engagement, sustainability and adaptation to climate change.

The context of this report within the overall Flood Study is shown in the Oban Flood Study Report Map.

The aim of the current report is to provide a non-technical overview of the study including the following elements:

Strategy and methodology applied to the study;
Characterisation of the study area and the community;
Assessment of flood risk from river, coastal and surface water sources;
Comparative assessment of flood risk over historic, current and future timescales;
Overview of the process leading to the generation of a short-list of flood management options; and
Recommendations for comprehensive flood management over the short, medium and long term.

1.4 Limitations and Assumptions

Uncertainties have been limited as far as possible within the scope of the study, for instance, through detailed consultation with key stakeholders, scenario testing and ground-truthing. Detailed limitations and assumptions are provided within technical reports, some of the most pertinent of which are:

The scope of the study has been set up to assess flood risk at catchment level and is not suitable for assessment of flood risk to individual properties.
It has been prepared using available information, with any significant uncertainties or data gaps highlighted as appropriate within technical assessments.
Climate change predictions are based on current best estimates provided from the UK Climate Projections programme.
Uncertainties exist in remotely-sensed ground elevation data used to produce flood mapping; although targeted ground and threshold level surveys have been used to improve accuracy.
Economic appraisal has been based on standard methods, estimated current day property values and indicative costings, all of which are based on generalised datasets which may not be directly representative of the unique setting in Oban.
The flood mitigation measures proposed are presented at a conceptual level of detail. More detailed assessments will be required to support any subsequent outline or detailed design.

1.5 Report Usage

The information and recommendations contained within this report have been prepared in the specific context stated above and should not be utilised in any other context without the permission of Argyll and Bute Council.

If this report is to be submitted for regulatory approval more than 12 months following the report date, it is recommended that it is referred to EnviroCentre Ltd for review to ensure that any relevant changes in data, best practice, guidance or legislation in the intervening period are integrated into an updated version of the report.

2. LEGISLATION AND POLICY CONTEXT

2.1 Responsibilities for Flooding

In Scotland, individuals are primarily responsible for managing their own flood risk. This means that the community has an important role to play in taking action to minimize flood risk, for instance through sharing of local knowledge and taking part in flood protection actions for their areas. Responsible Authorities are required to manage risks at a more strategic level, and each manage different aspects of flooding, as outlined in Figure 2.1. The Flood Risk Management (Scotland) Act of 2009 requires responsible authorities to manage flood in a sustainable way and to work in partnership.

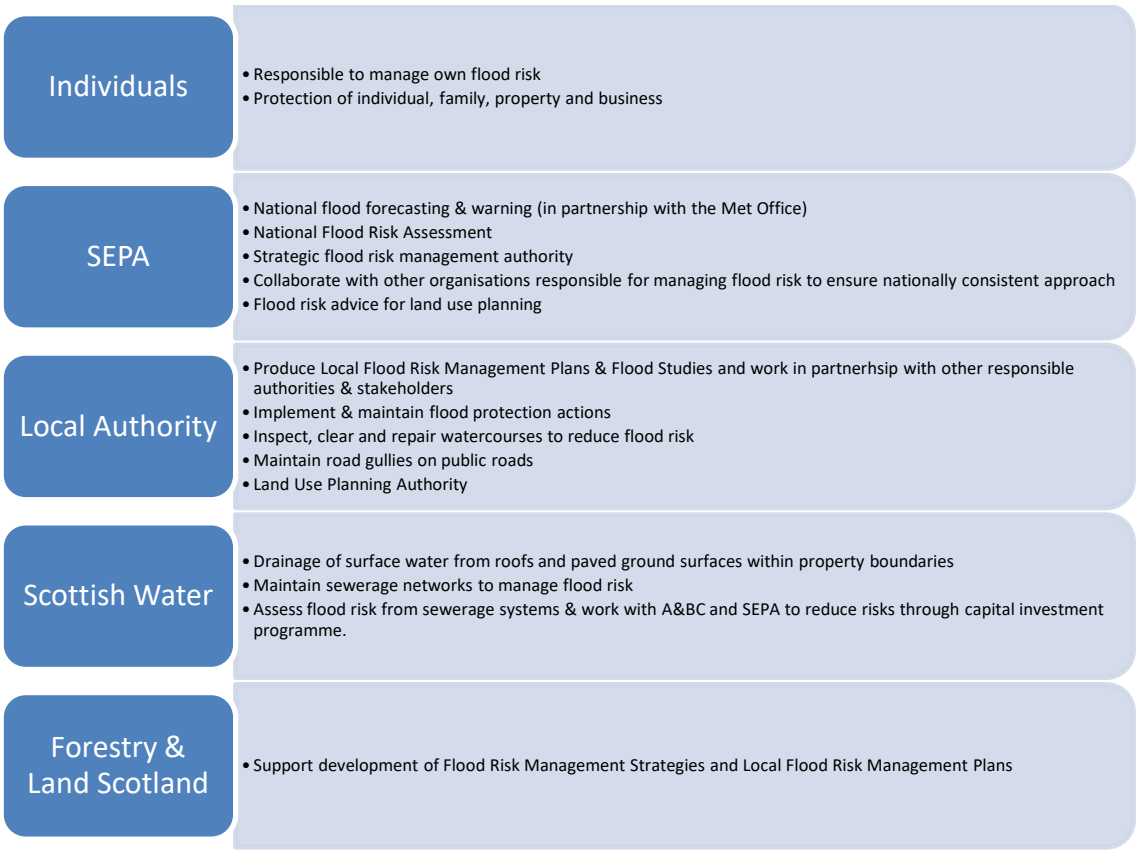


Figure 2.1 Key Roles and Responsibilities for Flooding in Scotland

Generally speaking, the Council are predominantly responsible for surface water above ground level and Scottish Water are predominantly responsible for the main underground elements of the drainage network. As there is substantial cross-over between these responsibilities, these authorities have a legal duty to work in partnership to manage surface water.

2.2 Legislation and Policy Context

The Flood Risk Management Act of 2009 brought about a change in the way flood risk is managed in Scotland. It aims to prioritise national spending on flood mitigation on the basis of strategic technical assessments. Firstly, the Scottish Environment Protection Agency (SEPA) have carried out a National Flood Risk Assessment. Leading on from this, Flood Risk Management Strategies (FRMS) were developed which are coordinated throughout Local Plan Districts and are based on a 6-year funding cycle (Figure 2.2). Actions are targeted through the identification of Potentially Vulnerable Areas (PVA) and associated recommendations to undertake site-specific Flood Studies. Outputs from the FRMS form the basis for the development of Local Flood Risk Management Plans (LFRMP), produced by Local Authorities.

Figure 2.2 Flood Risk Management Funding Cycles

The FRMS for the Highland and Argyll Local Plan District (SEPA, 2015) highlights Oban as a PVA, ranked 5 out of 168 PVAs on a national basis, and 1 out of 9 within Argyll and Bute. 320 residential and 310 non-residential properties were estimated to be at risk, with annual average damages of £1.8 million. 83% of the damages are assigned to river (fluvial) flooding, 11% to coastal flooding and 6% to surface water. For a 1 in 200 year flood event, the total damages predicted for the PVA are in excess of £26 million. Risks to community facilities (schools, hospitals, homes, etc), utilities, the transport network and agricultural land are also highlighted, as well as the fact that Oban has a higher than average proportion of vulnerable residents.

Specific objectives identified for the Oban PVA (PVA reference 01/31) are to:

> Reduce risk along the Oban Bay frontage from coastal flooding (objective 103101);
> Reduce river and coastal flooding in Oban from the Black Lynn Burn (objective 103102); and
> Reduce risk from surface water flooding (objective 103106).

A study was recommended to assess flood risk from the Black Lynn Burn, including tidal effects, and coastal flooding in Oban Bay. It was recommended that the study focus on direct defences, natural flood management (including flood storage, runoff control, and sediment management), increasing storage on the existing lochs (Loch Gleann a Bhearraidh and Luachrach Loch), property level protection and individual property relocation for residual risk. Other actions would also be considered to develop the most sustainable flood risk management options.

Argyll and Bute Council's Local Flood Risk Management Plan (2016) proposes a number of flood studies for PVAs in the area, including Oban, Lochgilphead, Helensburgh, Campbeltown, Clachan, Kilcreggan and Tarbert. These are proposed for Cycle 1 (2016-2022), with implementation of schemes proposed in Cycle 2 (2022-2028).

Prioritisation of national funding is required to ensure that funding is allocated where it is has the most potential to make the biggest impact on flood risk. Cost beneficial schemes may be eligible for 80% Scottish Government funding. To justify Government funding, the economic benefits of an option should be greater than the costs, including: property damages, clean-up, emergency services / provisions, other damages and loss of business. This should be supported by demonstration of wider social and environmental benefits, for instance, to health and wellbeing, habitats, cultural heritage and landscape and visual elements.

Appendix A provides more detail on the FRMA (2009), and also the Water Environment and Water Services (Scotland) Act (2003) and Scottish Planning Policy (2014) which have relevance in the development of flood schemes and local development planning.

Key guidance documents central to flood studies include:

Flood Study Checklist (SEPA 2018);
Flood Modelling Guidance for Responsible Authorities (SEPA 2016);
Surface Water Management Planning Guidance (Scottish Government, 2018);
Option Appraisal for Flood Risk Management: Guidance to Support SEPA and the Responsible Authorities (Scottish Government, 2016); and
Flood Protection Schemes – Guidance for Local Authorities (Scottish Government, 2012).

Climate change allowances used in the study follow contemporary guidance entitled Climate change allowances for flood risk assessment in land use planning (SEPA, 2019).

3. LOCAL CONTEXT

3.1 Study Area

Oban, meaning 'Little Bay' in Gaelic, is set in a bay in the Firth of Lorn, on the western coast of Argyll. The bay is sheltered by the Isle of Kerrera. The area of interest comprises Oban Bay and the Corran Esplanade, Lochavullin, and surrounding suburbs including Longsdale, Dunollie, Glencruitten, Mossfield, Glenshellach, Dalintart and Soroba. The study area extends to incorporate the catchment areas draining towards Oban, and is outlined in Figure 3.1. Higher resolution mapping is shown in *Drawing 170506_054, Appendix B*.

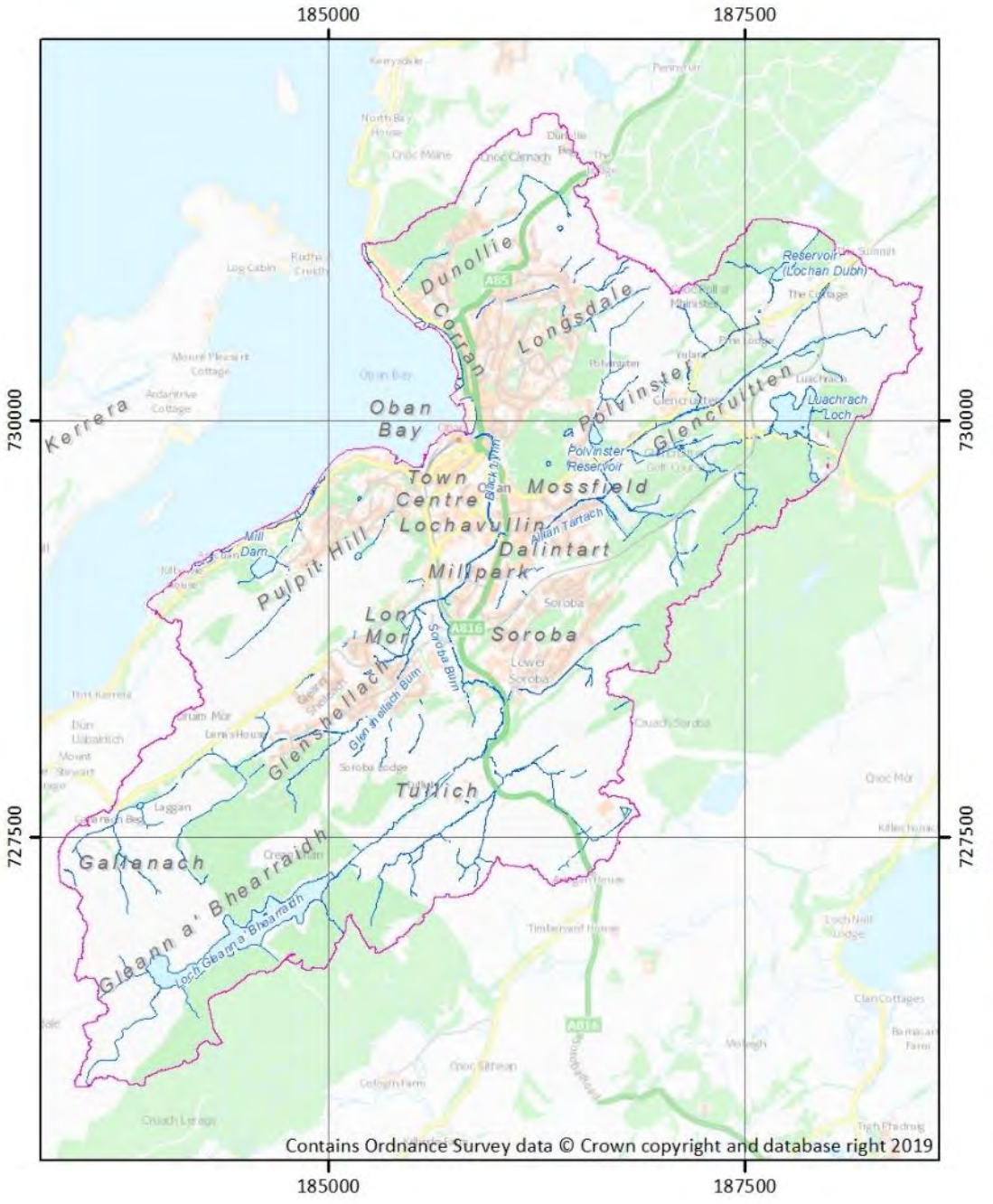


Figure 3.1 Study Area (pink boundary) and Main Watercourses (blue lines)

3.2 Oban and its People

Before addressing the flooding problem in Oban, it is first of all important to understand the problem from the point of view of the community. The community in Oban have been exposed to major flood events for a long time, with the earliest recorded event in 1869. Flood waters have damaged houses, businesses and other property. Coastal storms have flooded major roads and put lives at risk. Surface water flooding has damaged properties and limited passage on vital transport links.

Oban is home to over 8,500 people whose homes and livelihoods are potentially at risk of flooding. It is also an important hub for the wider rural community and tourism and at times the population can swell to 25,000.

Oban has important transport links. It is known as the 'Gateway to the Isles', with ferries linking the mainland to Mull, Kerrera, Lismore, Colonsay, Tiree, Barra, South Uist and Coll, amongst others. Beside the Ferry Terminal is the train station, which is the last station on the Glasgow to Oban line, linking central Scotland to Argyll and the western isles. The A85 Trunk Road connects the town to Perth and also to Inverness and Glasgow via the A82. The A85 joins the A816 within the town, which is the main route linking north and south Argyll. Flooding has caused major transport disruption on both of these routes within Oban, for example, when the A85 was exposed to dangerous coastal flooding in 2013 (Link to YouTube Video).

A number of important emergency services have bases in Oban. Lorn and Islands Hospital provides emergency care to the islands and the community over a radius of 30km or more. The next nearest Accident and Emergency facilities are in Lochgilphead and Fort William. Ambulance and fire services are based in the south side of the town and use the A85 to access areas to the north. When the A85 is flooded, these emergency services are forced to use smaller peripheral roads which would likely be under significant pressure from other traffic. Accessibility and safety limitations along these alternative routes led to proposals for an 'Oban Development Road' which have been under consideration by the Council for a number of years, but which were deferred in 2017 due to other local development planning commitments.

The town has a higher than average proportion of vulnerable residents, and sheltered housing units in the Lochavullin area have been highlighted as a particular concern following previous flooding.

Oban High School educates local young people as well as those commuting from many of the islands including Colonsay, Coll, Mull, Lismore, Iona and Kerrera. Many rely on consistent and safe passage to the Oban ferry terminal to commute home on a daily or weekly basis. Buses transport students from surrounding remote areas such as Dalmally and Kilmelford. The University of the Highlands and Islands also has a campus within Oban.

Oban provides key business services to the community. Lochavullin provides the only significant retail park in a 65km radius, at which multiple flooding events which have been reported. Well used supermarkets and their carparks have been flooded on multiple occasions due to a combination of tidal, fluvial and pluvial flooding. There is also a long-term public car park at Lochavullin, frequently used overnight by ferry users and tourist buses, often unaware of the flood risk here.

Flood management must take into account the needs of the people who are at risk and prepare them for future flooding by providing sustainable infrastructure, communicating risk and providing emergency support, as well as other adaptation and resilience measures.

4. APPROACH

4.1 Guiding Principles

From an early stage in the study, three guiding principles were established to focus the study, as follows:

Community safety - reducing the impacts of flooding;
Community awareness – sharing information and engaging with the community;
Sustainability – adaptation and resilience to prepare for future climate change and sea level rise; making use of sustainable solutions; and strategic long-term planning.

The study considers future scenarios based on best estimations and in some cases worst-case scenarios, to help to define the possible boundaries of the risk. Having sight of this means that flood management measures can be 'future-proofed', for instance by designing elements which can be adapted to cope with different levels of climate change.

4.2 Flood Management Process

Flood risk management is a continuous process. The risks vary over time in line with land use and climate change, and new information and technology becomes available which can support improvements. Sustainable flood management therefore requires a managed adaptive approach, as illustrated by Figure 4.1.

This report aims to support the process from defining Oban's flooding problems and objectives through to assessing economic viability of conceptual designs. From that point onwards, the Councilwill be responsible for obtaining funding to carry out detailed design, site-specific assessments, and ultimately construction and maintenance of flood management measures.

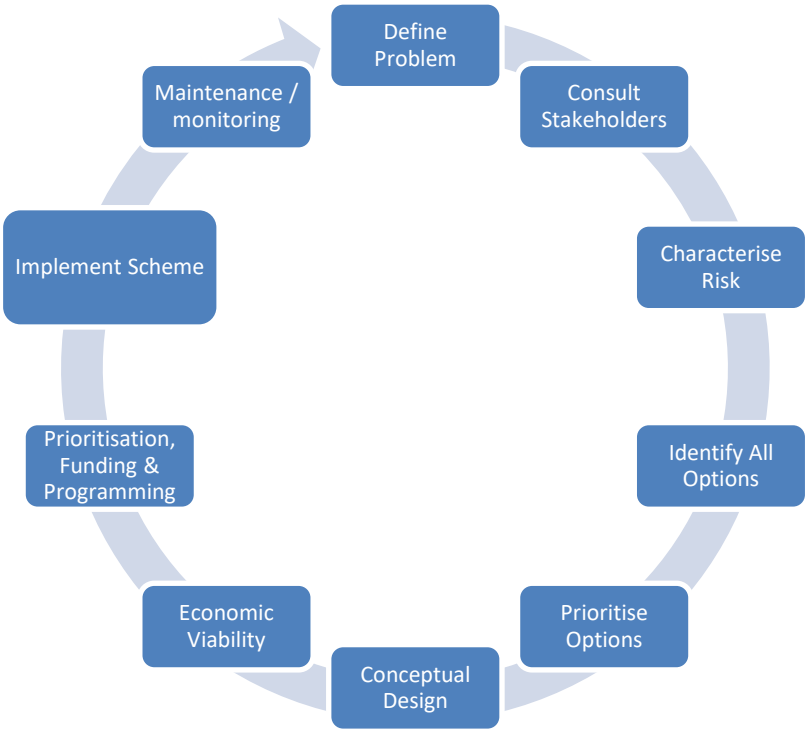


Figure 4.1 Adaptive Management Approach for Flood Management

4.3 Methodology

4.3.1 Overview

An overview of the methodology used in this study is presented in Figure 4.2 and described further in the following sections.

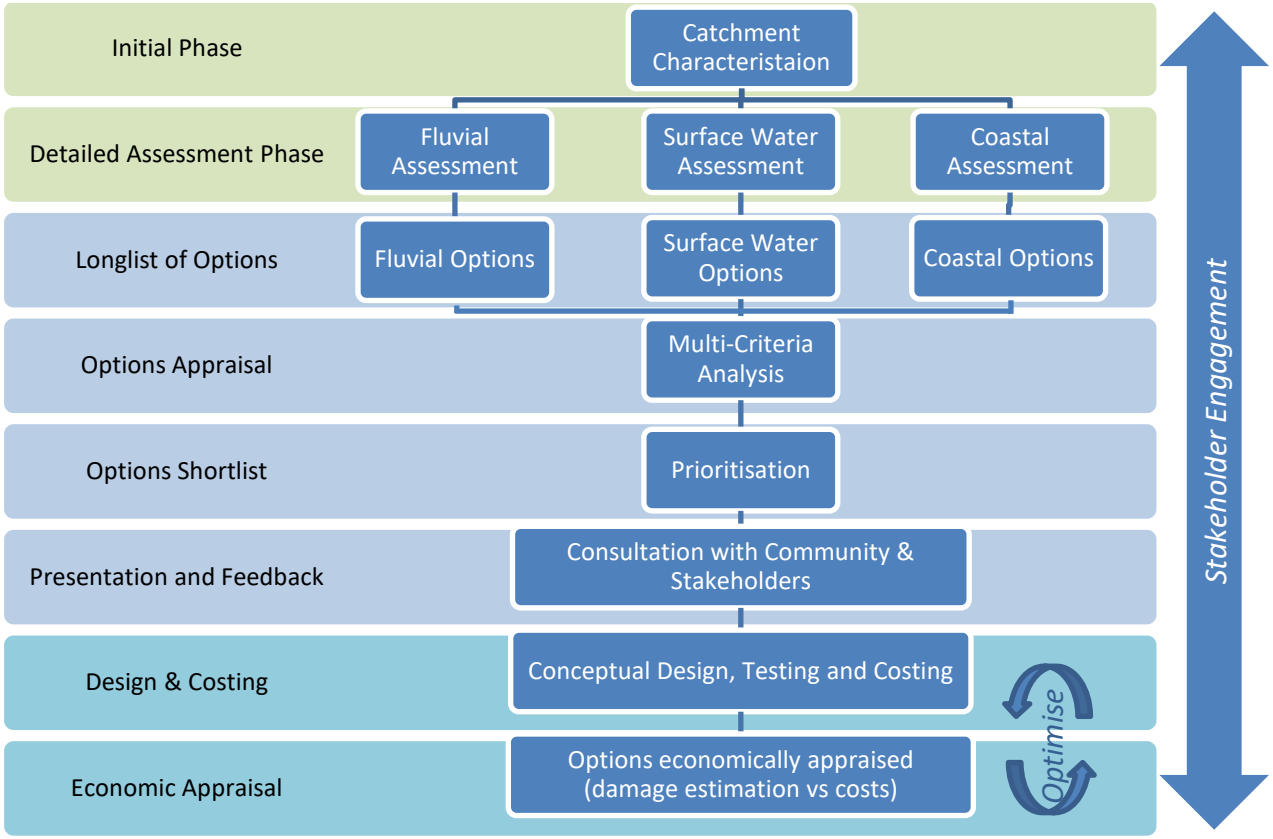


Figure 4.2 Study Methodology

4.3.2 Initial Phase

The initial phase of this study, presented in Sections 5 and 6 of this report, developed an understanding of the catchment. Desktop research and data collection were used to define the climate, physical nature and land use of the catchment. Historical flooding data was collected from published information and stakeholders to identify key locations at risk of flooding in the past. This phase also included catchment walkovers to identify key features and highlight potential hydrological interactions. Preliminary assessments of the fluvial, surface water and coastal flood risk in the catchment highlighted what information and assessments were required to conduct more detailed analysis of flooding within the catchment.

Key data sources used within the study are listed in *Volume 4: Maps, Media and Data Sources*.

4.3.3 Detailed Assessment Phase

The study has been divided into separate technical assessments which focus on three separate, but interacting, sources of floodwater present in Oban: River (Fluvial), Surface Water (Pluvial) and Coastal.

In Oban, multiple flood sources can combine to compound flood risk. Storms that cause a coastal storm surge leading to coastal flooding also bring heavy rains which cause pluvial flooding by exceeding drainage capacity in urban areas. The rainfall also increases flows in river channels, with out-of-bank flows inundating the drainage network which may in turn be unable to discharge freely to the river or sea due to high water levels in the receiving water body.

These different sources of flood risk have been modelled and where significant interactions that may influcce the flood dynamics have been identified, these have been assessed in relation to each other. Where there has been greater uncertainty in the magnitude of these effects, such as the river-tidal interactions, these have been integrated into the relevant models and assessed accordingly.

4.3.3.1 Black Lynn Flood Study (Fluvial)

There are two parts to the Black Lynn fluvial flood study. The first is the hydrological assessment (*Report 2A: Hydrological Analysis*), which uses existing hydrological data, flood event information and catchment descriptors to quantify flood flows and generate design flood events for the Black Lynn and its three main tributaries: the Alltan Tartach, Soroba Burn and Glenshellach Burn.

Report 2B: Black Lynn Flood Modelling then uses a 1D-2D hydraulic model to route the design flows through the channel network and over floodplain areas, while also accounting for tidally-influenced time varying water levels at the coastal outfall of the Black Lynn. The model was built using extensive watercourse surveys and ground models. A broad range of scenarios were tested to understand flooding dynamics and to develop flood maps of the catchment. Joint Probability Analysis (JPA) was used to define realistic interactions between river flows and tidal levels in the lower reaches of the river.

4.3.3.2 Surface Water Management Plan

Report 2C: Surface Water Management Plan investigated the risk of flooding from surface water sources, namely drainage networks and direct rainfall (pluvial). The assessment utilised Scottish Water's Section 16 drainage model to identify areas at risk of flooding due to insufficient drainage. The catchment was divided into distinct zones based on the physical characteristics, modelled flooding extents and historical flooding. The assessment used Geographic Information System (GIS) tools and ground truthing surveys to identify potential pluvial flow paths in the catchment and possible ponding areas. Community engagement meetings and stakeholder workshops informed the investigation and identified additional pluvial and surface water flood risks.

4.3.3.3 Oban Bay Flood Study (Coastal)

Report 2D: Oban Coastal Flood Modelling investigated the risk of flooding in Oban Bay and along the Corran Esplanade. Spectral wave and wave overtopping models were built using detailed bathymetric data. Scenario testing was used to develop coastal flood maps and identify key areas at risk of extreme tides and wave overtopping.

4.3.4 Identification of Potential Flood Management Options (Long List)

The outcomes of each technical assessment were used to identify a broad range of potential options to resolve the identified flood risk (*Report 3A: Options Appraisal - Long-list to Short-list*).

Fluvial (watercourse) flood management options included increasing upstream flood storage (measures to attenuate flood peaks moving downstream, e.g. active reservoir management at Loch Gleann a' Bhearraidh or floodplain restoration), enhancing channel or structural capacities, overland flood routing (to divert floodwater away from vulnerable receptors) and traditional engineered defences.

Surface Water options were identified through a compatibility assessment detailed within *Report 3C: Surface Water Management Plan*. The zones created in the assessment phase were characterised and potential

surface water solutions were selected based on their compatibility with the zone. A total of 27 solutions were assessed, and 5 detailed solutions were developed to resolve Surface Water in key areas. Options included drainage network upgrades and retrofit Sustainable Drainage Systems (SuDS) features, such as attenuation basins and swales.

Coastal options identified include measures which could be undertaken along the shoreline, such as set-back defences, demountable defences or embankments, as well as offshore options such as tidal reefs or barrages.

A separate technical assessment, *Report 2E: Natural Flood Management*, was carried out to identify potential for sustainable interventions at a catchment level, such as wetland or channel restoration. Hydrological modelling was used to assess the flood attenuation benefits of potential widespread woodland planting.

The Options Appraisal also considers other means by which the Council and the community can pro-actively address flood risk, such as flood alerts, emergency planning, property-level protection and changes to the long-term planning strategy.

The full range of interventions considered were listed within a Flood Management Toolbox, grouped under the following headings: Surface Water; Waterbody Engineering; Natural Flood Management (NFM); Coastal; Other: Structural; and Other: Non-structural. The potential locations where each measure could be implemented were compiled to form a 'long-list' of approximately 90 options.

4.3.5 Screening and Prioritisation of Options (Short-List)

The long-list of options were appraised using multi-criteria analysis. This involved subjective scoring of each option taking into account potential impacts, both positive and negative, over a range of criteria. These include effectiveness against flooding, buildability, land use compatibility, economic performance, environmental impact, social impact and regulatory requirements. Total scores were ranked to help distill the long-list to a short-list of priority options which could then be explored in more depth through subsequent stakeholder engagement, conceptual design and economic appraisal.

4.3.6 Conceptual Design and Costing

Short-listed options were conceptually designed, drawing guidance from technical assessments and community and stakeholder engagement (*Report 3C: Conceptual Designs and Factsheets*). Costings were compiled to indicate the potential lifetime cost of each option, from design and construction through to maintenance and operation over the long-term. Factsheets were prepared to accompany technical drawings to support any subsequent detailed design.

4.3.7 Economic Appraisal

Report 3B: Options Appraisal- Economic Appraisal assesses the solutions based on their economic costs and benefits over a 100 year period, using a standard methodology and in adherence with Scottish Government options appraisal guidance[1]. The cost of the solution is calculated including capital and operational/ maintenance expenditure, with appropriate discounting of future costs. The primary benefit of flood management measures is a reduction in flood damages to properties and their contents, which can be estimated based on property type and predicted peak inundation depth for each property over a range of return periods, using statistical depth-damage tables provided in the Flooding and Coastal Erosion Risk

[1] Scottish Government (2016). Option appraisal for flood risk management: Guidance to support SEPA and the responsible authorities.

Management Multi-Coloured Handbook. The appraisal encompasses a range of return periods and climate change scenarios between current day and the year 2100.

Economic appraisal first identifies those options with a business case (i.e. where whole life benefits exceed whole life costs, such that the benefit-cost ratio (BCR) is greater than 1). Economically viable options can then be examined in combination to determine a preferred option combination; this was achieved by commencing with well-performing individual options, combining them in turn and continuing the process so long as an overall business case can be demonstrated (i.e. total benefits exceed total costs) as well as an incremental business case (i.e. where the additional benefit provide by each successive element being added to the combination exceeds the additional cost of that element).

This approach ensures that the preferred option identified at the end of the process is optimal in terms of maximising flood damage reduction benefit while remaining economically justifiable.

4.4 Consultation

This project has been stakeholder led throughout. Emphasis has been put into engaging with the community and other key stakeholders to gather information on flood history, potential opportunities and constraints, as well as opinions on potential flood management measures. This information has been used to guide the technical assessments and to inform key decisions, and to ensure that the solutions being proposed are in line with the expectations of the stakeholders.

4.4.1 Responsible Authorities for Flooding

There are three key authorities who are responsible for flood management at a strategic level for Oban: the Council, SEPA and Scottish Water. The roles of these organisations are listed in Figure 2.1.

An initial meeting was held with SEPA in November 2018 and technical consultation has been carried out at key stages throughout the process. SEPA have reviewed the technical outputs of the study at crucial points to ensure that the methods and outcomes meet the required standard for their prioritisation process and public funding.

Scottish Water have provided information to support the SWMP, most notably a copy of their drainage network plans and associated hydraulic model, as well as details of their reservoir at Loch Gleann a' Bhearraidh. An initial meeting was held with Scottish Water to discuss their model setup, and was followed by two workshops held with Scottish Water and the Council, in February and April 2019, to discuss opportunities and limitations in relation to potential surface water management measures.

A stakeholder consultation meeting was held in May 2019, attended by members of the Council, Scottish Water and Forestry Scotland, to share the findings of the study and to openly discuss short-listed options and potential opportunities to collaborate.

4.4.2 Local Community

Various avenues were taken to consult with the local community. The community includes:

Permanent residents of the town and the surrounding rural area it serves;
Landowners, businesses and local service providers, who may be directly and indirectly affected by flooding in Oban;

Temporary residents, who are in some cases more vulnerable to flood safety issues in an unfamiliar environment; and
Community groups such as Oban Community Council and BID4Oban, as well as education establishments, who provide a representation of the wider community and play an influential role through awareness raising and facilitation of community action.

Engaging with local residents, members of the community council and business owners has revealed information that technical assessments and modelling could not. This local knowledge has led to a better understanding of the flooding pressures Oban is experiencing, and which specific flooding causes the most critical harm to the community and its most vulnerable residents. Witness accounts and photos provided by the community have helped interpretation of flooding dynamics and verification of model results.

The community also have a good understanding of what opportunities and constraints to flood management exist in the catchment. Reflections on how channel or land use changes have exacerbated flooding in recent years and information on potentially conflicting land uses has been used to guide options development.

Importantly, the consultation process created a forum two-way sharing of information and encouraged the public to actively engage with flood protection activities in their areas. The Scottish Flood Forum have actively offered practical support to the community and participated in one of four public consultations held for the study.

The consultation events, listed in Table 4.1, were advertised publically through articles in the Oban Times, a pop-up stand in the town's main supermarket, posters and the Council's social media pages. Approximately 30 attendees were noted at each event. Follow-up articles were reported in local newspapers, such as the Oban Times and Press and Journal.

A project-specific email address was set up to enable the public to share additional information and comments (ObanFRM@envirocentre.co.uk).

Several members of the project's technical team are local to the area and further local knowledge was obtained through direct consultation with local contacts, together with active efforts to speak with residents encountered through site visits.

Table 4.1 Public Consultations

Title	Focus / Outcomes
Initial Public Engagement Session: 27/06/2018, Rockfield Centre, Oban 	Residents, business owners, Councillors, Community Council members and other key stakeholders participated in an open drop-in session. Initial findings were shared and the aims of the study were communicated. Attendees shared memories and photos of flood events from throughout their lifetime and completed a survey to gather opinions on potential flood management measures that might be relevant to Oban. The majority of respondents were supportive of sustainable solutions such as natural flood management, channel restoration, channel maintenance, property-level protection, emergency planning and flood diversions. Traditional defences were also emphasised as being necessary.
Interim Consultation Session: 30/01/2019, Rockfield Centre, Oban 	A drop-in session designed to share interim results of the study and gather information on the local impacts of the severe flooding on 9th October, 2018. Scottish Flood Forum provided practical flood protection advice for individuals (e.g. emergency planning, property-level protection and flood insurance). Residents and businesses reported significant damages and disruption in October 2018. Local Councillors and Community Council members were well represented, and various potential means to manage flooding were discussed, including flood storage within Lochavullin carpark (assuming appropriate alternative parking facilities were facilitated), upstream flood storage opportunities and catchment woodland planting. Potential community contributions and funding opportunities were also explored.
Afternoon Drop-in Session & Evening Presentation: 20/06/2019, Corran Halls, Oban Link to presentation	Presentation on findings of study and discussion around short-listed options and initial conceptual designs. Residents, businesses, Councillors and Community Council members were well represented and actively shared opinions and further experiences. Generally attendees were supportive of the study, its findings and the proposed short-listed options.
Afternoon & Evening Drop-in Sessions & Presentations: 28/11/2019, Rockfield Centre, Oban  Link to presentation	Conceptual design drawings and presentations were used to communicate the recommended flood scheme measures to be put forward as part of the application for prioritisation. Residents, businesses, Community Council members and temporary visitors were in attendance and actively involved in discussions. Generally attendees were supportive of the recommended measures and understood the need for the economic evaluation required to justify the public spend. A number of attendees and also two email correspondents highlighted concerns over Japanese Knotweed and channel maintenance (in Lochavullin and Miller Road particularly) and the potential impact of new developments (in Glenshellach particularly).

4.4.3 Other Stakeholders

Additional stakeholders are listed in Table 4.2. Strategic consultation has been carried out particularly with Transport Scotland, Scottish Forestry and Scottish Natural Heritage, to obtain relevant information and opinions on potential flood management measures.

Table 4.2 Other Stakeholders

Organisation	Key Responsibilities / Interests in Relation to Flood Study
Transport Scotland	Coastal section of Trunk Road (A85)
Scottish Forestry	Natural flood management strategies
Scottish Natural Heritage	Designated sites and species of national and international importance
Network Rail	Safety and management of Glasgow-Oban railway line and terminal station
Ferry Operators (CalMac)	Safety and management of ferry terminal, harbour operations and navigable routes
Crown Estate	Ownership of Scotland's sea bed and part of the coastal foreshore (between mean high and low water springs).
Marine Scotland	Responsible Authority for marine planning, licensing and fisheries management between Mean High Water Springs (MHWS) and 12 nautical miles from the coast.
Historic Scotland	Cultural heritage features
NHS Scotland, Police Scotland, Scottish Fire & Rescue Service	Emergency service access routes and emergency planning. Local health services
Oban Schools & University of Highlands & Islands	Transport and accessibility for students
Oban Community Council	Representation of community interests. Potential role in sharing information, gathering public opinion, guiding options development and engaging the wider community in future flood management actions
Argyll Community Housing Association (ACHA)	Registered social landlord with responsibility for maintenance of publicly-owned residential properties and safety of tenants.
Bid4Oban	A business-led initiative, supported by legislation, where businesses work together and invest collectively in local improvements and community initiatives. Potential interest in local business impacts and role in supporting flood management initiatives
National Farmers Union Scotland	NFU Scotland is a member-led organisation representing the farming industry in Scotland. Potential role in supporting collaborative implementation of natural flood management measures.
Argyll Fisheries Trust; Argyll District Salmon Fisheries Board; and Oban & Lorne Angling Club	Fish habitat and potential barriers to migration; and fisheries impacts / fishing rights.
VisitScotland / other tourism organisations	Potential impacts on tourist access and safety

5. CATCHMENT CHARACTERISATION

5.1 Climate

Oban is located on the west coast of Scotland where the local climate is much wetter and subject to more unpredictable weather than areas to the east. It is, however, generally milder than other parts of the country due to Gulf Stream influences.

Observed rainfall for Oban is recorded by the Met Office weather station in Dunstaffnage, approximately 5km north of Oban. Since 1981, there has been an average total rainfall of 1681mm per year. The wettest periods are typically between October and February, which have average monthly rainfalls of around 200mm. The driest months are between April and July, with 80-110mm of rain. Further information can be found at the Met Office Climate Averages Website and in *Report 2A: Hydrological Analysis*.

The influence of climate change over the last century has meant that precipitation patterns in Scotland have changed, with a trend towards drier summers, wetter winters and more frequent heavy rainfall (Scotland's Environment Climate Report, 2014). Going forward, this effect is predicted to affect the west of Scotland most particularly, with over 55% increase in extreme rainfall predicted in the Argyll and Bute region (SEPA, 2019) between current day and the year 2080.

5.2 Geology, Hydrogeology and Soils

The geology of the study area (*Drawing 170506_044, Appendix B*) has been assessed using the British Geological Survey Geology of Britain resources.

Superficial deposits in the Oban Bay, Corran, and Glenshellach areas consist of Holocene Beach Deposits (sands and gravels). These typically have high porosity and permeability, depending upon the level of compaction. Towards the east, through Lochavullin, Soroba and Mossfield the superficial deposits are finer, containing clays, sand and silt. The clay component of these sediments will reduce the porosity and permeability here. Small pockets of alluvium (river deposits) are also present to the north east, in upper Glencruitten.

The bedrock geology in Oban is varied. The bedrock underlying the town is dominated by metamorphose sedimentary rock, with sandstone, siltstone and mudstone in peripheral areas and igneous bedrock at higher elevations in the upper catchment. Mafic igneous intrusions (dykes) and Precambrian calcareous rocks are also present. Dykes and metamorphose sedimentary rocks typically have low primary permeability and porosity, whilst the calcareous rocks (such as pelites) have the potential for groundwater to move within the fractures and cracks of the rock.

The soils in the catchment are also varied, with brown earths through much of the study area, and peat and peaty gleys at higher elevations. Soils in the Glenshellach area are dominated by mineral gleys. Rocky outcrops, particularly on steeper slopes, indicate that soil depths are likely to be relatively shallow over much of the catchment. *Drawing 170506_099, Appendix B* shows soil distributions throughout the study area.

No significant aquifers are present in the study area. SEPA flood maps indicate there is a low risk of flooding from groundwater within the town. Flooding from groundwater is not therefore specifically considered within this study.

5.3 Topography

Ground surface elevations and slopes are presented in Drawings 170506_ 057 and 170506_096, in Appendix B. Elevations range from sea level along the coastline to 230 metres Above Ordnance Datum (mAOD) in the south. The landscape is generally steep and rugged, with a central low-lying depression in the area of the town centre and narrow, shallower gradient valley floors at mid elevations.

5.4 Land Use

Land use distributions (Drawing *170506_098, Appendix B)* are closely related to topography and slopes.

The town has a commercial centre focussing around the Lochavullin area and along the coastal front. Beyond this the surrounding residential areas are generally found on more steeply sloping ground. Educational and recreational facilities (such as the sports centre and Glencruitten Golf Course) are generally found in peripheral areas.

The town centre is the main commercial zone in the town, with many shops, hotels and restaurants which serve the community and visitors. Lochavullin is an important retail centre, with several supermarkets, a garden centre and other retail units. Several important health and social facilities are also present to the east of Lochavullin. Public car parks in Lochavullin are valued by the community, because availability of car parking in Oban is restrictive, particularly during peak tourist times.

To the south of the town centre are the Oban Ferry Terminal and Railway Station, which provide important transport links. The North Pier is also a focus for boat activity. Public access along the Oban Bay Promenade and Corran Esplanade to the north are important features for tourism.

Residential areas tend to have gardens or green space, but other than schools, leisure facilities and the hill bearing McCaig's Tower, there is not a large amount of open public greenspace within the town.

Development has tended to focus on shallower slopes, which are at a premium in the landscape. The Argyll and Bute Council Local Development Plan (Argyll & Bute Council, 2015) shows the land use types and potential future development areas. In recent years residential and industrial development has extended up into the Glenshellach area.

The rugged landscape limits the potential for arable or dairy farming, and so for the most part agriculture is dominated by low-intensity grazing over semi-improved or unimproved ground. Forestry covers a large proportion of the upper catchment, particularly around Scottish Water's Loch Gleann a' Bhearraidh reservoir and Glencruitten.

5.5 Historic Development

Historic maps from the National Library of Scotland were used to examine the evolution of the town and associated changes to land uses and watercourses (*Drawing 170506_047, Appendix B*).

The Roy Military Maps (1747-52) show Oban as a small cluster of houses around Oban Bay and 'Loch Oban', a tidal loch (now Lochavullin). The Admiralty Chart from 1855 and 1870 Ordnance Survey map indicate this feature as 'Loch a' Mhuilinn'; a wetland area with evidence of engineered drainage channels, including a lade associated with a corn mill.

Similarly, Lon Mor (meaning 'Big Bog' in Gaelic) is shown to be drained in maps from the mid 1800's onwards, as this area was used as seasonal grazing pasture / hay meadow. Some locals still know this area as the 'Meadows' and recall frequent waterlogging over this area.

The Callander to Oban railway line opened in 1880 and this enabled the establishment of a livestock market on the edge of Lochavullin. A railway quay was established in association with this, involving land reclamation extending up to 130m from the shoreline, to support rail and ferry transport operations. 'Shore Street' behind the railway station indicates the historic location of the sea front.

This was a period of significant investment as other watercourse engineering projects were undertaken at around the same time. In the 1874 Ordnance Survey County Series, the upper reaches of the Black Lynn are shown to meander naturally along the edge of Lochavullin, but it was fully straightened to its current route by 1895. The Alltan Tartach was culverted from Miller Road (formerly Burnside Street) to the Black Lynn confluence at about the same time. Further upstream on the Alltan Tartach, the burn was also culverted at Mossfield, although by 1938 recreational grounds had been formed and the channel had become de-culverted and realigned to more or less its current position.

By the middle of the 20th Century the Lochavullin wetland had been drained to a point where it could be used to develop playing fields and a car park. According to local accounts, the area had also historically been used as the town dump which helped to raise ground levels, although this feature has not been mapped.

In the 1990's the Auction Market was moved out of town, and a large supermarket, carparking and other retail units were built over the former market and playing fields.

Since the 1990's, Glenshellach has been the main focus for new residential and industrial development in Oban. In the mid 1990's, substantial landraising at Lon Mor also enabled the construction of the Lorn and Islands Hospital. From a review of historic map contours and consultation with local residents whose family historically farmed over Lon Mor, it is estimated that 30 to 40% of floodplain storage potential may have been lost here due to landscaping and development.

5.6 Watercourses and Catchments

Where it discharges into Oban Bay, the Black Lynn drains a catchment area of just over 10km^2. There are three main tributaries in the catchment (Figure 5.1). The Glenshellach Burn joins the Soroba Burn just upstream of the railway embankment. According to Ordnance Survey 1 in 10,000 mapping, the Soroba Burn and Alltan Tartach then combine to form the Black Lynn at the upstream end of Lochavullin, which discharges into Oban Bay over 750m downstream. Other map resources and local residents frequently also refer to the reach between the Glenshellach Burn and Alltan Tartach confluences as the Black Lynn, or Lynn Burn.

An overview of these watercourses is given in Table 5.1 and detailed catchment characteristics are provided in *Report 2A: Hydrological Analysis*.

More detailed catchment boundary and overland flow path analysis is provided in *Drawing 170506_018*, *Appendix B*. Analysis of potential for overland flow accumulations (based on contributing catchment area and slope) has generated a map of Topographic Wetness, as shown in *Drawing 170506_097, Appendix B*.

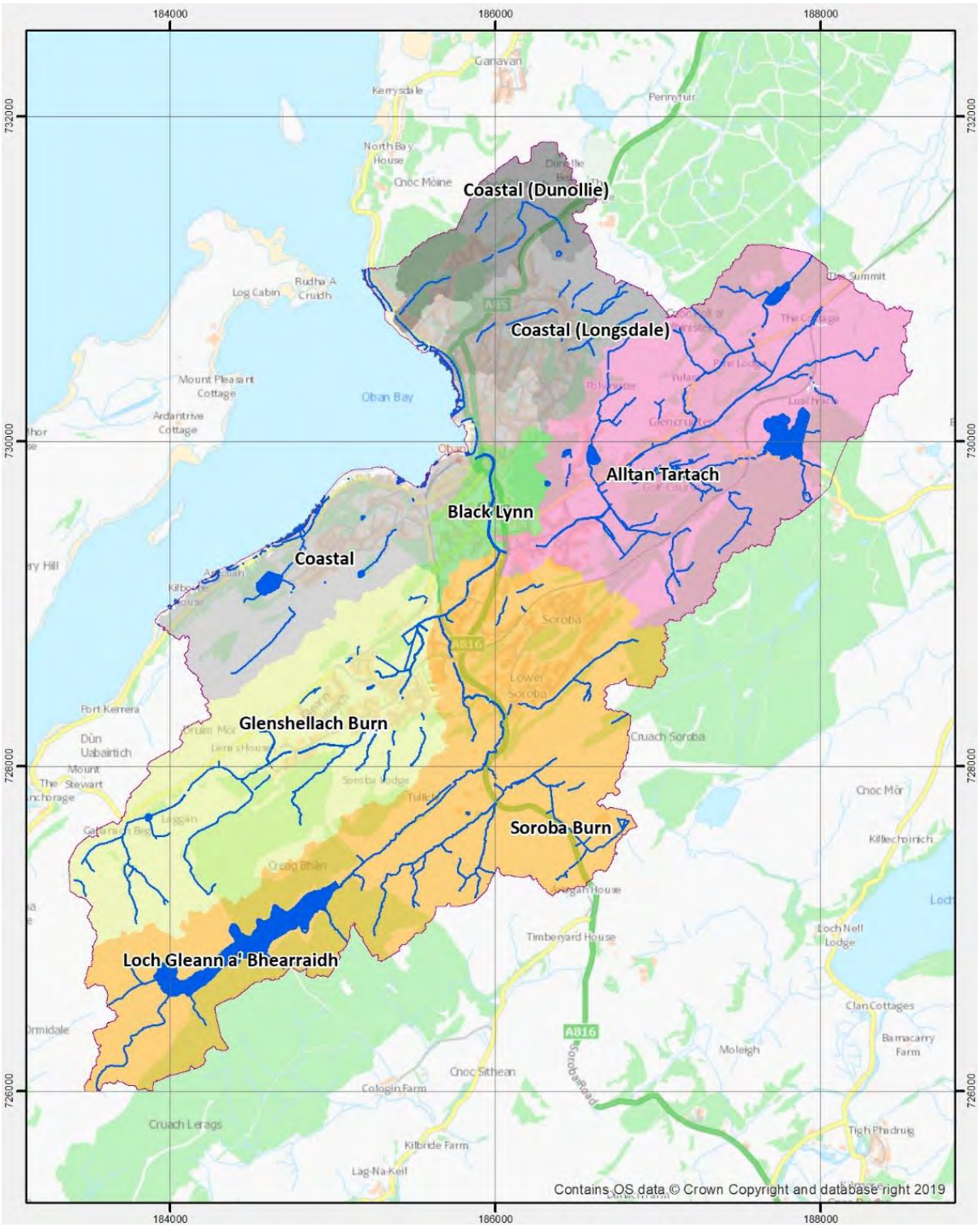


Figure 5.1 Study Area Catchments

Table 5.1 Watercourse Descriptions

Name	Description
Soroba Burn  *Soroba Burn alongside Soroba Road*	The Soroba burn is a relatively steep watercourse which generally routes in a north easterly direction. It originates from Loch Gleann a' Bhearraidh, around 2.5km south west of Oban, and now represents the primary overflow discharge from Scottish Water's reservoir here. At times, flows are supplemented by intercatchment transfer of water from Loch Nell to Loch Gleann a' Bhearraidh. From the reservoir, the Soroba Burn routes through Tullich towards Soroba Road (A816), following it northwards. On the approach to the town the channel is relatively steep and unmodified, but shallows out alongside the Lorn and Isles Hospital where the channel becomes more engineered. As it reaches the railway line it has a catchment area of 3.5km^2, and is joined by the Glenshellach Burn immediately upstream of the masonry culvert through the railway embankment. Downstream of this, the burn is also known locally as the Black Lynn, and has been straightened through the Millpark area, joining the Alltan Tartach near Lynn Road.
Glenshellach Burn  *Glenshellach Burn at Lon Mor*	The Glenshellach, or Gleann Sheilleach, Burn rises south west of the town, in a wetland area called Gallanach Beg. It flows through the base of Glen Sheilleach, where it has been straightened historically to enable agriculture, and laterally culverted along much of its length to enable industrial and residential developments. It passes below Glengallan Road into a highly engineered channel, before issuing into the Lon Mor wetland. Straight drainage channels have been cut through the bog for nearly 200 years, although it continues to function as a wetland, in part due to a low bund formed across Lon Mor through which the burn is culverted. The burn joins the Soroba Burn just upstream of the railway embankment. Here it has a catchment area of 2.5km^2.
Alltan Tartach  *Alltan Tartach through Mossfield*	The Alltan Tartach rises to the north east of Oban, at the top of Glen Cruitten. The catchment includes Luachrach Loch and also the disused Polvinster reservoir, which has been drained by Scottish Water. The burn drains south west through the Glencruitten Golf Course, where the channel has been significantly straightened, particularly where it passes along the edge of Glencruitten Road. It is then sharply diverted around the edge of Mossfield Stadium and flows through the residential area of Mossfield. It enters a long culvert at Miller Road and joins the Soroba Burn to form the Black Lynn just downstream of Lynn Road. At this point it has a catchment area of 3.4 km^2.
Black Lynn  *Black Lynn downstream of Market St*	The Black Lynn is heavily modified and channelised along its length. It conveys flow through Lochavullin parallel to Soroba Road. A significant reach is densely vegetated with the invasive Japanese Knotweed and other invasive non-native species. Associated with this large accumulations of fine sediment have formed here. Downstream of the Soroba Lane Bridge the watercourse is straightened and uniform in nature, with multiple bridge or culvert crossings. Walls and buildings line the banktops through much of the town, limiting the habitat value of this reach as well as connectivity with the floodplain. The Black Lynn issues into Oban Bay through a culvert under Queen's Park Place, at which point it drains a 10.4km^2 catchment.

5.7 Morphology

SEPAs water environment classification does not classify all of the tributaries, although the Black Lynn Burn (Waterbody ID 10304) is shown to be inclusive of the Soroba Burn. The waterbody has been canalised through the urban environment and has been designated as a Heavily Modified Water Body on account of physical alterations that cannot be addressed without significant impact on water storage for public drinking supply.

The overall status of the waterbody is Moderate, on the basis of ecological, chemical and physical conditions. An objective has been set to attain Good status by 2027. The overall Hydromorphological classification of the waterbody is Moderate, with key pressures identified as impoundment and abstraction, associated predominantly with Loch Gleann a' Bhearraidh.

Field visits, historic maps and a stream power assessment based on the hydraulic model developed for the Black Lynn have been used to develop an understanding of the morphological characteristics and processes present through the system and to appraise potential sensitivities to changes in morphological pressures.

Stream power can be used as an indicator of river dynamics, based on the rate of energy loss against the bed or banks of a channel and indicates the capacity of a channel to carry out geomorphological processes (erosion, transport and deposition). It provides a useful indication of reaches which may be sensitive to changes in flow regime or channel engineering. The stream power as derived from the hydraulic model detailed in *Report 2B: Black Lynn Flood Modelling* is presented in Figure 5.2, which identifies the surface water network as being a generally low to medium energy environment, with occasional zones of higher energy associated with steeper drops around bedrock exposures. This is consistent with the observed conditions on the ground.

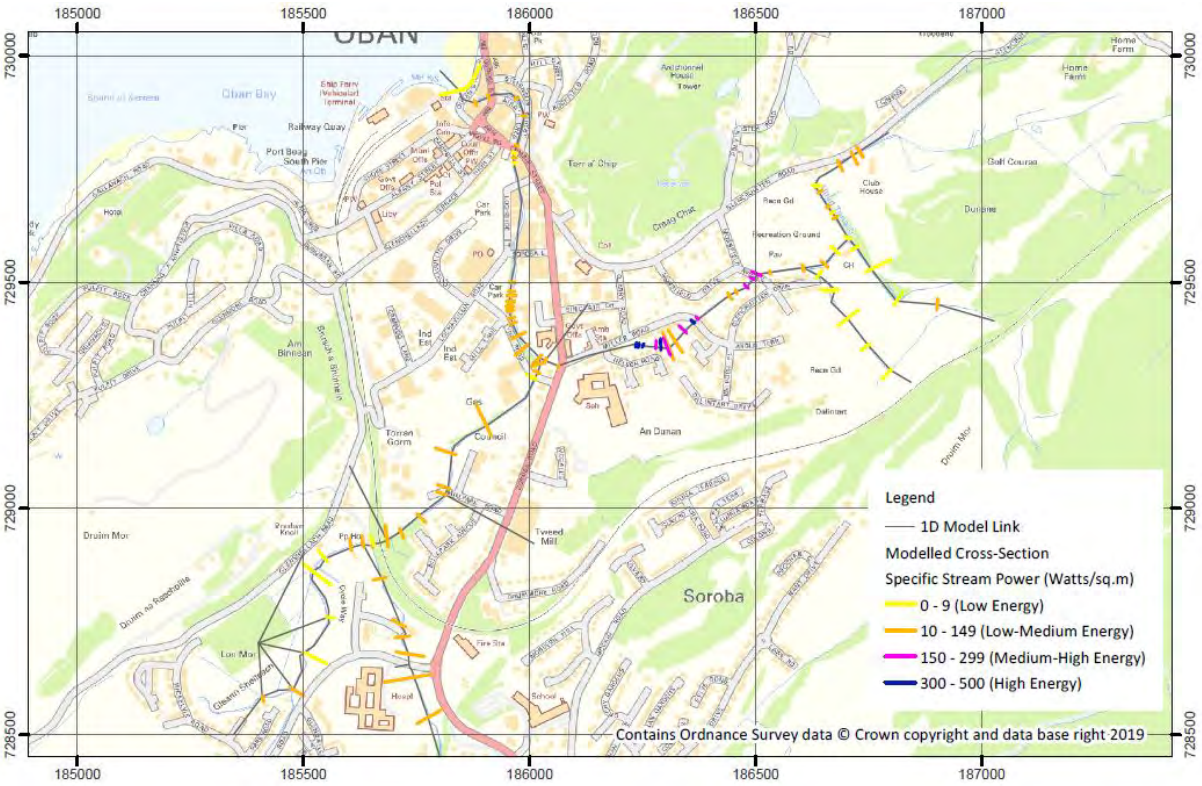


Figure 5.2 Stream Power

The Alltan Tartach has been realigned and modified along much of its length, particularly from Glencruitten Golf Course and downstream. Currently, the channel exhibits features associated with plane-bed / plane-riffle / step-pool typologies. Under natural conditions, it is likely that it would have had a step-pool morphology in steeper reaches, with poorly defined or passive meandering reaches through lower gradient areas such as Mossfield, where extensive floodplain wetland would have been present. Between Mossfield and Miller Road the channel steepens and larger sediment sizes dominate. Localised erosion and bank protection was noted in places during the site walkover. Overall, it is likely that the channel in its current form has a moderate sensitivity to morphological pressures.

Upstream of Glenshellach, the Soroba Burn is relatively steep and predominantly displays features associated with a cascade or step-pool type channel, indicating that it will be relatively stable and less sensitive to morphological pressures; although it is understood from a local resident that there is an actively eroding reach upstream of the hospital. The channel has lower energy where it shallows out on the approach to Lon Mor and has been more significantly straightened and modified. It flows through a large attenuation basin beside the hospital. The lower reaches of the Soroba Burn are considered to be relatively stable.

The Glenshellach Burn has a shallower gradient and has been more extensively modified than the Soroba Burn. It is characterised as having a plane-bed or plane-riffle type morphology, and is considered to have a relatively stable planform following field visits and historical map review. In the absence of historic channel straightening or drainage works, it is considered likely that the channel would originally have been less well-defined flowing through floodplain areas such as Lon Mor, and would have had more features associated with a low-gradient, passive meandering channel. On balance, it is likely that this channel has a low sensitivity to changes in morphological pressures.

The confluence of the Soroba and Glenshellach Burns appears to be relatively stable, with no significant deposition or erosion. Downstream, between the railway embankment culvert and Lynn Road, the main channel is significantly straightened. Earth embankments along most of the reach show few signs of instability or erosion, and there are few significant sediment deposits on the channel bed. Sediment sorting and vegetation indicates stability.

The Black Lynn has been significantly realigned and confined within engineered banks along its entire length through the urban centre. Historic maps show that the Lochavullin area was historically a tidal loch or wetland area. The watercourse feeding into this would naturally have been a low-gradient passive meandering type channel. It currently has morphological features generally associated with a plane-bed / plane-riffle typology.

Between the Lynn Road and Soroba Lane bridges, the gradient is shallow and the channel has been over-widened, as indicated by the presence of large berms and accumulations of fine sediment. The presence of dense vegetation enhances deposition in this reach and river processes will continue to narrow the channel until a dynamic equilibrium between erosion, transport and deposition is achieved. This low gradient and low energy reach at the upper end of the tidal influence primarily functions as a deposition area for fine sediments.

From Soroba Lane downwards, there is a distinct coarsening of sediments. The canalised channel is more stable and efficient hydraulically, and functions primarily as a transport reach. This is supported by the higher stream power shown on Figure 5.2. There are a number of bridges and banks are generally formed with concrete or masonry walls. On the channel bed there are localised areas of bedrock outcrop or concrete which act as hydromorphological controls. Generally there are few signs of significant erosion or deposition of sediments throughout this reach.

On the whole, the watercourses in the study area are relatively stable and do not indicate significant dynamic conditions in terms of erosion or deposition of sediments.

5.8 Drainage

The stormwater drainage system in the study area has developed over many decades and contains a significant proportion of traditional combined sewers (i.e. sewers containing surface water runoff as well as foul flows). Most of the combined system, and the foul system, drains to the Corran Park Pumping Station before being pumped to the Oban Wastewater Treatment Works.

There are some areas of separate foul-only sewers and surface water sewers, predominantly where newer properties are located. Most of the separate system are in the south, in Lochavullin, Glenshellach, and Soroba. The surface water flows in these areas tend to drain to small watercourses or the Black Lynn. At Lochavullin, the drainage system is augmented by an automatic pumping station, because in this low-lying area gravity drainage is not possible when levels in the Black Lynn are high.

Drainage plans and more information on the drainage network is provided in *Report 2C: Surface Water Management Plan*.

5.9 Coast

The sea front stretches for over 3km, encompassing the Corran Esplanade and Oban Bay, with the North Pier in between (Figure 5.3). The Ferry and Railway terminals have been established on an extensive area of reclaimed ground between Oban Bay and the South Pier.

The seafront and harbour are sheltered by the presence of Kerrera to the west. Exposure to offshore waves and wind is greatest from the Sound of Kerrera to the south, with wave penetration also possible through the straight between the northern tip of Kerrera and Dunollie Castle to the north-west.

Further information on coastal features and dynamics are provided in *Report 2D: Oban Coastal Modelling*.

Figure 5.3 Oban Bay towards North Pier, including the Black Lynn Outfall

5.10 Pressures

The existing and potential future pressures experienced in Oban in relation to flooding and flood risk are summarised in Table 5.2 .

Table 5.2 Oban Pressures

Pressure	Comment
Climate Change: Rainfall	Climate change is expected to have a significant impact on the intensity and frequency of rainstorms and floods going forward.
Climate Change: Sea Levels	Climate change is expected to cause sea level rise.
Deforestation	Significant areas of the catchment are forested. Extensive deforestation could remove the buffering effect of trees and increase runoff of water and sediments to watercourses.
Agricultural Change	While the study catchment is not intensively farmed currently, there is potential for future changes in grazing intensity or drainage to increase runoff rates.
Water Resource Management	Loch Gleann a' Bhearraidh is Scottish Water's reservoir supplying Oban and surrounding areas. Active management, including inter-catchment transfer of water from Loch Nell, has the potential to affect flood flows if not managed appropriately. There is also a very low risk of dam failure causing extreme flooding, although regular dam inspections minimise this risk.
Complex Interactions	In the setting of Oban, multiple flooding sources can combine – particularly in Lochavullin. Fluvial, pluvial and tidal flooding can all interact and resolving one may have an inadvertent detriment on another. For example, using conventional flood defence measures to minimise fluvial flood risk tends to increase river water levels, which may therefore increase the risk of pluvial flooding (specifically, sewer network flooding) by causing existing river outfalls to back up.
Maintenance Regimes	As public budgets and environmental priorities change over time, so maintenance regimes can shift. Changes can result in, for instance, blocked road gullies and sewers, blocked culverts, excessive bank erosion and overly-vegetated channels with poor conveyance capacity. Structural failures can also occur due to insufficient maintenance.
Invasive species	Japanese knotweed is present in the Black Lynn catchment. It encroaches into channels and exacerbates fine sediment deposition. It requires an intensive treatment regime, can take several years to eradicate and requires specialist waste disposal.
Development on the floodplain	Approving developments within the floodplain increases the number of receptors exposed to flood risk. Flood walls and land raising have disconnected watercourses from their floodplains, causing flood risk to be pushed either up- or downstream. The proximity of buildings to the watercourse, particularly along the lower Black Lynn, limits the opportunities for sustainable flood management or river restoration.
Urban Creep	Urban creep refers to the gradual tendency for green permeable areas to be converted to impermeable surfaces (e.g. paving over gardens, extensions to existing buildings), which increases both runoff volume and runoff velocity. The installation of SuDS in newer developments offsets some of this effect.
Drainage Capacity	The surface water network has limits in terms of how much water it can receive, convey and drain, and investments to improve sewers may not "keep up" with growing flow contributions, due to new development and urban creep. As such, the risk of network flooding may increase with time, above and beyond any increase due to climate change and other pressures.
Wastewater Treatment Works (WwTW) Capacity	The WwTW is the main outfall for the combined sewer network which drains most of the surface water flows. The WwTW is currently limited to processing up to 160 l/s peak inflow. There is a 3800m^3 storage tank located at the pumping station. Excess surface water will discharge from the Combined Sewer Overflow (CSO), which directs flow to the sea. Discharges from the CSO will be limited by its conveyance capacity and may also be affected by tidal locking (restriction of free flow due to high tide conditions at the downstream outlet).

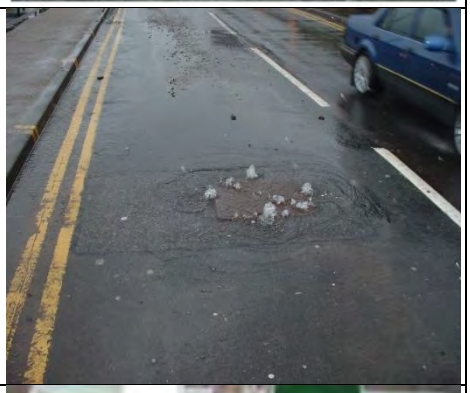
Pressure	Comment
Ageing Infrastructure	Some asset are ageing, which can reduce the efficiency of their operation. For example flap valves protecting against backflow from rivers and the sea can rust and fail to close during flood events. Siltation has been noted in parts of the drainage system, particularly Lochavullin. Ageing also increases the chance of cracks and root intrusion which can increase roughness of pipes and culverts. Deformation and varying degrees of structural failure may also occur as pipes and culverts age. Ragging can also occur in combined sewers. All of these factors can reduce the overall conveyance ability of the drainage system (including river culverts). Existing embankments and walls along the river and coastline, which deliberately or incidentally offer protection against flooding, may erode or decay over time, thus increasing flood risk.
Subsidence	Subsiding ground levels in Lochavullin have been implicated in recent years as problematic to drainage (e.g. due to cracking pipes and reduction in pipe gradient). Significant changes to ground levels could also affect overland flood routing over the longer-term.
Subsurface upwelling	In Lochavullin, it has been noted that high water levels in the Black Lynn may induce upwelling in the Lochavullin car park, possibly exacerbated by subsurface piping. Without management, piping is likely to become progressively worse with time, increasing flood risk to the Lochavullin area even when river banks are not overtopping, as well as posing a risk of continuous subsurface erosive damage and further subsidence in the Lochavullin area.

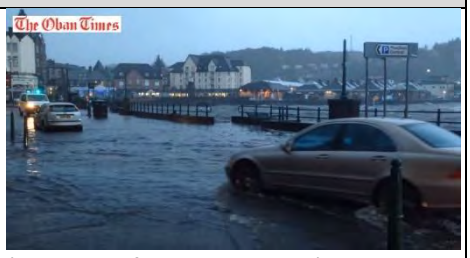
6. FLOOD HISTORY

The earliest recorded flood event was in January 1869, when coastal flooding caused properties to be inundated to a depth of 2 to 3 feet and damaged roads, the sea wall and pier. It is recognised that there are gaps in the flood records for the town, but it is notable that since the year 2000, there seem to have been a significant increase in the number of recorded flood events; particularly in Lochavullin. It may be that floods have always occurred but have gone unrecorded; but it is considered likely that a combination of pressures, as listed in section 5.10, have caused this upward trend in flooding. This view is supported by many members of the local community.

The following table details major flooding incidents, and a full list of recorded events is provided in Appendix B. This list was compiled using information from internet searches, Council records, public consultation events and via email. There have been approximately 25 separate flooding events recorded within the catchment, varying in spatial distribution and character.

Table 6.1 Major Flooding Events

Date	Flooding Type	Description	Image
1869	Coastal	Property inundation to 2-3 foot deep. Damage to roads, seawall and pier.	N/A
1960's	Coastal	Coastal flooding over esplanade	
30/10/2001 & 01/11/2001	Fluvial and Surface Water	The wastewater network around Lochavullin was surcharged and caused some flooding in the supermarket carpark.	
11 & 12/01/2005 'Cyclone Gero'	Coastal	Coastal flooding reported within Oban and along west coast of UK. High winds with gusts of up to 31m/s in Oban. Over 3,000 sandbags were deployed. Link to BBC Article Link to BBC Article Link to MetOffice Article	 (Courtesy of BBC)
08/12/2011 'Cyclone Friedhelm' or 'Hurricane Bawbag'	Coastal	The most significant storm across Scotland since the January 2005 event. Winds gusts of up to 80 – 90mph in Oban, the highest since January 1993. Video evidence shows wave overtopping on George St, to the south of the North Pier, and Corran Esplanade to the north of the North Pier. Approaching wave direction appears to be from the south-west through Sound of Kerrera. Link to YouTube Video Link to MetOffice Article	 (Courtesy of the Oban Times)

Date	Flooding Type	Description	Image
05/12/2013 'Cyclone Xaver'	Coastal	Corran Esplanade and George Street subject to coastal flooding, with high tide, storm surge and wave overtopping. Link to Wikipedia Article Link to the Oban Times Article Link to YouTube Video	 (Courtesy of the Oban Times)
28/10/2014	Fluvial and Surface Water	Lochavullin carpark was inundated to depths greater than a metre, damaging many cars. The car park was inundated due to the Black Lynn overtopping its banks. Link to YouTube Video	
29/01/2016 'Storm Gertrude'	Coastal	Flooding and wave overtopping on Corran Esplanade and George Street. Seaweed deposited on esplanade, and 100mph (45m/s) gusts recorded. Link to the Press and Journal Article Link to Vimeo Article Link to Vimeo Article Link to Newsflare Article	 (Courtesy of the Press and Journal)
09/10/2018 - 11/10/2018	Fluvial and Surface Water	The Black Lynn inundated the carpark affecting many parked cars and local businesses. A residential property to the east of the river, upstream of Lynn Road, has been inundated multiple times, most notably in this event. Link to the Oban Times Article Link to the Daily Record Article Link to BBC Article Link to the Northern Echo Article	

7. FLOOD RISK

7.1 Definitions

7.1.1 Flood Risk

SEPA defines flood risk as: "A measure of the combination of the likelihood of flooding occurring and the associated impacts on people, the economy and the environment." (SEPA, n.d.).

The probability of flooding is typically defined using the concept of return periods, e.g. a 1 in 200 year flood. Appendix A of *Report 2A: Hydrological Analysis* provides detail on how flood risk probabilities are defined.

As well as probability of flooding, the vulnerability of a property or community also needs to be considered as part of any assessment of flood risk. Figure 7.1 presents a simplified flood risk matrix, which demonstrates the relationship between vulnerability, probability and risk.

	Low Probability	**High Probability**
Low Vulnerability	Low Risk	Medium Risk
High Vulnerability	Medium Risk	High Risk

Figure 7.1 Simplified Flood Risk Matrix

7.1.2 Probabilities

There are three major possible flood sources within Oban: coastal, fluvial (watercourses) and surface water (rainwater / drainage). To calculate the flood risk from these flooding sources various hydrological and hydraulic assessments were completed. These assessments aimed to calculate the extents and depths of flooding at a given probability, or return period of flood event.

For instance, a 1 in 200 year flood has a 1 in 200 year chance of happening in any given year. This is also known as a 0.5% Annual Exceedance Probability (AEP) event, meaning that there is a 0.5% chance of occurrence within any given year.

To help contextualise these return periods, Table 7.1 presents the probability of experiencing floods over a range of return periods within the lifetimes of three individuals aged 10, 25, and 80. An Oban resident living to the age of 80 has a 33% chance of experiencing a 1 in 200 year flood in their lifetime.

Table 7.1 Lifetime Chance of Experiencing Various Return Period Flood Events

Age	**Chance of Flooding in Any Given Year**		
	1 in 10	**1 in 200**	**1 in 1000**
10	65%	5%	1%
25	93%	12%	2%
80	100%	33%	8%

7.1.3 Vulnerability

The vulnerability of a building or land use describes the consequence of the property being flooded. In this context this term is unconnected to probability of flooding. Flood Risk and Land Use Vulnerability Guidance (SEPA, 2018) provides descriptions of the level of vulnerability of flooding of different types of land-use. Oban has land uses of all types, examples of which are listed in Table 7.2. Land use vulnerability distribution is presented in *Drawing 170506_100, Appendix B*.

Table 7.2 Example of Land Uses in Oban

Land Use	Examples within Oban
Most Vulnerable Uses	Oban Community Fire Station Lorn and Islands Hospital Residential care homes / sheltered housing facilities Oban schools and nurseries Service stations
Highly Vulnerable Uses	Private dwellings throughout the town Hotels and hostels located along the coast Non-residential health services / social services
Least Vulnerable Uses	Restaurants Shops and offices Industrial & commercial units in Lochavullin Leisure centre
Essential Infrastructure	A85 and A816 roads Oban Railway Station Oban Ferry Terminal
Water Compatible Uses	Harbour facilities e.g. jetties, piers, slipways Leisure facilities e.g. Mossfield Stadium

7.2 Flood Risk Assessment

Together with an understanding of previous flood events developed through stakeholder consultation and desk-based research, flood risk has been quantified through the following technical assessments:

Report 2B: Black Lynn Flood Modelling;
Report 2D: Oban Coastal Flood Modelling; and
Report 2C: Surface Water Management Plan.

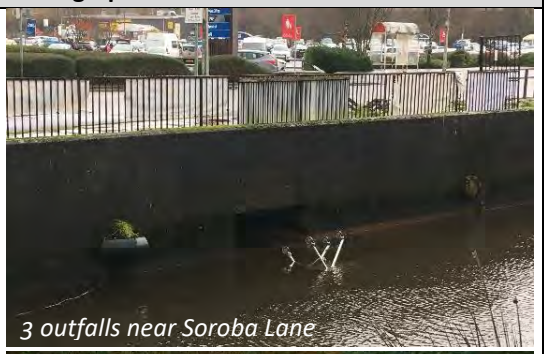
Flood maps have been produced for coastal, fluvial and surface water flooding, which are collated in *Volume 4: Maps, Media and Data Sources*.

On balance, it is noted that there are flooding issues distributed throughout the study area, however, there are particular 'hotspots' where flooding is particularly severe and/or problematic to the community. Interacting flood sources are found at many of these hotspots.

7.3 Flood Risk Interactions

The approach of the flood study was to initially quantify the flooding aspects individually, and use a combination of stakeholder engagement, site walkovers and model interpretation to build up a conceptual understanding of the dynamic interactions between flood sources and how they can potentially combine to compound flood risk. Selected examples of interacting flood risk are given in Table 7.3.

Table 7.3 Examples of Interacting Flood Sources in Oban

Interaction	Description	Photograph
Surface Water Network Discharging to Watercourses	There are 49 known surface water outfalls discharging to watercourses in the study area. Generally, the surface water is discharged through a non-return valve, which needs to be maintained and replaced over time as they can become stuck open or closed as they degrade over time. If the water level is high in the receiving water course, discharge may reduce or stop altogether, causing backup in the sewer network which may cause surcharging / flooding. If a non-return valve is stuck open, high water levels in the river can cause backflow into the drainage network. Lochavullin and Soroba Road are noted as key areas for this potential combination of flood sources.	 *3 outfalls near Soroba Lane*  *Manhole surcharging in Lochavullin*
Surface Water Network Discharging to the Sea	There are approximately 12 surface water outfalls discharging to the sea. This is similar to the surface water network discharging to the watercourse, in that drainage can be impeded or negative flow can occur at high tides. Wave overtopping over the sea wall in Oban Bay may result in water becoming trapped when surface water drainage systems are exceeding capacity.	 *Small coastal discharge*
Black Lynn Discharging to the Sea	The Black Lynn discharges to the sea through a large culvert in Oban Bay. High tides can cause fluvial discharge to be impeded and 'tidal locking' may occur. This interaction is very important to model and is accounted for by using Joint Probability Analysis (JPA), which calculates the probability of extreme tides coinciding with high river flows. There is a correlation in the causal mechanisms of both types of flooding (i.e. the same climate conditions causing extreme tidal levels may cause extreme rainfall and hence river flows).	

7.4 Flooding Hotspots

Figure 7.2 highlights observed flooding hotspots in Oban and more detailed descriptions of key flooding hotspots are given in Table 7.4. These represent flooding from different floodwater sources and have primarily been compiled on the basis of information provided by the local community and other stakeholders, supported by review of historic flood records, topography and model results. The low-lying Lochavullin area and the exposed coastal strip are the most significant areas of observed and predicted flooding, and also have a high density of receptors.

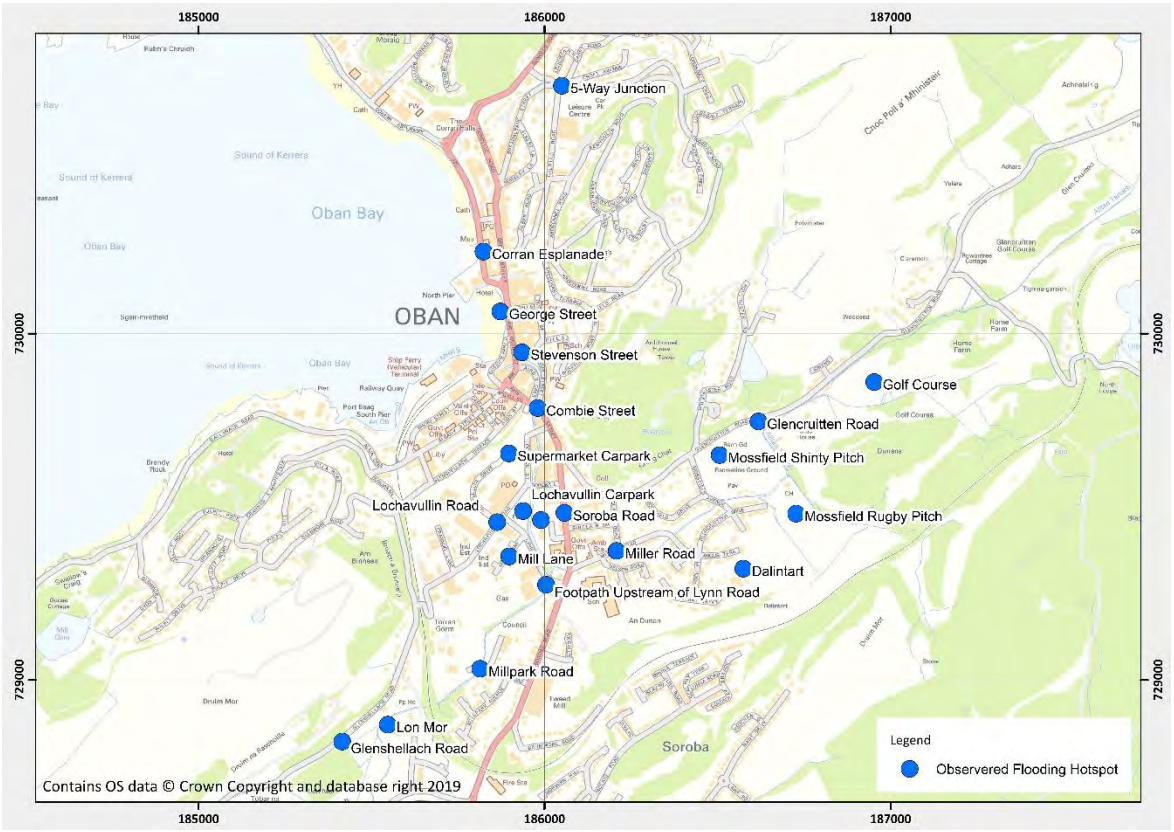


Figure 7.2 Locations of Observed Flooding

Table 7.4 Key Flooding Hotspots

Hotspot	Vulnerability	Flooding Probability	Comment
Oban Coast	The Oban coast contains multiple "highly vulnerable" uses, the majority of which are hotels and hostels, although there are also dwellings. In addition, there are a number of "least vulnerable" uses including restaurants and shops. Some of the properties also have basements which increases their vulnerability. The A85 passes along the shoreline, which is a vital trunk road and has had to be closed during previous flood events.	The area has a high probability of flooding from coastal flooding. Coastal modelling indicates that there is some flooding during a 1 in 30 year event or smaller, and significant flooding during a 1 in 200 year event. In addition to coastal flooding, *Report 3: Surface Water Management Plan* indicated there is a risk of pluvial flooding in this area. The trunk sewer is surcharged (overloaded beyond design capacity) during a 1 in 5 year event. The high sea level also potentially presents a compound risk as the discharge from the local surface water network is impeded.	Historical events along the Oban Coast have caused significant damage to properties and buildings. Significant coastal events also present a risk to life, particularly associated with wave overtopping.
Lochavullin	Lochavullin contains some "highly vulnerable" uses, but the majority of the area is occupied by "least vulnerable" uses. Lochavullin is an important hub for the community and the primary location for car parking, which is otherwise restrictive in Oban. In previous events, floods have damaged business assets and multiple cars and access to services and workplaces has been impeded.	There is a high probability of compound flooding from all three flood sources here. The fluvial model indicates that the area is at high risk of fluvial flooding from the Black Lynn. Commercial and public carparking in the Lochavullin area is predicted to be at risk of flooding for the smallest event considered in analysis (the 1 in 2 year return period event), with some non-residential buildings in the area at risk from the 1 in 5 year return period event. The surface water model also indicates that the area is at risk of pluvial flooding. Due to the low lying nature of Lochavullin, the interaction between flow in the Black Lynn and the drainage network is important, as described in Table 7.3, and there is substantial reliance on the pumping station in this area to minimise flood risk from both of these sources. In addition, the area is also affected by the sea level and storm surge, with extreme tidal levels being capable of flooding the area even in the absence of significant river flows.	Lochavullin has been highlighted by the community and the council as a high risk for flooding. There are complex interactions of flooding from all sources which will need to be considered to produce a successful solution. This area is particularly susceptible to the effects of climate change on flooding; with a rise in 1 in 200 year flood levels of 0.5m or more expected by the year 2100.

Hotspot	Vulnerability	Flooding Probability	Comment
Mossfield	Mossfield contains multiple "highly vulnerable" uses (residential dwellings and a Multiple Sclerosis Therapy Centre). There are also several "water compatible" uses such as Mossfield Stadium, rugby pitches and the Glencruitten Golf Course immediately upstream.	Pluvial flooding is noted within Mossfield. The surface water model shows there is potentially flooding at properties to the south west of the Mossfield Stadium. There is also a risk of fluvial flooding from Alltan Tartach, which mainly affects the Mossfield Stadium. The shinty pitch and adjacent car park were inundated during the October 2018 flood event due to a hole in the flood wall along the Alltan Tartach, as well as surcharging from a manhole in the car park. Videos of these flood mechanisms are provided in *Volume 4: Maps, Media and Data Sources.*	The fact that there is flooding in the publically owned Mossfield Stadium can be considered an opportunity. The land use here is classed as "water compatible". Temporary floodwater storage within this area could have significant potential to reduce flood risk to a large number of properties downstream.
Lon Mor & Glenshellach	There are a large number of "highly vulnerable" uses in this area, including the Lorne and Islands Hospital and residential dwellings. One residential property has been left isolated by previous flood events and various outbuildings and assets have been damaged.	There has been flooding in this area reported by the community and Council. The surface water model indicates there is a high risk of pluvial flooding in Lon Mor and in Glenshellach. Much of the flooding is contained within roads, but some properties are at risk of surface water flooding. Extensive flooding over the Lon Mor wetland from the Glenshellach Burn occurs on a frequent basis (<1 in 2 years); an effect enhanced by the bund and railway embankment.	Glenshellach is at risk of pluvial flooding. Lon Mor is a significant natural flood storage area, which could be enhanced to increase local floodwater storage and therefore reduce flood risk to many downstream receptors.
Soroba Road	There are a significant number of "most vulnerable" uses in this area, including sheltered housing units, a health centre and a service station. There are also social services facilities, an electricity substation, and multiple dwellings within this area.	The surface water model shows there is a high probability of pluvial flooding. The drainage network lacks capacity and it is understood that siltation is an ongoing issue here, together with potential fracturing of pipes. There is also a risk of overland flooding from the steep roads nearby, which may be significantly exacerbated if high river flows in the Alltan Tartach cause the culvert inlet headwall on Miller Road to overtop, which fluvial modelling predicts will occur for events of 1 in 5 year return period and above.	Soroba Road is at a high risk of combined pluvial and fluvial flooding, which may affect some of the most vulnerable users in the area. Soroba Road is a major transport route and flooding here can isolate members of the community and prevent access to workplaces and important services.

7.5 Climate Change Impacts

The probability of flooding within Oban is likely to increase due to the effects of climate change. Climate change is likely to increase the frequency and intensity of rain falling over the catchment, the flow within the watercourses and the sea level in Oban Bay.

The report entitled 'Climate change allowances for flood risk assessment in land use planning' (SEPA, 2019) provides guidance on how to incorporate the potential impacts on rainfall, sea level and river flow in flood assessments. **Error! Reference source not found.Error! Reference source not found.** presents the required allowances for the 2100 scenario.

Table 7.5 Climate Change Allowances for Rainfall, Sea Level and River Flow in Oban for the 2100 Scenario

Climate Factor	Increase	1 in 200 year Peak	1 in 200 year + Climate Change Peak
Rainfall	55%	10.2 mm/hour	15.8 mm/hour
River Flows (Black Lynn)*	56%	26.0 m^3/s	40.6 m^3/s
Sea Level (Oban Bay)	0.8m	3.87 mAOD	4.67 mAOD

**Based on 9 hour duration design event derived by ReFH2, as detailed in Report 2A: Hydrological Analysis*

Climate change is predicted to affect all parts of the catchment, but most notably Lochavullin, which will be affected by compounding increases in all three flood sources interacting in this low-lying area. By the year 2100, it is predicted that 1 in 200 year flood levels here will be over 0.5m higher than they are for current climate conditions.

7.6 Economic Impacts of Flooding

Report 3B: Options Appraisal – Economic Appraisal estimates fluvial flood damages associated with the Black Lynn and its key tributaries, including tidal influence, to be **£17.9 million** over the next 100 years in present value terms, comprising:

£3.3 million direct residential property flood damage;
£11.9 million direct non-residential property flood damage;
£356k indirect damage to non-residential properties;
£851k emergency services response costs;
£715k evacuation and relocation costs due to flooding; and
£787k vehicle damage.

Without investment in flood management, average annual damages (AAD) due to fluvial-tidal flooding are predicted to increase from £205,000 per year for current conditions to £704,000 per year by 2050 and £1.87 million per year by 2100.

Similarly, without investment, present value damages associated with coastal flooding in Oban (excluding tidal flooding via the river, which is included in the fluvial total above) are estimated at **£10.35 million** over the next 100 years, with average annual damages increasing from £53,000 per year for current conditions to £197,000 per year by 2050 and £1.87 million per year by 2100.

Flood damages associated with surface water flooding are estimated to be approximately **£3.0 million** over the next 100 years, accounting for approximately 10% of the total flood damages in Oban.

Table 7.6 puts these values into the context of the number of properties potentially affected by flooding over the next 100 years. 143 properties are currently at risk of inundation from a 1 in 200 year fluvial flood, which is

predicted to rise to 298 by the year 2100 assuming no investment in flood management over that period. For the 1 in 200 year coastal flood, 36 properties have been identified to be at risk currently, rising to 133 by 2100. 22 properties are identified to be at risk of surface water flooding under current climate, and although it is understood that this number will rise in line with climate change, the assessment methodology used by Scottish Water's Section 16 drainage model does not enable a calculation of the 2100 equivalent.

Table 7.6 Comparison of Predicted Property Numbers Affected by Flooding Between Current Day and 2100

Property Type	Fluvial Flooding				Coastal Flooding				Surface Water Flooding			
	1 in 5 year flood		1 in 200 year flood		1 in 5 year flood		1 in 200 year flood		1 in 5 year flood		1 in 200 year flood	
	2020	2100	2020	2100	2020	2100	2020	2100	2020	2100*	2020	2100*
Residential	0	32	103	189	0	7	5	19	1	-	13	-
Non-Residential	6	28	40	109	0	36	31	114	0	-	9	-

*2100 climate change surface water flooding estimates were not estimated by Scottish Water's model

8. FLOOD RISK MANAGEMENT

8.1 Strategy

A flood risk management strategy has been produced for Oban, to provide a framework for reducing flood risk and improving the resilience of the community to current and future flood risk (Figure 8.1). This framework has been used to guide the study and support identification of appropriate flood management measures, both structural and non-structural, and with a focus on both the short and long term. These measures are grouped according to the three guiding principles introduced in section 4.1 (Community Safety, Community Awareness and Sustainability).

8.2 Prioritisation

Analysis has confirmed that no single measure will be capable of reducing multi-source flood risk in Oban to acceptable levels. Instead, a combination of cost-effective actions are required, together with strategic phasing. The available funding for flood management needs to be appropriately allocated to provide the community the best value for money, using a combination of robust engineering augmented by sustainable actions and resilience measures.

Full accounts of the options identification and appraisal process are provided in Volume 3. Table 8.1 presents an overview of the prioritisation factors applied in the development of the flood management strategy.

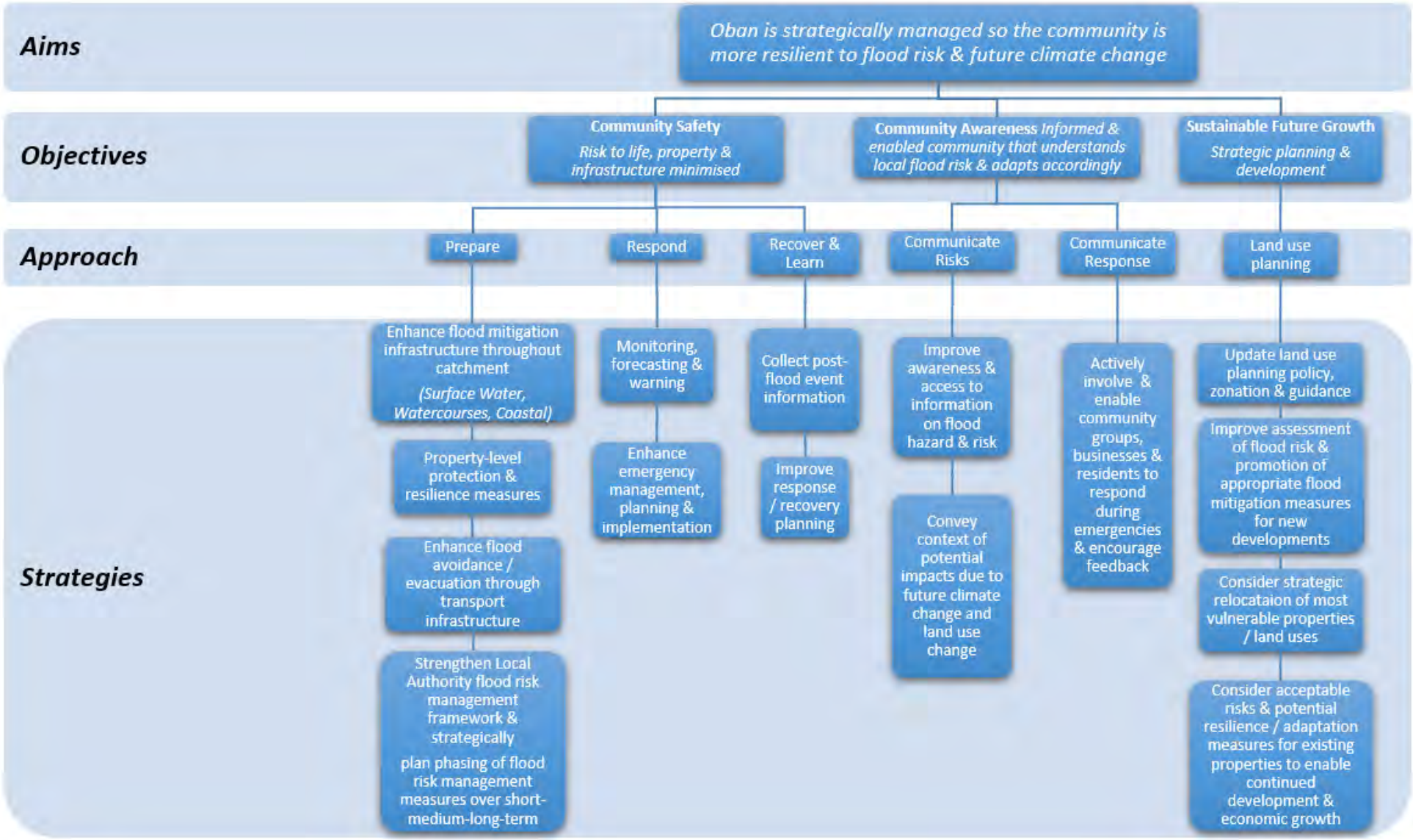


Figure 8.1 Oban Flood Risk Management Strategy

Table 8.1 Key Considerations in the Prioritisation of Flood Management Measures

Priorities	Description
High Impact	Highest impact solutions reduce flood risk where it is most urgently required: for the most vulnerable individuals and essential services. Actions which can protect a high number of properties or high value properties are also considered; e.g. upstream options which benefit a large number of downstream users.
High Cost-Benefit Ratio	Traditional solutions typically require large capital investment from public sources. To justify this, the benefit of the solution should be greater than its cost over its lifetime. This is detailed in *Report 3B: Options Appraisal (Economic Appraisal)*.
Strategic Combinations	In certain combinations, solutions can reduce flooding damages to a larger extent than the sum of their individual parts. The converse is also true; that some flood management options may partially counter-act the benefits of others if pursued in combination. Through strategic testing of options variations and combinations, the benefits of proposed measures can be optimised.
Sustainability	Measures which can restore (or mimic) natural processes to store, attenuate, convey or discharge flow are prioritised, particularly those which have minimal maintenance requirements. These options will provide a buffer against future climate change impacts. Examples include natural flood management, upstream flood storage areas, Sustainable Drainage Systems (SuDS) and removal of artificial hydraulic constrictions.
Multiple Benefits	Some flood management solutions potentially have multiple benefits beyond reducing flood damages; they may also provide environmental benefits through creation of new habitats or water quality improvements, for example, and/or social benefits such as improved amenity value and educational benefits. Multiple benefits should be explored and developed in consultation with the community. For instance, it may be possible to achieve multi-functional flood management zones by integrating public access and habitat features in design.
No Land Use Conflicts	Solutions need to fit into the exiting environment and be achievable without creating potential controversy or conflict. Those which make the most of available opportunities on publically-owned land without significantly impacting public utility are prioritised, while solutions which would require land purchase of third-party owned land or would result in the loss of current use for a given area of publically-owned land are considered less favourable.

Flooding in recent years has highlighted that there is an urgent need to control flooding at key flooding hotspots in the town. Core actions or combinations of actions are required to target flood management efforts where it is most needed, and in the most cost-effective manner. Such core options should be prioritised for short-term implementation.

For management of fluvial flooding, the most sustainable and cost-effective approach is to prioritise storage and attenuation of floodwater at source (upstream) or else in “sacrificial” locations where the consequence of flooding is very low, such as parks and greenspace. Source control and upper catchment attenuation measures effectively slow the catchment flood response, resulting in delayed and reduced flow peaks; these measures may also reduce the overall volume of “quick flow” into the lower catchment, where they result in long-term storage, infiltration or enhanced evapotranspiration. These measures reduce the scale of interventions required further downstream. Resolving existing in-channel bottlenecks at culverts, bridges and other in-line structures may also offer flood reduction benefits. Next, efficient routing or conveyance of floodwaters through flood risk areas is prioritised to minimise the accumulation of water and associated damage and disruption. When it is no longer possible to ‘store or move’ flood water, the final measure is engineered flood

defence; these are considered the least sustainable of the measures available, although sustainability can be improved through the inclusion of adaptation and resilience measures.

Options for managing coastal flood risk are, by comparison, more limited since there is less scope for altering the water level and wave height and energy impacting on the shoreline. There are offshore wave-reduction solutions such as tidal barrages and reefs, although by and large coastal flood management involves conventional engineered flood defence structures, such as flood embankments, floodwalls and floodgates.

The most sustainable method for managing surface water flood risk is through provision of Sustainable Drainage System (SuDS) measures, which may include source control measures (such as rain gardens, infiltration/filter trenches, permeable paving, etc.) conveyance measures (e.g. swales) and local and regional storage and attenuation measures (e.g. SuDS ponds, basins and wetlands). As well as achieving attenuation, if retrofitted in areas which currently discharge into conventional sewers, they reduce sewer loading and therefore the impact of existing sewer capacity constraints upon flooding.

SuDS measures also provide multiple secondary benefits, including reducing wastewater treatment requirements and the frequency and volume of combined sewer overflow at river outfalls (thereby improving water quality), habitat creation and amenity benefits. Where SuDS measures are unable to achieve acceptable reductions in flood risk, conventional engineered solutions may be considered. These may include passive measures, such as pipe upsizing, rebranching of the sewer network, and buried storage options, as well as active measures, such as pump provision (or increasing the capacity of existing pumps).

In any flood management scheme, there will always be an element of residual risk, which must be given due consideration in the detailed design of management measures and be communicated effectively to the community.

In parallel to this, there also needs to have a long-term focus, as climate change predictions indicate that there will be an increasing need to build up community resilience and adaptation over the longer-term. This concept, which is complementary with the adaptive management concept in section 4.2, is illustrated in Figure 8.2.

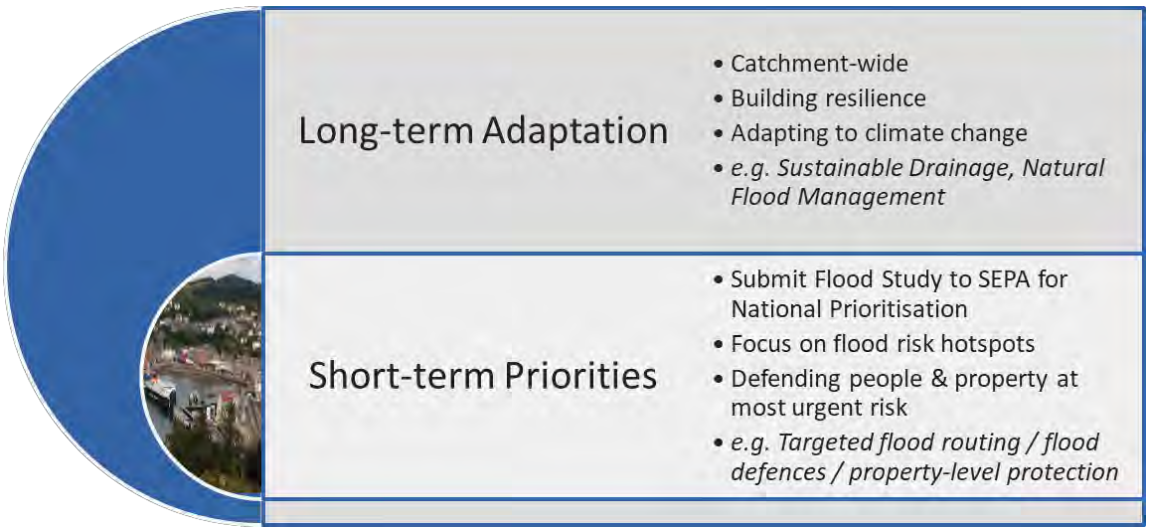


Figure 8.2 Strategic Phasing Concept

8.3 Short-term Priorities

8.3.1 Recommended Flood Scheme Measures

The main priority of the flood study is to support an application for prioritisation and part government funding of an economically viable flood scheme. Economic appraisal indicates that the most appropriate combination of measures involves structural solutions to store water upstream, conveying water away from vulnerable users and directly defending them against flooding. Recommended core measures are as follows:

Fluvial Measures (Combination 5E)

- Enhancing existing flood storage in the Lon Mor area, by raising of a flood bund and alteration to the existing culvert arrangement, to attenuate flows from the Glenshellach Burn, and thereby reduce flood risk in the downstream Soroba Burn and Black Lynn.
- Lowering a section of existing wall and raising a flood bund to preferentially flood the Mossfield Stadium area, thereby reducing flood risk downstream in the Alltan Tartach and Black Lynn, including reducing the risk of overtopping of the Miller Road culvert inlet.
- Dualling the Miller Road culvert, to substantially reduce the risk of overtopping of the inlet of this culvert (only in combination with other options which address the risk this option creates of increasing flood risk elsewhere).
- Widening of the Market Street bridge and adjacent river section, in order to reduce the existing hydraulic bottleneck at this location, which is worsening flood risk in the Lochavullin area.
- Raising new defence walls and embankments in the Black Lynn, particularly in the Lochavullin area, to achieve a minimum bank level in the Black Lynn of 4.0 mAOD (only in combination with other options which address the risk this option creates of increasing flood risk elsewhere).

Coastal Measures

Targeted Coastal Property Level Protection (PLP) for properties identified at being at risk during flood events with a 1 in 50 year return period or lower. The recommended combination of fluvial options is found to be capable of reducing property-related fluvial flood damages over the next 100 years by up to 78% and achieving property-related flood damage reduction benefits of £13.8 million. At a whole life cost of £8.2 million (with capital cost element of £7.6 million), this would achieve an overall BCR of 1.68.

Other benefits, including reduction in traffic-related damages (i.e. road closure and traffic diversion and delays due to flooding), reduction in loss of productivity (i.e. loss of access to workplaces due to road flooding), and reductions in the risk of injury and death due to flooding, may provide up to £9.6 million of additional benefit and improve the BCR of the preferred option to 2.84, although there are higher uncertainties associated with monetising of these benefits.

Within the area benefitting from the proposed fluvial elements of the scheme, options combination 5E is predicted to increase the minimum standard of flood protection (SoP) for residential properties from 1 in 5 years (currently) to 1 in 50 years for existing climate conditions, with the equivalent minimum SoP for non-residential properties improved from less than 1 in 2 years to 1 in 100 years.

Targeted coastal PLP is predicted to reduce damages by £809,000, at a cost of £407,000 over a 25 year economic appraisal period, resulting in a cost-effective BCR of 1.99. The potential funding mechanisms for capital and maintenance costs for this measure are under consideration by the Council at the time of writing. It is likely that property owners will have maintenance responsibilities.

As well as the measures central to the formal flood scheme, a wide range of other measures which could be adopted by the Council, the local community and other stakeholders are recommended over the short-term.

8.3.2 Maintenance

The Council have a duty to monitor and assess watercourses and to carry out clearance and repair works which would substantially reduce flood risk, and to produce maintenance schedules. Scottish Government guidance entitled 'Clearance and Repair to Reduce Flood Risk: Local Authority Guidance' (Scottish Government, 2017) was produced in response to the 2009 Flood Risk Management (Scotland) Act.

The Oban Flood Study highlights the following specific priority maintenance actions:

Restore full functioning of Lochavullin car park pumping system and pipe network;
Vegetation management along Black Lynn (particularly in middle and upper reaches), including a robust programme of Japanese Knotweed eradication;
Inspect for potential flood by-pass routes associated with temporary flood defences on right bank upstream of Lynn Road and resolve if required; together with routine checks and maintenance);
Removal of excess fine sediments in the Black Lynn at Lochavullin, particularly around piped outfalls;
Road gully clearance e.g. Soroba Road, Miller Road, Millpark Road;
Routine and responsive clearance of Miller Road culvert trash screens;
Routine and responsive clearance of 5-Way Junction trash screens; and
Repairs to Alltan Tartach flood wall at Mossfield.

Scottish Water have a duty to inspect and repair the public sewer network to maintain functionality, and priority areas for maintenance and routine upgrades are highlighted in the SWMP. Where interactions occur with Council-maintained assets, partnership working will be essential. Most notably, this is the case in Lochavullin, which is subject to interactions between surface water and fluvial sources. *Report 2C: Surface Water Management Plan* lists further specific drainage maintenance and upgrade actions.

Commercial or Private riparian landowners are responsible for the maintenance and management of their own assets including those which have an impact on flood risk. Debris blockages can significantly increase flood risk in an unpredictable way, and so landowner actions should include routine maintenance of crossing structures, bankside trees and avoidance of storage of loose materials beside the watercourse.

8.3.3 Monitoring

Hand in hand with maintenance is monitoring. Monitoring of flood management measures will identify what measures are working and might be replicated elsewhere, and will help to target areas for improvement.

In April 2019 the Council established a water level gauging station to monitor water levels in the Black Lynn. This will provide information on the rainfall-runoff response, and forms a useful 'pre-scheme' baseline dataset against which comparisons can be drawn in future.

Conversations with stakeholders and the community need to continue into the future, with this feedback cycle ensuring ongoing improvements and sustainability.

8.3.4 Community Resilience

8.3.4.1 Safety Signage

As shown by the images in Table 6.1, there have been numerous instances where the community has been impacted by flooding without sufficient warning. Safety signage is recommended, particularly in the vicinity of the Lochavullin car park and along the coastal front (alerting to the risk of wave overtopping in the latter case).

8.3.4.2 Flood Forecasting and Alerts

SEPA monitor weather conditions and river levels at a national level, and work with the Met Office to co-ordinate 'Floodline' flood warnings at regional level. Oban is identified as a coastal flood warning area which is part of the Firth of Lorn and Loch Linnhe coastal flood warning scheme currently operated by SEPA. Stakeholders should all be encouraged to sign up to this scheme to enable preparedness.

The Black Lynn water level gauging station can be used to alert the Council to rising water levels. Combined, these systems will enable the Council to respond pro-actively and trigger emergency responses.

8.3.4.3 Emergency Planning

In conjunction with monitoring and forecasting is emergency planning. Providing an emergency response to flooding is the responsibility of many organisations, including the Council, the emergency services and SEPA. Effective management of an emergency response relies on emergency plans that are prepared under the Civil Contingencies Act 2004. The emergency response by these organisations is co-ordinated through regional and local resilience partnerships.

Opportunities to gain additional emergency response support form voluntary organisations and individuals should also be sought. This should be explored with groups such as the Scottish Flood Forum, Oban Community Council, Oban Mountain Rescue Team, BID4Oban, and other community groups.

Emergency response planning should also be encouraged at individual property level, particularly where there is known flood risk. This could include preparing a flood plan and flood kit, keeping valuables in an elevated location, installing property level protection, signing up to SEPA Floodline and Resilient Communities initiatives (e.g. https://www.readyscotland.org/get-involved/local-plans-and-good-practice/argyll-and-bute-council-community-emergency-plan-handbook/) and ensuring that properties and businesses are insured against flood damage.

8.3.4.4 Property Level Protection

PLP options may be considered the most cost effective means to defend a property from flooding; however, this option is not as reliable as other options due to the risks associated with the reliance on residents being aware of the problem in advance and being capable of installing the PLP in good time. This is particularly a problem where there is no flood warning. The reliability of PLP is particularly reduced where residents are isolated, vulnerable or absent. There is also a risk of overtopping of defences or bypassing via unforeseen mechanisms (e.g. though vents or upwelling from below ground).

Nevertheless, PLP is recommended as an important means improve the resilience of the community to flooding. It is a means to manage risks outwith the areas benefitting directly from the main flood scheme or to address residual flood risk; in effect supplementing the main flood scheme.

Reliability of PLP can be improved through expert property surveys and specifications, use of automated flood barriers, awareness, emergency planning, and community action (e.g. local warning communications and concerted efforts to support more vulnerable or absent neighbours).

PLP technologies are undergoing constant improvements and organisations such as the Scottish Flood Forum can help to provide relevant advice and information to the community as and when appropriate.

8.3.4.5 Public awareness

Improved knowledge of local flood risk and awareness of potential dangers and mitigation measures is a crucial means to reduce damages, distress and disruption caused by flooding. Social media, local community groups and educational establishments offer potential avenues to improve awareness and to engage the public more actively.

Strengthening of the benefits associated with flood management, for instance, making the most of opportunities to improve the access, amenity, habitat and aesthetic value of the river, would help to promote community engagement and custodianship of the river.

8.4 Long-Term Adaptation Measures

Over and above the short-term priority actions, there is a need to maintain a long-term focus and to foster adaptation in light of our changing climate.

8.4.1 Strategic Land Use Planning

Local Development Planning should give due attention to the findings of the flood study and use this to guide future development strategies and policies. Modelled flood maps and levels would also provide a useful resource to support planning decisions.

Lochavullin and other town centre areas are more appropriate for non-residential purposes, and so commercial or water-compatible developments should be favoured here going forward. Staged retreat or individual property relocation from the worst-affected flood risk areas should also be considered, particularly for the most vulnerable uses, such as sheltered housing and medical facilities.

Opportunities to open out river channels and form riparian buffer zones or multi-functional floodplain storage areas should be sought. Opportunities to create alternative car parking facilities (e.g. park and ride or multi-storey car parks) would reduce flood risk pressures in the Lochavullin area.

The prospective Oban Development Road also presents a potential future opportunity to manage surface water runoff sustainably and to provide a safe alternative route when other roads are flooded.

More generally, development or redevelopment in the Oban area should be seen as an opportunity to achieve "step by step" improvement in flood risk management through existing legal requirements for all new developments to implement sustainable drainage (i.e. SuDS) maintain appropriate "no-build" riparian buffers and ensure finished floor levels achieve freeboard protection above the design flood event. For most developments in Scotland, the design flood event is the 1 in 200 year event, inclusive of appropriate climate change uplift. Scottish Planning Policy (Scottish Government, 2014) and SEPAs Development Plan Guidance Note 2a (SEPA, 2018) provide clear guidance on appropriate planning requirements.

8.4.2 Community Adaptation

Similarly, residents, business owners and service providers need to fully engage with flood risk and plan strategically to help counteract the negative effects of climate change.

Long-term asset and business planning is to be encouraged with a view to avoiding and protecting against flooding. Simple measures individuals or businesses can undertake include de-paving (i.e. returning unnecessary paved surfaces to green surfaces), rainwater harvesting and carrying out routine maintenance and improvements to any drainage or channel features under their responsibility. Ongoing property improvements should consider flood risk, and incorporate secondary flood mitigation features where appropriate (e.g. raised electrical networks, concrete floors).

Effective communication and education will be an important means to convey this message. Local schools have potential to deliver this message through the upcoming generation.

A community-focussed, co-operative approach would ensure that the most vulnerable people get the support they need from the neighbouring community. This could be effectively co-ordinated through existing community groups or through new groups with a specific focus on flooding.

8.4.3 Natural Flood Management

Natural flood management (NFM) aims to work with natural hydrological and morphological processes, features and characteristics to manage sources and pathways of flood waters. For Oban, blanket woodland planting, riparian woodland planting and wetland restoration have been highlighted amongst potentially appropriate measures (*Report 2E: Natural Flood Management*). Whilst it can take a number of years to reach full effectiveness and the potential risk reduction is difficult to quantify, NFM is widely understood to bring about multiple benefits, and can be considered a 'no regrets' option. It offers a means to adapt in line with climate change, including carbon sequestration.

NFM is recommended to be implemented as part of a longer term strategy, rather than as part of the proposed flood scheme. A number of alternative funding sources have been highlighted in *Report 2E: Natural Flood Management*, including agri-environment schemes and woodland grants. Again, a collaborative approach across multiple landowners is recommended to ensure optimal implementation.

9. NEXT STEPS

9.1 Forward Strategy

The first priority of the flood study is to support an application for prioritisation and subsequent Scottish Government funding support for a flood scheme. If the application for prioritisation in December 2019 is successful and funding is granted, it is possible that implementation could commence in Cycle 2 (2022-2028).

The aims, design, standard of protection and limitations must be communicated effectively to the community to ensure expectations are realistic and to inform long-term planning.

A collaborative approach is required from Responsible Authorities, the community and other stakeholders. This may be supported by the establishment of flooding-specific community forums and action groups, with representation from local business groups and other stakeholder organisations.

9.2 Future Design Refinement

In the event that the proposed flood scheme elements resulting from this study are taken forward, there would be a need for further refinements in the underlying assessments and development of a detailed design. Conceptual design drawings, costings and factsheet information developed by this study would guide this process. Additional elements would likely include:

Landowner and stakeholder consultation;
Land purchase / legal agreements for use of land where not publically owned;
Targeted environmental assessments, e.g. habitats and protected species, geomorphology, archaeology, landscape and visual assessments and potentially Environmental Impact Assessment;
Targeted surveys, e.g. ground investigations, topographic, utilities surveys;
Engineering assessments e.g. geotechnical, structural, hydraulic;
Detailed design and costing; and
Planning and Controlled Activities Regulations applications (including consultation with SEPA regulatory function for the latter).

9.3 Potential Additional Funding Sources

Aside from national and local government funding, other potential sources of support include:

Scottish Water;
Private and commercial contributions;
Charitable groups;
Local community trusts;
Agri-Environment Climate Scheme;
Forestry Grant Scheme;
LEADER initiative (operated by the Scottish Rural Network, grants are awarded by Local Action Groups to projects that support the delivery of a Local Development Strategy);
Carbon capture funds;
Local fishery groups / River Trusts; and
National Lottery Heritage Fund.

9.4 Possible Future Opportunities

Several measures which were not deemed to be viable at the time of writing should be re-explored as and when opportunities arise. These include:

Pro-active reservoir operation at Loch Gleann a Bhearraidh (e.g. forecasting and active drawdown);
Potential alteration to Scottish Water's disused Polvinster Loch to re-enable flood storage;
In Glencruitten, substantial opportunities exist over the golf course to implement NFM, particularly channel and floodplain restoration. At this point, it is understood that these actions are not compatible with current recreational use, although there may be intermediate solutions or longer-term solutions that can be explored in the future;
The business case for improved coastal defences will start to become more compelling with climate change. If current defences deteriorate requiring significant cost to repair, the economic case for upgrading will improve further;
Opportunities to alter or improve existing structures (such as existing defence walls and embankments, culverts, etc.) should be considered as these assets approach the end of their operational life or when significant "capital maintenance" to maintain their functionality is needed;
Opportunities to relocate vulnerable properties out of flood risk areas should be sought;
Within the urban area, opportunities to open out channels, restoring riparian and/or floodplain areas would go a long way to managing flood risk, and would be likely to bring multiple benefits e.g. habitat, aesthetic, amenity and water quality improvements.
Argyll and Bute Council's forthcoming Local Development Plan 2 (LDP2) is due for adoption in 2020 and presents an opportunity to incorporate sustainable long-term planning strategies that would help to avoid and mitigate against future flood risk.

10. CONCLUSIONS

In response to significant flooding events over recent years, and in light of predictions of exacerbated flood risk due to climate change, Argyll and Bute Council commissioned a flood study for Oban. Stakeholder engagement and technical assessments have been used to understand the complex flooding dynamics of the Black Lynn, Oban Bay and in the surface water drainage network. Flood risk has been quantified through modelling and scenario testing. The most significant flood risks are centred around the low-lying Lochavulllin area, a former tidal loch which has been drained and developed as a commercial centre.

Options identification and appraisal, including economic assessment, has resulted in a suite of flood management measures which have been conceptually designed and costed, which are recommended to form the basis of a potential flood scheme for Oban.

The fluvial measures recommended include a combination of upstream storage, flood routing, relief of hydraulic bottlenecks and traditional flood defences. The proposed suite of fluvial measures has the potential to reduce property-related fluvial flood damages by 77%, or £13.8 million over the next 100 years, at a whole life cost of £8.2 million. With a benefit-cost ratio in excess of 1.6, it is anticipated that this will be sufficient to justify 80% government funding for the proposed scheme. Beyond property-related damages, the recommended fluvial measures could potentially provide up to £9.6 million of additional benefits associated with traffic, business and health impacts, resulting in a potential benefit-cost ratio in excess of 2.8.

Engineered coastal defences along the shoreline have not been found to be economically viable at this point in time, but this should be reviewed as climate change progresses over coming decades. Over the short-term, targeted coastal Property Level Protection is recommended. Economic appraisal of this measure indicates that over a 25 year period, coastal flood damages could be reduced by £809,000, at a cost of £407,000; with a cost-effective benefit-cost ratio of 1.99.

To complement the flood scheme over the longer-term, a range of strategic and sustainable improvements to surface water drainage network are recommended through a stand-alone Surface Water Management Plan intended to be implemented by Argyll and Bute Council, in partnership with Scottish Water.

The proposed flood scheme is nested within a wider flood management strategy which has been recommended, combining structural and non-structural options, with a focus on adaptive management over both short and long terms. Sustainability, community resilience and adaptation are key themes to be taken forward for future flood management for Oban.

REFERENCES

Agryll, & Bute District Council (1978). *Lochavullin Feasibility Study: Oban Lorn Local Plan*. Argyll and Bute District Council Department of Physical Planning Kilmory, Lochgilphead Argyll, PA318RT: Agryll and Bute District Council.

Argyll, & Bute Council (1999). *Report on The Flood Prevention Black Lynn, Lochavullin, Oban*. Design Services Kilbowie House Oban: Argyll and Bute Council.

Argyll, & Bute District Council (1978). *Lochavullin Feasibility Study: Oban Lorn Local Plan Factual Site Investigation Data*. Argyll and Bute District Council, Department of Physical Planning Kilmory, Lochgilphead Argyll, PA318RT: Argyll and Bute District Council.

Argyll, & Bute District Council (1989). *Lorn Local Plan First Review and Alteration Public Local Inquiry*. Argyll and Bute District Council.

EnviroCentre Limited (2008). *Oban Drainage Study*. EnviroCentre, Craighall Business Park, Eagle Street, Glasgow, G4 9XA.

Environment Agency (2019). *Assessing the Potential Hazard of using Leaky Woody Structures for Natural Flood Management*. Environment Agency.

Fleming, G. (2001). *Learning to Live With Rivers*. Institute of Civil Engineers.

Forest Research (2018). *Valuing flood regulation services of existing forest cover to inform natural capital accounts*. Forestry Commission.

Met Office (2019, March). UKCP18 Science Overview Report. Met Office, EA, Department for Environment Food & Rural Affairs. Retrieved from https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf

MetOffice (2019, March). UKCP18 Science Overview Report. Met Office, EA, Department for Environment Food & Rural Affairs. Retrieved from https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf

Scottish Government (2014, June). Scotland's Environment. Scottish Government. Retrieved from https://www.environment.gov.scot/media/1185/climate-climate.pdf

Scottish Water (2017). *Tullich WTW ComCommission Flows; Assessment of Impact on Flood Risk and Channel Erosion*. St Vincent Plaza, 319 St Vicent Street, Glasgow G2 5LD United Kingdom: Scottish Water.

SEPA (2014, June). Scottish Planning Policy. The Scottish Government St Andrew's House Edinburgh EH1 3DG: The Scottish Government. Retrieved from https://www.gov.scot/publications/scottish-planning-policy/

SEPA (2018, September). Local Authority flood study checklist. SEPA. Retrieved from https://www.sepa.org.uk/media/375525/flood-study-checklist-for-las-3rd-version-final-2018-09-10.pdfArgyll, & Bute Council (2015). Argyll and Bute Local Development Plan Written Statement.

Scottish Government (2014). *Scottish Planning Policy*. Edinburgh: Scottish Government.

SEPA (2018). *Land Use Planning System: SEPA Development Plan Guidance Note 2a* (No. LUPS-DM-GU2a). SEPA. Retrieved from https://www.sepa.org.uk/media/306609/lups-dm-gu2a-development-management-guidance-on-flood-risk.pdf

SEPA (2019). *Land Use Planning System SEPA Guidance: Climate change allowances for flood risk assessment in land use planning* (No. 1). Retrieved from https://www.sepa.org.uk/media/426913/lups_cc1.pdf

APPENDICES

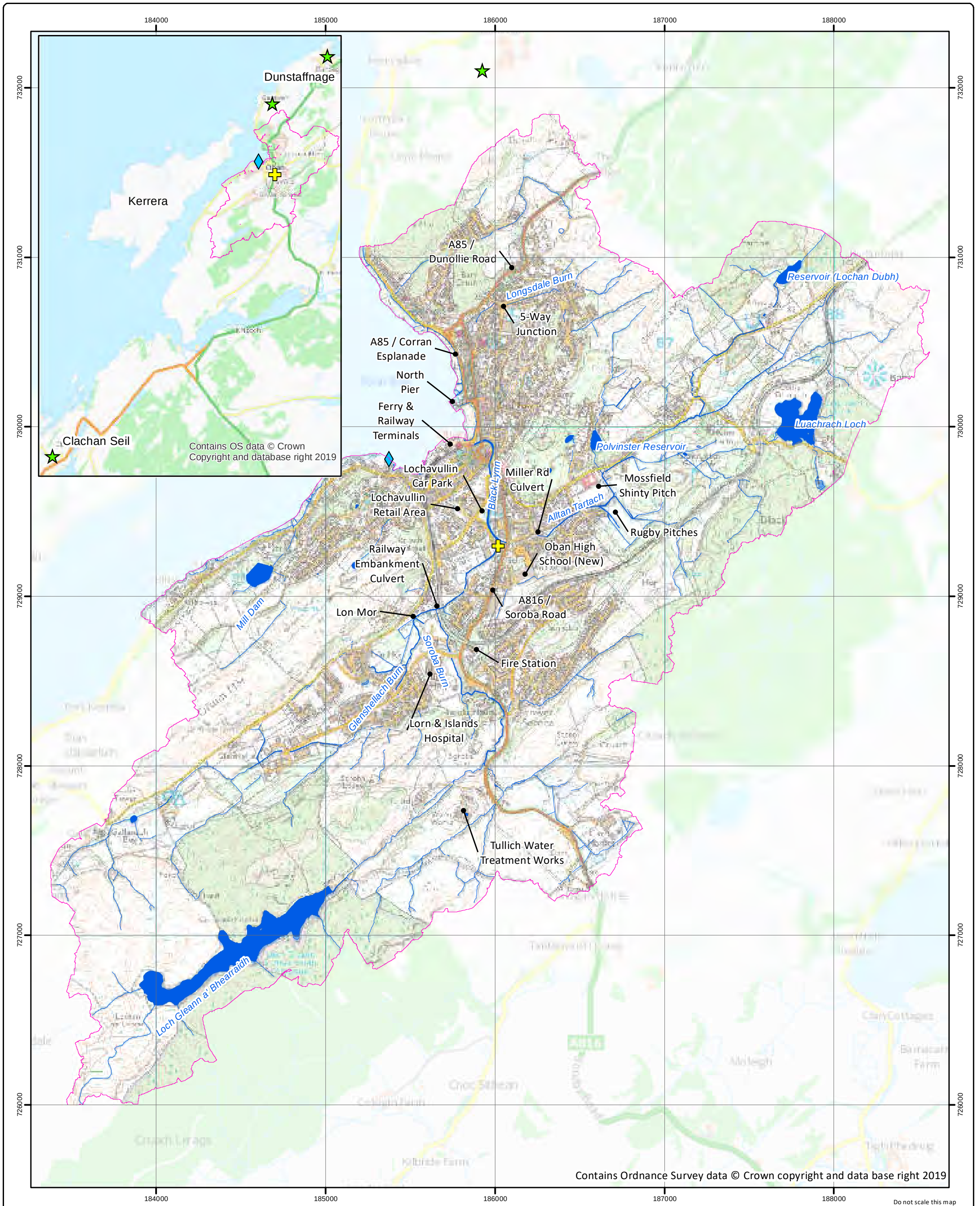
A LEGISLATIVE CONTEXT

Legislation	Relevance
Water Environment and Water Services (Scotland) Act, 2003 (WEWS Act)	Implementation of the Water Framework Directive (2000/60/EC) in Scotland. Established a new legal framework for the protection, improvement and sustainable use of water bodies and, while taking account of sustainability and social and economic impacts, aims to: o Prevent deterioration and enhance status of aquatic ecosystems, including groundwater; o Promote sustainable water use; o Reduce pollution; and o Contribute to the mitigation of floods and droughts. Places duties on a number of responsible authorities to undertake their statutory functions in a way that secures compliance with the WFD. SEPA are the competent authority responsible for coordinating the production of River Basin Management Plans (RBMP) in Scotland. Water bodies have been classified in terms of status, and environmental objectives set out by this process are to be achieved by 2015, although some commitments set out in the RBMP may extend to 2021 or 2027. Enacted through the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), or 'CAR'.
Flood Risk Management (Scotland) Act, 2009 (FRM Act)	Implementation of the EU Flood Directive (2007/60/EC) in Scotland. Creates a framework for the assessment and sustainable management of flooding. Linked to the Water Environment and Water Services (Scotland) Act (WEWS) through the statutory duty imposed by the Act to promote "Sustainable Flood Management". Holistic and catchment-scale approach to flood risk management. Places duty on SEPA to consider whether Natural Flood Management (NFM) techniques can contribute to management of flood risk. A risk-based approach to managing floods requires an assessment of where impacts are likely to be greatest in future. These areas are classified as Potentially Vulnerable Areas (PVA). This allows responsible public bodies to target efforts to maximise benefits to people, the economy and the environment. Within the Act, the consideration of NFM techniques within local Flood Risk Management (FRM) plans is to be managed in three phases as follows: o Section 20: Identification of Potential • Assess where alteration or restoration of natural features could contribute to flood risk management, and produce Section 20 maps (Responsibility: SEPA 2012). o Section 28: Appraisals and strategies • Consider Section 20 assessment when setting FRM objectives and strategies and produce list of preferred FRM measures (Responsibility: SEPA 2013-14). o Section 34: Local FRM Plans • Detail how implementation of the plan may alter, enhance or restore natural features and characteristics and produce Local FRM Plans (Responsibility: relevant Responsible Authority 2015-16).
Scottish Planning Policy (2014)	Sets out national priorities for the operation of the planning system and for the development and use of land. Supports a catchment-scale approach to sustainable flood risk management and aims to build the resilience of our cities and towns, encourage sustainable land management in rural areas, and to address the long-term vulnerability of parts of our coasts and islands. Avoid new development in areas with medium to high likelihood of flooding.

B CATCHMENT CHARACTERISATION MAPS

The following maps are provided within this appendix, as well as *Volume 4: Maps, Media and Data Sources*

Title	Drawing Reference
Study Area and Hydrometric Network	170506_054
Geology & Hydrogeology	170506_044
Soils	170506_099
Land cover	170506_098
Topography	170506_057
Slopes	170506_096
Historic	170506_047
Catchments & Overland Flow Paths	170506_018
Topographic Wetness Index	170506_097
Land use vulnerability classification	170506_100



Do not scale this map

Legend

- Study Area
- Rain Gauges
- Oban Bay Tidal Gauge
- Black Lynn River Level Gauge

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Study Area & Hydrometric Network

Status: FINAL

Drawing No.: 170506_054

Revision:

Scale: 1:20,000

A3

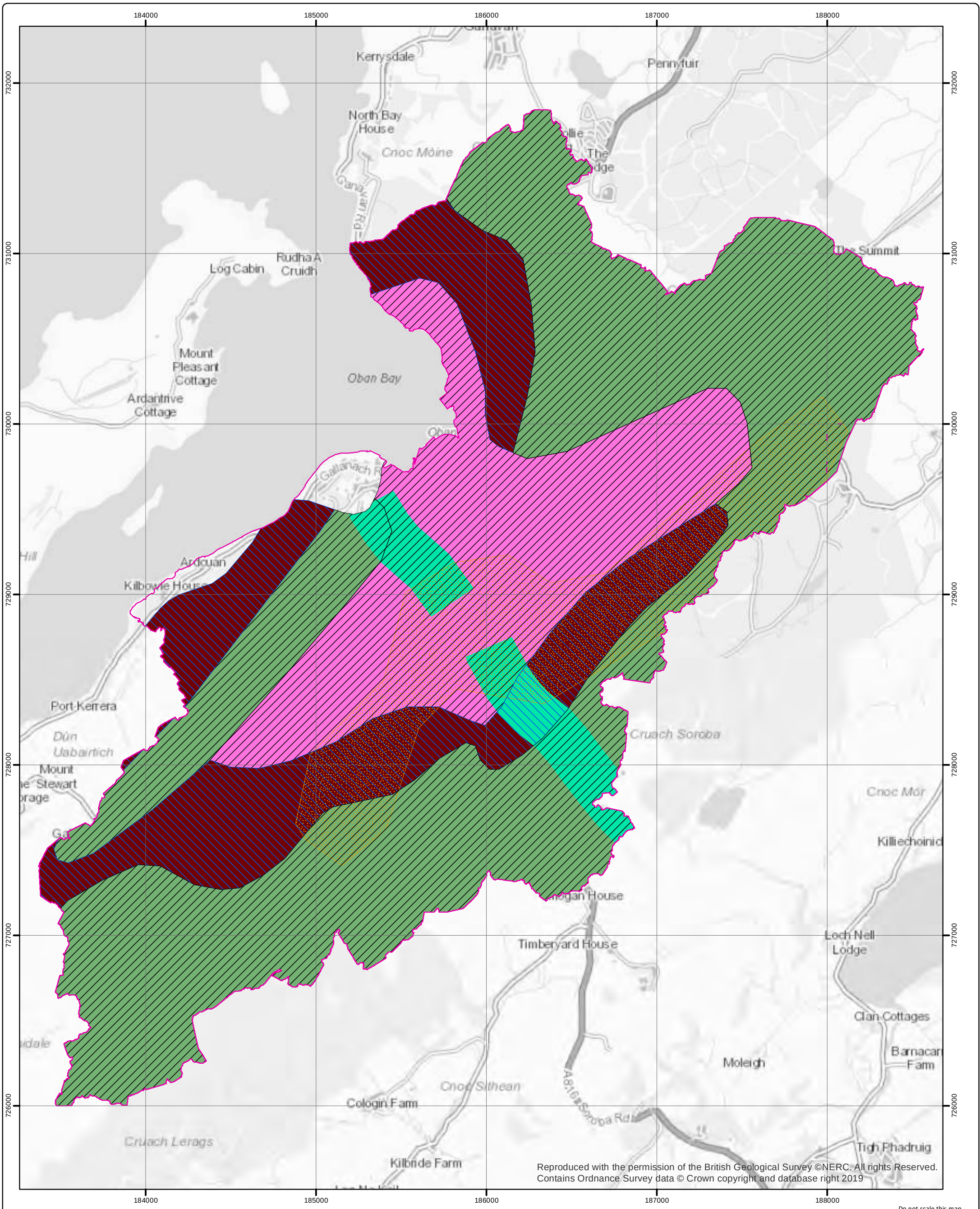
Date: 21 Oct 2019

Drawn: AL

Checked: EM

Approved: EM

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Do not scale this map

Legend

- Study Area

Aquifer Productivity

- Low Productivity Aquifer
- Moderately Productive Aquifer

Superficial Geology

- Sand and Gravel

Bedrock

- Lower Old Red Sandstone - Conglomerate, Sandstone, Siltstone and Mudstone
- Unnamed Extrusive Rocks, Silurian to Devonian - Mafic Lava and Mafic Tuff
- Argyll Group - Psammite, Semipelite and Pelite
- Unnamed Igneous Intrusion (Dyke) - Mafic Igneous Rock

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Geology & Hydrogeology

Status: FINAL

Drawing No.: 170506_044

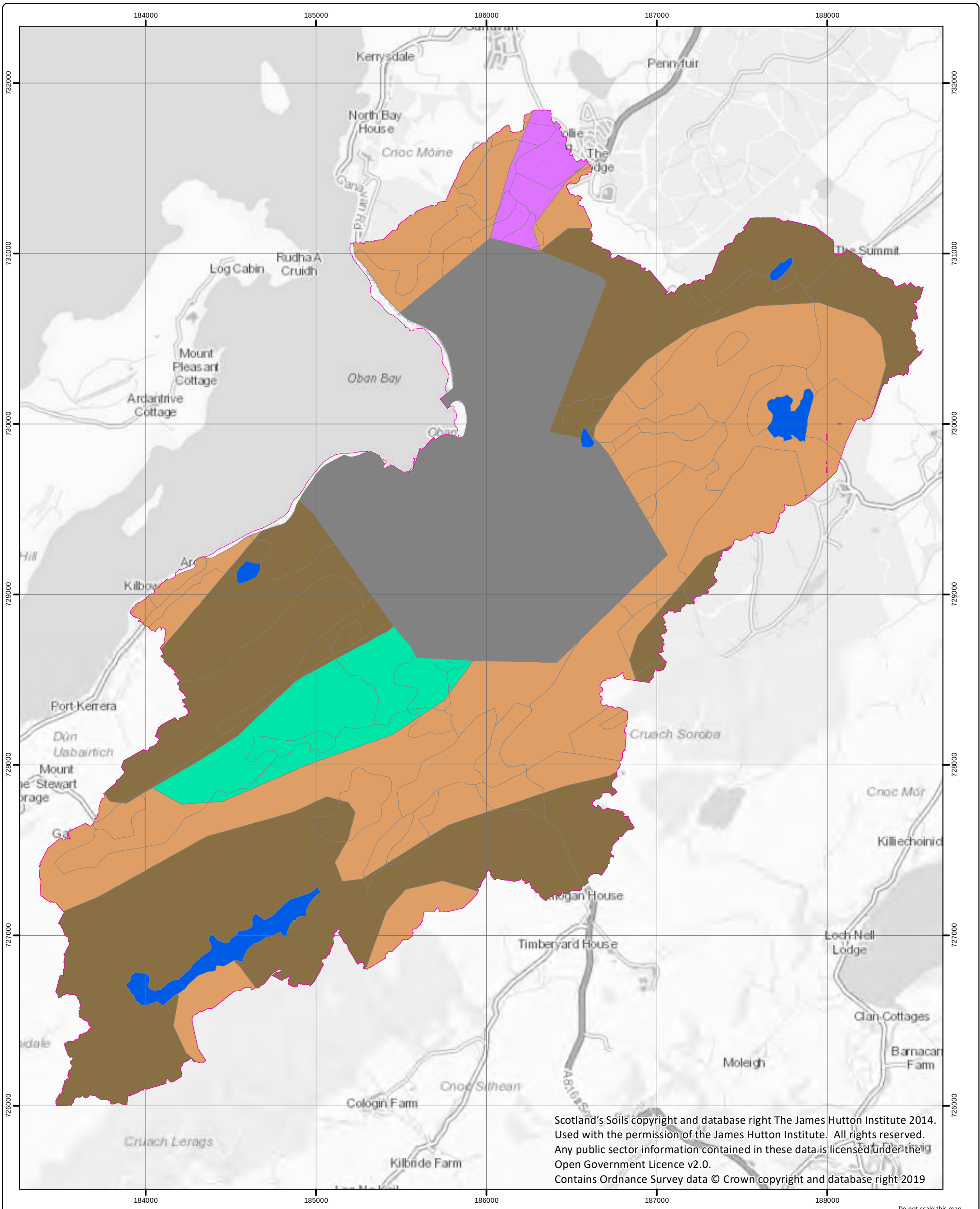
Revision:

Scale: 1:20,000 | A3

Date: 21 Oct 2019

Drawn: AL | Checked: EM | Approved: KMD

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Do not scale this map

Legend

- Study Area
- Urban
- Water
- Brown Earths
- Humus-iron Podzols with Peaty Gleys
- Noncalcareous Gleys with Humic Gleys
- Peaty Gleys with Dystrophic Blanket Peat with Peaty Gleyed Podzols

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Soils

Status: FINAL

Drawing No.: 170506_099

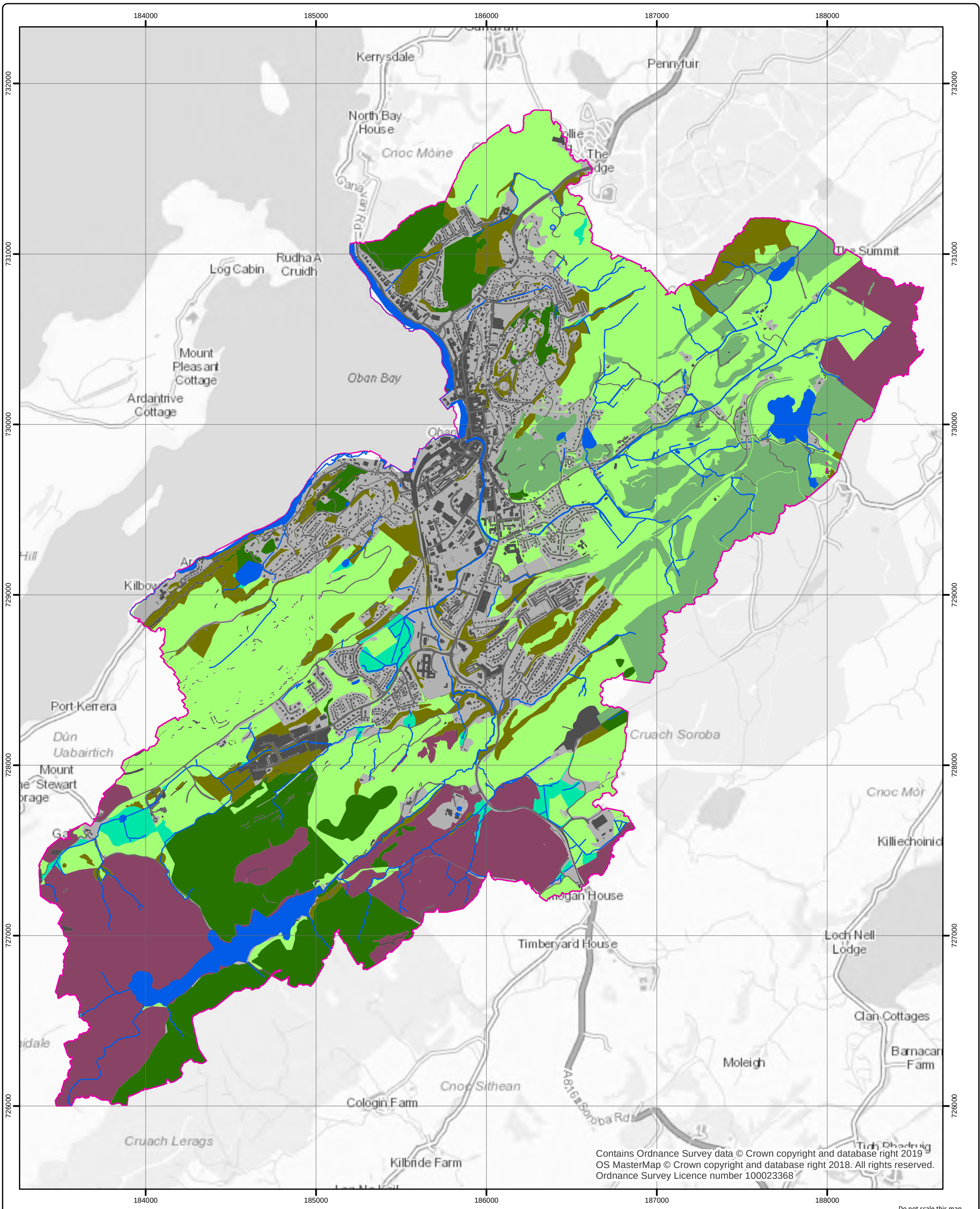
Revision:

Scale: 1:20,000 | A3

Date: 24 Oct 2019

Drawn: AL | Checked: EM | Approved: EM

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Do not scale this map

Legend

- Study Area
- Land Cover
- Grass / Scrub
- Heath
- Impermeable
- Mixed
- Wetland
- Woodland (Mixed)
- Woodland (Coniferous)
- Woodland (Non-coniferous)
- Water

Note: Land Cover is a composite dataset derived using Ordnance Survey MasterMap and ESRI Clarity aerial imagery

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Land Cover

Status: FINAL

Drawing No.: 170506_098

Revision:

Scale: 1:20,000

A3

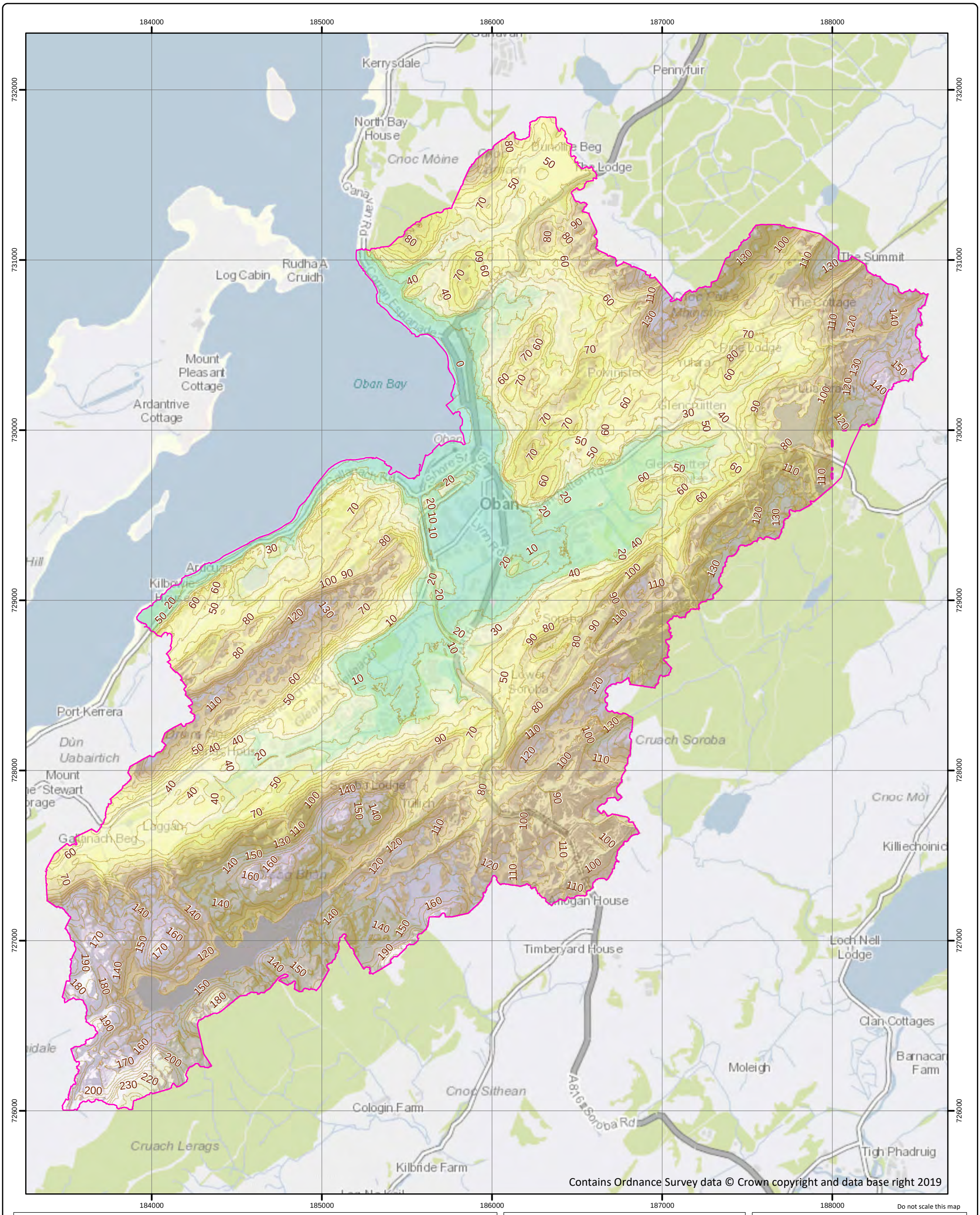
Date: 30 Oct 2019

Drawn: AL

Checked: EM

Approved: KMD

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Legend

Study Area

Elevation (mAOD)

Value

High : 245

Low : 0

Remotely sensed elevation data obtained using Light Detection and Radar (LiDAR) technology.

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: LiDAR Topography

Status: FINAL

Drawing No.: 170506_057

Revision:

Scale: 1:20,000

A3

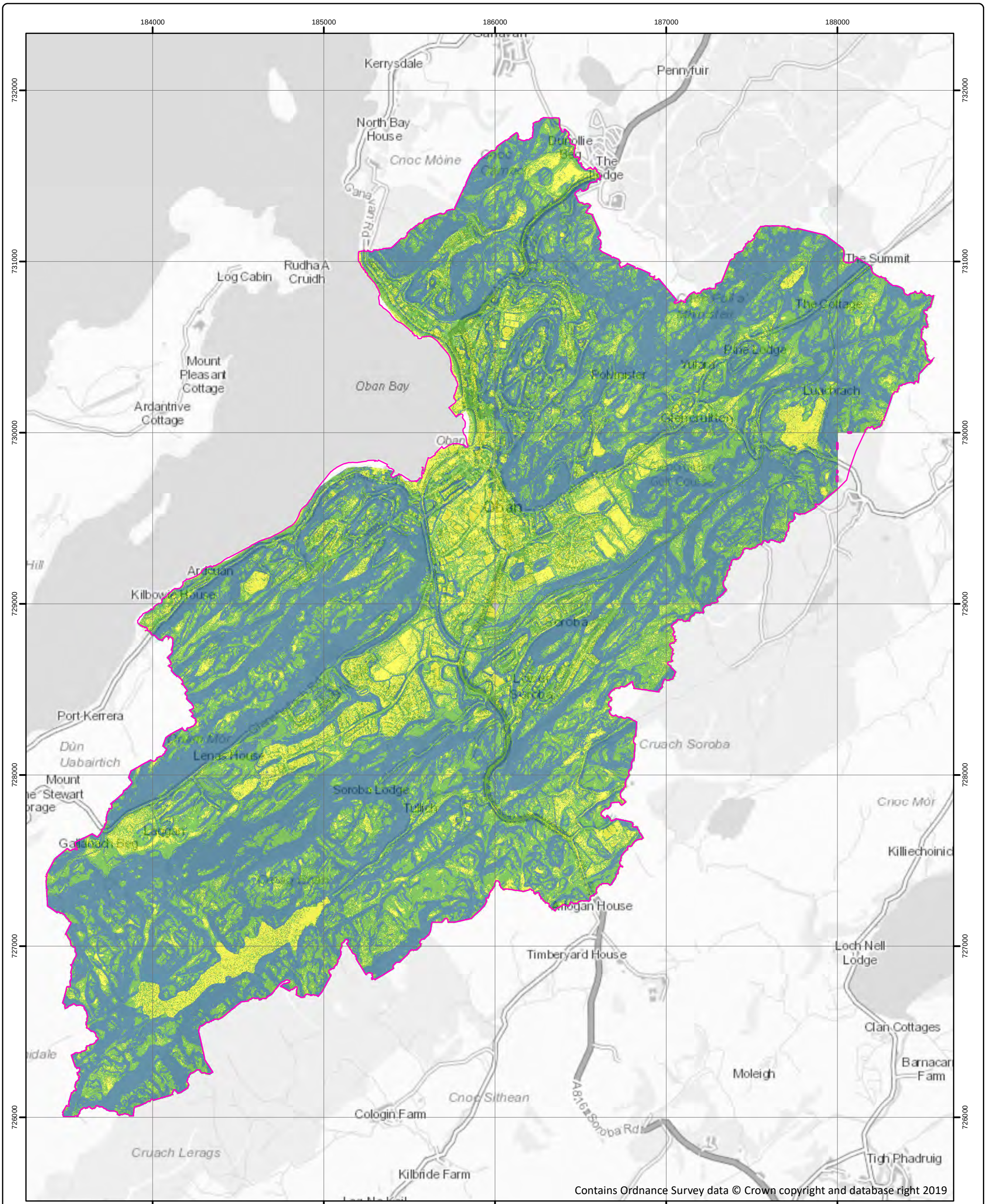
Date: 21 Oct 2019

Drawn: AL

Checked: EM

Approved: EM

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Legend

- Study Area

Slope (Degrees)

- 0 - 2
- 2 - 10
- 10 - 85

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Catchment Slopes

Status: FINAL

Drawing No.: 170506_096

Revision:

Scale: 1:20,000

A3

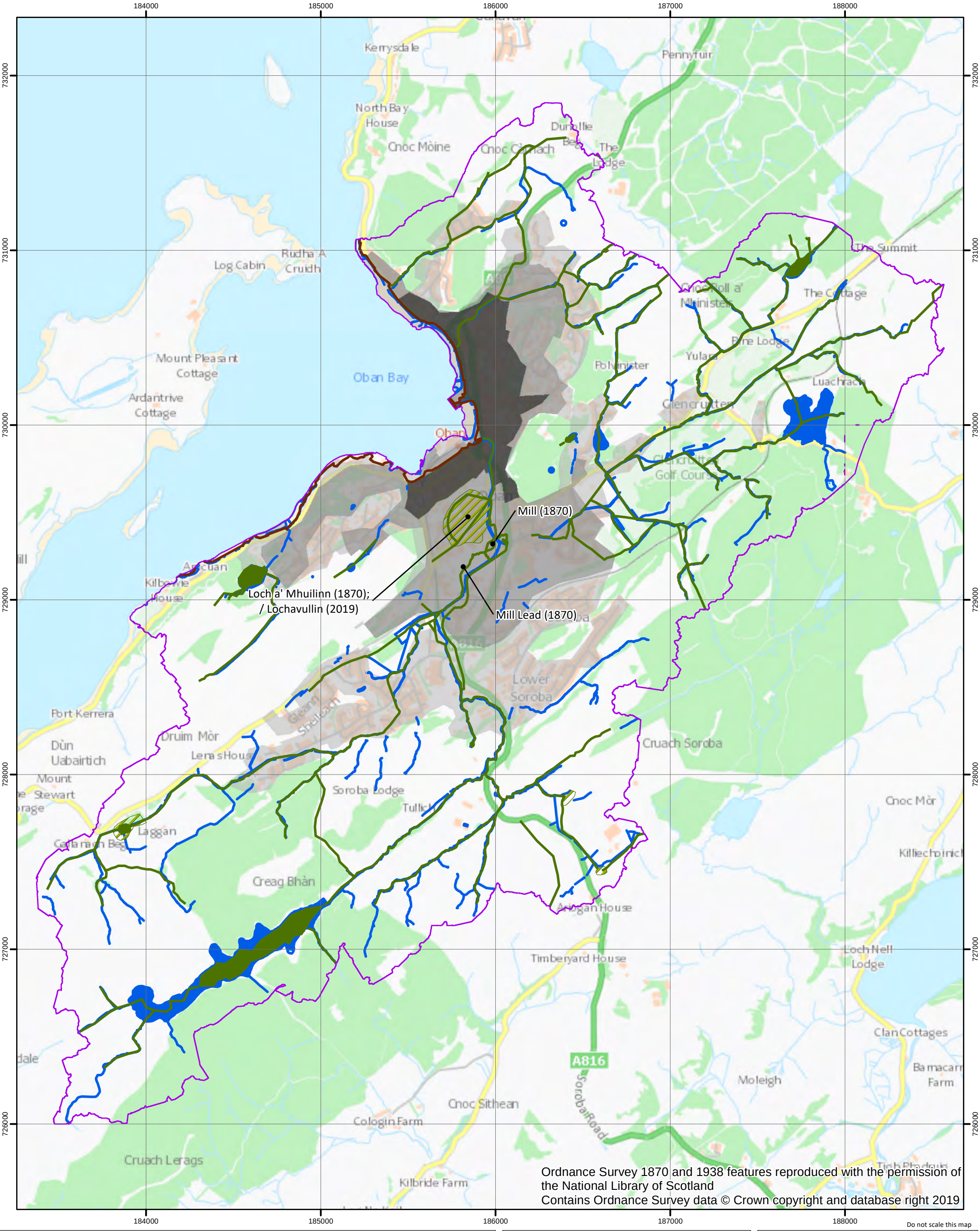
Date: 21 Oct 2019

Drawn: AL

Checked: EM

Approved: EM

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Ordnance Survey 1870 and 1938 features reproduced with the permission of the National Library of Scotland
Contains Ordnance Survey data © Crown copyright and database right 2019

Do not scale this map

Legend

- Study Area
- 1870 Waterbody
- 1870 Watercourse
- 1870 Wetland
- 1870 Coastline
- 2019 Watercourse
- 2019 Waterbody
- 1870 Urban Extent
- 1938 Urban Extent
- 2019 Urban Extent

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Historic Development

Status: FINAL

Drawing No.: 170506_047

Revision:

Scale: 1:20,000

A3

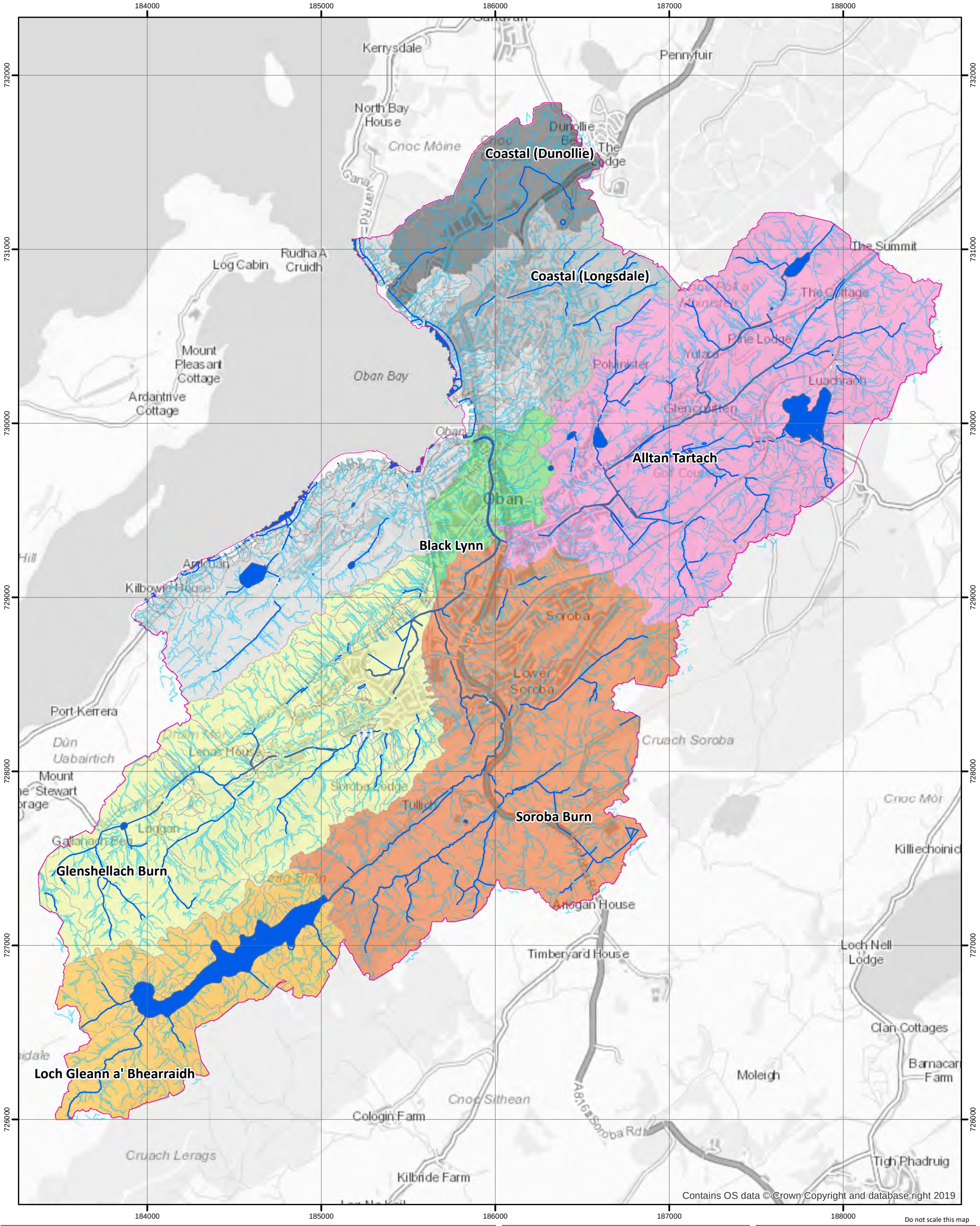
Date: 28 Oct 2019

Drawn: EM

Checked: JP

Approved: EM

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Do not scale this map

Legend

- Study Area
- Overland Flow Routes

Main subcatchments [Area, sq. km]

- Alltan Tartach [3.2]
- Black Lynn [0.4]
- Coastal: Dunollie [0.6]
- Coastal: Longsdale [0.8]
- Coastal: Other [1.4]
- Glenshellach Burn [2.3]
- Soroba Burn [3.4, inc. Gleann a' Bhearraidh]
- Loch Gleann a' Bhearraidh [1.7]

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Catchments and Overland Flow Paths

Status: FINAL

Drawing No.: 170506_018

Revision:

Scale: 1:20,000

A3

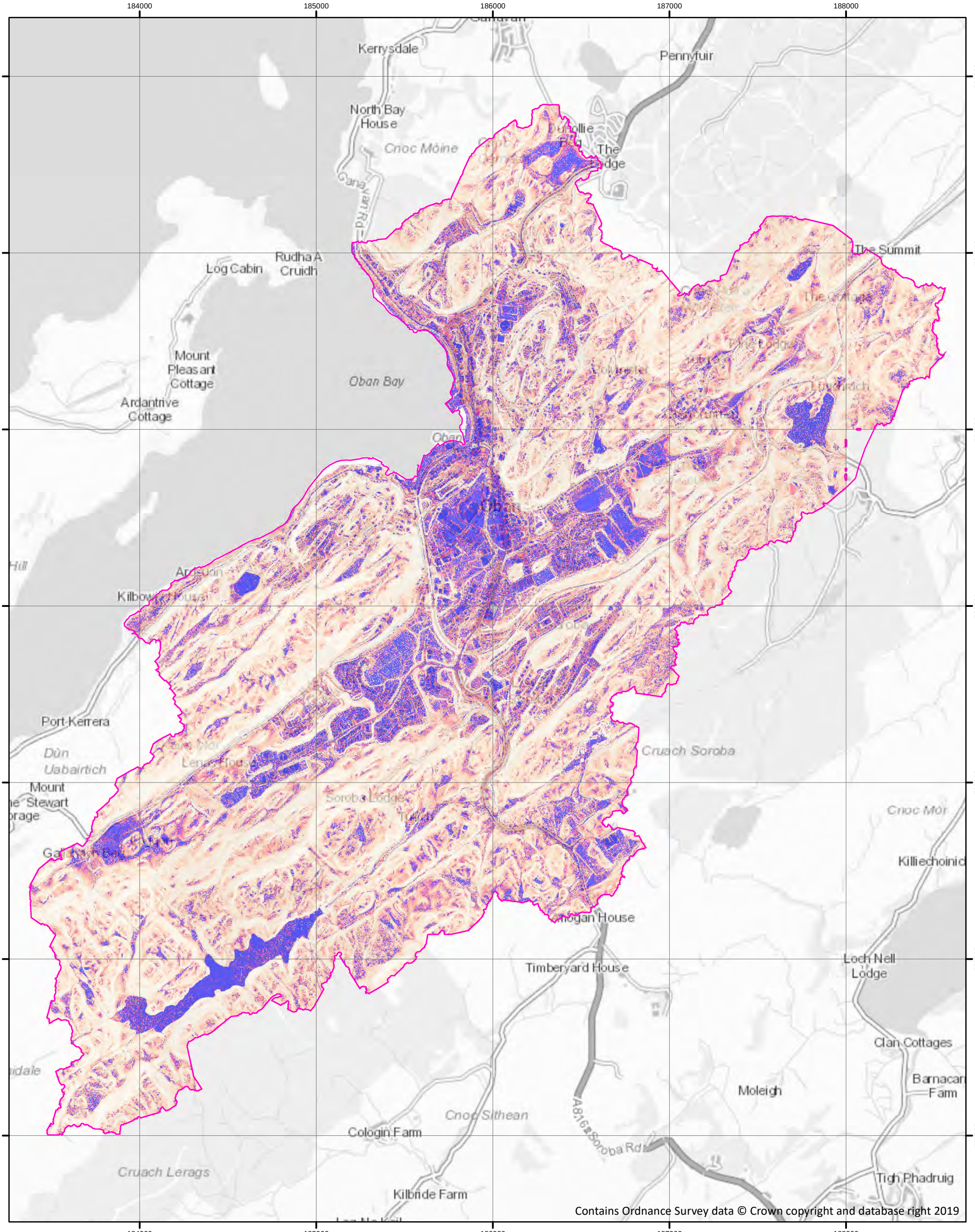
Date: 23 Oct 2019

Drawn: AL

Checked: EM

Approved: EM

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Do not scale this map

Legend

Study Area

Topographic Wetness Index

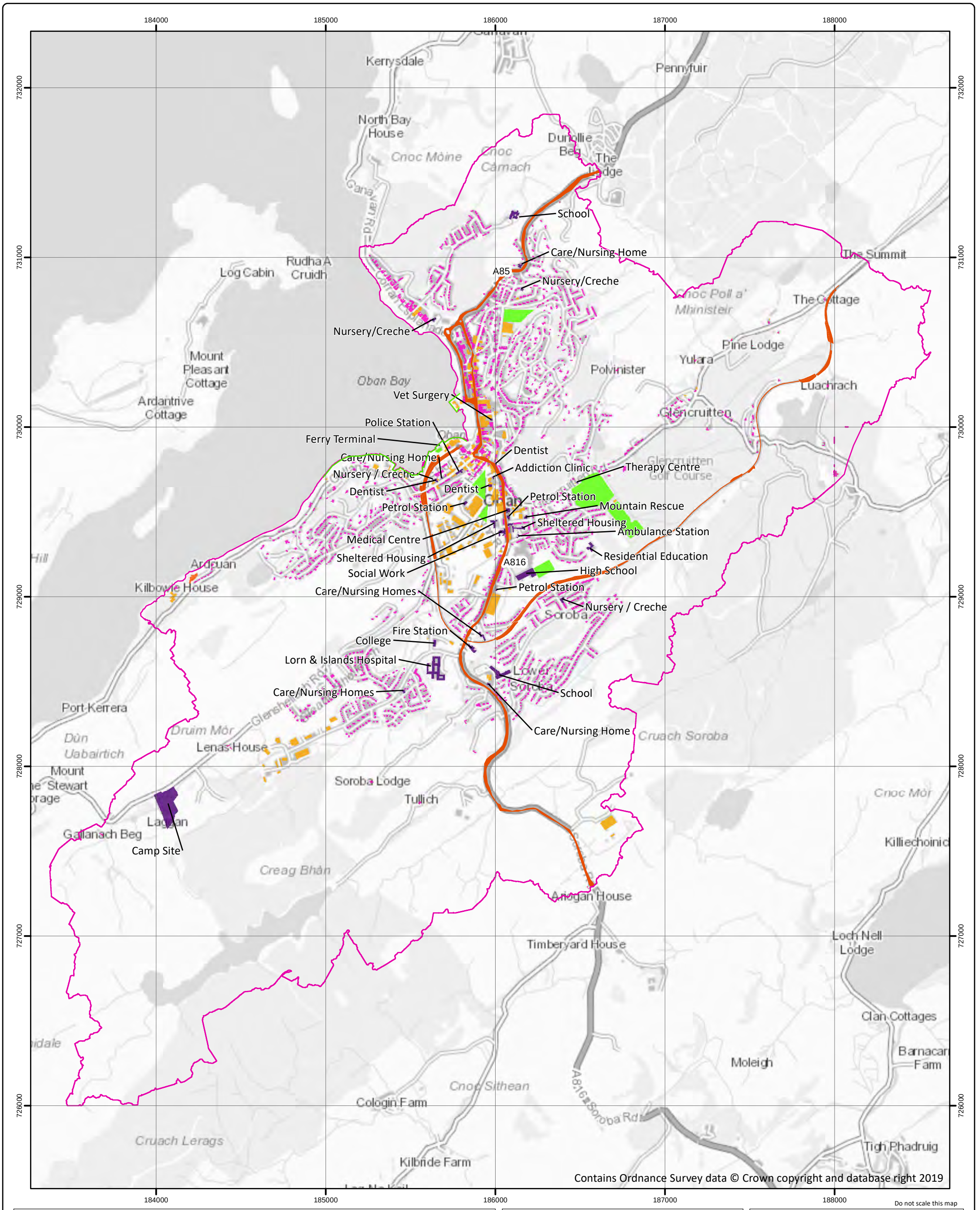
High : 250

Low : 0

Note: Topographic Wetness Index (TWI) combines slope and upstream contributing area to quantify potential for runoff generation & water accumulation

Client	Argyll and Bute Council
Project	Oban Flood Study
Title	Topographic Wetness Index
Status	FINAL
Drawing No.	170506_097
Revision	
Scale	1:20,000
A3	
Date	21 Oct 2019
Drawn	AL
Checked	EM
Approved	EM

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045



Do not scale this map

Legend

- Study Area

SEPA Land Use Vulnerability Categories

- 1 Most Vulnerable (e.g. Emergency Services, Schools)
- 2 Highly Vulnerable (e.g. Homes and Hotels)
- 3 Least Vulnerable (e.g. Shops and Offices)
- 4 Essential Infrastructure (e.g. Trunk Roads, Railway)
- 5 Water Compatible Uses (e.g. Car Parks, Sports Fields)

Client: Argyll and Bute Council

Project: Oban Flood Study

Title: Land Use Vulnerability Distribution

Status: FINAL

Drawing No.: 170506_100

Revision:

Scale: 1:20,000

A3

Date: 28 Oct 2019

Drawn: EM

Checked: KMD

Approved: KMD

ENVIRO Centre
Craighall Business Park, Eagle Street, Glasgow, G4 9XA
Tel: 0141 341 5040
Fax: 0141 341 5045

C FLOOD HISTORY

Date	Location	Brief Description	Source
05/12/2019	Lochavullin car park	Localised surface water flooding associated with drainage / pump maintenance issues (not fluvial overtopping). Resolved in each case by manual override of automatic pump trigger. Active investigations and repairs ongoing.	Council engineers
10/10/2019			
08/10/2019			
06/10/2019			
10/09/2019			
31/08/2019			
05/08/2019			
22/06/2019			
31/05/2019			
11/10/2018	Supermarket Carpark	Fluvial flooding from the Black Lynn and drainage network flooding. Exacerbated by requirement for manual triggering of pumping system in car park.	Oban Times
11/10/2018	Roseburn Cottage	Fluvial flooding from the Black Lynn	Oban Times
11/10/2018	Café, Gibraltar Street	Garden and basement flooding due to drainage impedance. Vehicle damage and flood depths in excess of 150mm noted.	Public Consultation
11/10/2018	1 Mill Lane	Around £80k to Property and machinery damage due to flooding. The flooding came from the direction of the Tesco Roundabout.	Public Consultation
11/10/2018	George Street	Surface water flooding at the pavement by Carol Lekalake Optometrist	Public Consultation
11/10/2018	Lochavullin Road	Surface water flooding in Lochavullin, both in the car parks and along Lochavullin road.	Public Consultation
16/10/2017	Longsdale Road	Depths of around 5ft were experienced within the Burn as is flowed alongside Croft Avenue, Due to potential blockage at the structure inlet.	Public Consultation
28/10/2014	Supermarket Carpark	Fluvial flooding from the Black Lynn	Archive
28/10/2014	Roseburn Cottage	Fluvial flooding from the Black Lynn	Email communication
05/12/2013	Corran Esplanade & George Street	Coastal flooding associated with Cyclone Xaver	Oban Times
29/06/2012	Supermarket Carpark	Fluvial flooding from the Black Lynn	Archive
29/06/2012	34 Combie Street	Garden inundated with potentially foul flood water	Email Communication
02/2007	A816 Glengallen Road	Heavy rain washing debris down to block culvert	SEPA Flood report
12/2006	Soroba Road	Oban Flooding of property due to overflowing burn and sewer backup	SEPA Flood report

Date	Location	Brief Description	Source
12/2006	Roseburn Cottage	Flooded due to out of bank flow from Soroba Burn	Oban Drainage Report 2008
01/2005	Stevenson Street, Ganavan Road and Esplanade, Oban	Roads closed due to flooding caused by tidal surge and strong winds	SEPA Flood report
Pre 2005	Dalintart, Oban	Flooding of Roads and properties	SEPA Flood report
11/2003 - 12/2003	Branksome Park, Oban	Watercourse close to overtopping	SEPA Flood report
01/11/2001	Supermarket Carpark	Network surcharged	Archive
30/10/2001	Supermarket Carpark	Network surcharged	Archive
1995	Dalintart & Glencruitten Hostel	First reported flooding at Glencruitten Hostel, although there may have been previous flooding. Locals indicate flooding got worse over time. Remedial works were undertaken in 2005.	Oban Drainage Report 2008
15/11/1978	Miller Road	Alltan Tartach flooding from entrance of Miller Road culvert, flowing down Miller Road and Down/across Soroba Road.	Oban Drainage Report 2008
15/11/1978	Lochavullin	Black Lynn out of bank at Soroba Lane Bridge causing ponding to the west in Lochavullin Road and car park between the Black Lynn and Lochavullin Road to a reported level of 3.6mAOD.	Oban Drainage Report 2008
1869	Coastal	First recording of flooding in Oban. Coastal flooding inundated properties to a depth of 2-3 feet and damaged roads, the sea wall and the pier.	SEPA: FRM Strategies