

Flood Risk Management Strategy

Clyde and Loch Lomond Local Plan District

This section provides supplementary information on the characteristics and impacts of river, coastal and surface water flooding. Future impacts due to climate change, the potential for natural flood management and links to river basin management are also described within these chapters.

Detailed information about the objectives and actions to manage flooding are provided in Section 2.

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3.1 Introduction

In the Clyde and Loch Lomond Local Plan District, river flooding is reported across three distinct river catchments. Coastal flooding and surface water flooding are reported across the whole Local Plan District. A summary of the number of properties and Annual Average Damages from river, coastal and surface water flooding is outlined in Table 1.

	Total number of properties at risk ¹	Annual Average Damages	Local Authority
River catchments			
River Clyde catchment group	9,600	£22 million	Dumfries and Galloway Council, East Ayrshire Council, East Dunbartonshire Council, East Renfrewshire Council, Falkirk Council, Glasgow City Council, Inverclyde Council, North Ayrshire Council, North Lanarkshire Council, Renfrewshire Council, Scottish Borders Council, South Lanarkshire Council, Stirling Council, West Dunbartonshire Council, West Lothian Council.
River Leven (Dunbartonshire) catchment group	1,100	£4.2 million	Argyll and Bute Council, Stirling Council, West Dunbartonshire Council.
Firth of Clyde catchment group	920	£1.8 million	Argyll and Bute Council, Inverclyde Council, North Ayrshire Council.
Coastal flooding			
Clyde and Loch Lomond coastal area	4,900	£19 million	Argyll and Bute Council, Glasgow City Council, Inverclyde Council, Renfrewshire Council, North Ayrshire Council, South Lanarkshire Council, West Dunbartonshire Council
Surface water flooding			
Clyde and Loch Lomond Local Plan District	19,000	£20 million	Argyll and Bute Council, Dumfries and Galloway Council, East Ayrshire Council, East Dunbartonshire Council, East Renfrewshire Council, Falkirk Council, Glasgow City Council, Inverclyde Council, North Ayrshire Council, North Lanarkshire Council, Renfrewshire Council, Scottish Borders Council, South Lanarkshire Council, Stirling Council, West Dunbartonshire Council, West Lothian Council.

Table 1: Summary of flood risk from various sources within the Clyde and Loch Lomond Local Plan District

¹ Total number of residential and non-residential properties at risk of flooding.

3.2 River flooding

Clyde and Loch Lomond Local Plan District

This section provides supplementary information on river flooding at the catchment level. It provides an overview of the catchment's natural characteristics, flood risk and the existing actions to manage flooding. It outlines the likely impact of climate change and the potential for natural flood management.

Detailed information about the objectives and actions to manage flooding are provided in Section 2.

In the Clyde and Loch Lomond Local Plan District, river flooding is reported across three distinct river catchments, shown below.

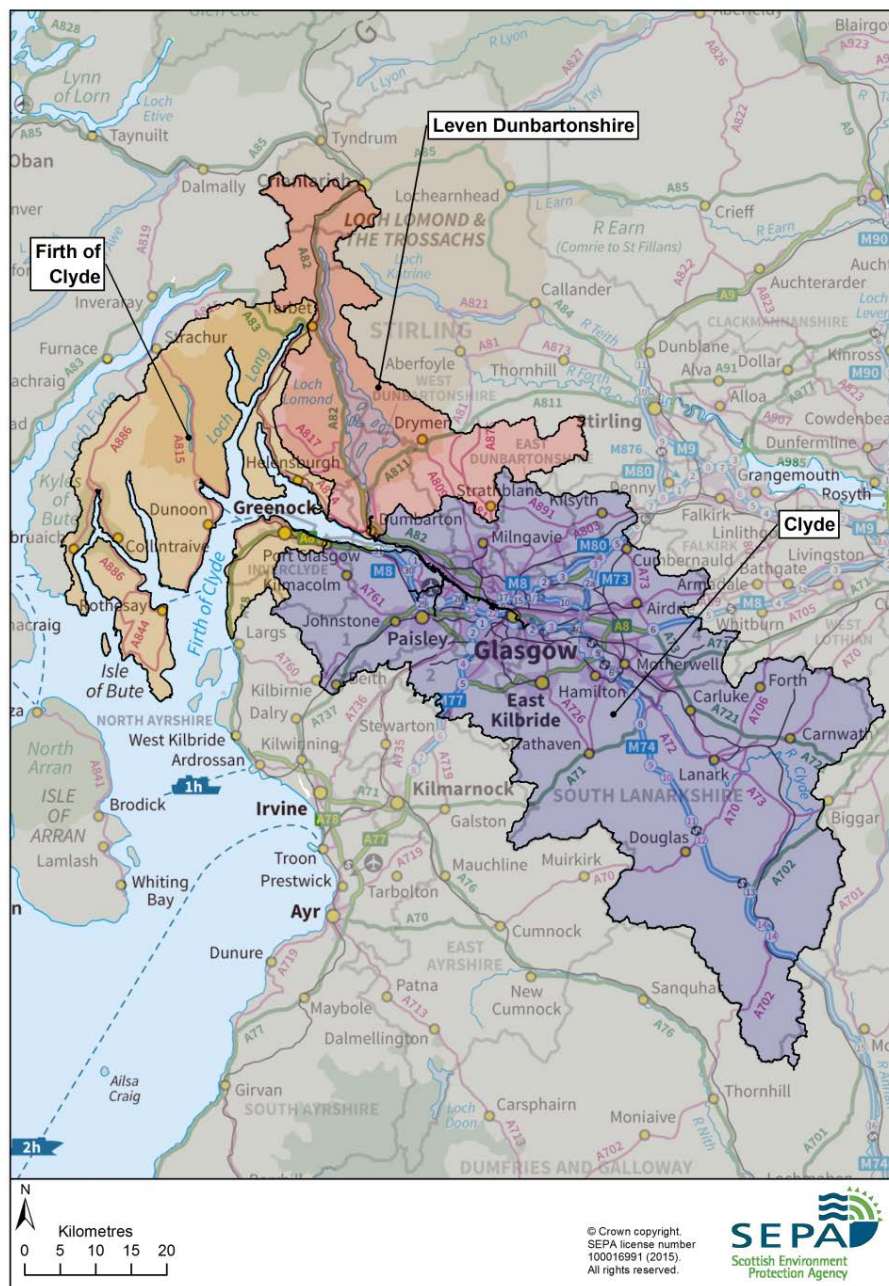


Figure 1: River catchments within the Clyde and Loch Lomond Local Plan District

River flooding

River Clyde catchment group

Catchment overview

The Clyde catchment group is located within the Clyde and Loch Lomond Local Plan District covering an area of over 3,000km². The catchment is over 86% rural and almost 14% urban with a population of approximately 1.7 million people.

This river catchment group contains 15 local authorities: Dumfries and Galloway Council, East Ayrshire Council, East Dunbartonshire Council, East Renfrewshire Council, Falkirk Council, Glasgow City Council, Inverclyde Council, North Ayrshire Council, North Lanarkshire Council, Renfrewshire Council, Scottish Borders Council, South Lanarkshire Council, Stirling Council, West Dunbartonshire Council and West Lothian Council.

The catchment group is largely dominated by the River Clyde which is formed by the confluence of two streams in the far south of the catchment (the Daer Water and the Portrail Water). From here, it flows mostly in a north-westerly direction before continuing into Glasgow and finally flowing into the Firth of Clyde. The north west of the area is dominated by three main river catchments: the White Cart Water, the Black Cart Water (which join to become the River Cart shortly before flowing into the Firth of Clyde) and the Gryfe Water. The River Kelvin dominates the north east and its origin is Kelvinhead, to the east of Kilsyth. The River Kelvin flows past Kirkintilloch and Bersden before heading south into Glasgow and discharging into the River Clyde near Yorkhill.

The average annual rainfall for the Clyde catchment group is average for Scotland, ranging between 1,269mm and 1,726mm in the upper parts of the catchment and 1,124mm and 1,717mm in the lower reaches.

Flood risk in the catchment

Within the Clyde catchment group approximately 7,800 residential properties are predicted to be at risk of river flooding, 95% of which are located within a Potentially Vulnerable Area. Approximately 1,800 non-residential properties are predicted to be at risk of river flooding, 96% of which are located within a Potentially Vulnerable Area. There are 16 Potentially Vulnerable Areas and one candidate Potentially Vulnerable Area at risk of flooding in this catchment group. One of these (11/01) is also partially in the Leven catchment group. (Figure 1):

- Loch Lomond and Vale of Leven (11/01)
- Kilsyth to Bearsden – north of Glasgow City (11/04)
- Yoker catchment – Clydebank to Partick (11/05)
- Clyde south – Port Glasgow to Inchinnan (11/09)
- Bishopton (11/10)
- Gryfe catchment – Bridge of Weir to Houston (11/11)
- Black Cart Water catchment – Lochwinnoch to Johnstone (11/12)
- White Cart Water catchment (11/13)
- Rutherglen (11/14)
- Glasgow City north (11/15)
- East of Glasgow (11/17/1)
- Clyde catchment – Motherwell to Lesmahagow (11/17/2)
- Coatbridge and Airdrie (11/17/3)

- Coatbridge/Viewpark (11/18)
- North of Wishaw (11/19)
- Shotts (11/20)
- Kilmacolm (11/21c)

One of the Potentially Vulnerable Areas (11/17) has been split into three sections to aid reporting of the risks.

Main areas at risk

The main areas with a risk of river flooding can be seen in Table 1 which shows the number of properties at risk and the Annual Average Damages caused by river flooding. This includes damages to residential and non-residential properties, transport and agriculture.

	Residential and non-residential properties at risk of river flooding	Annual Average Damages
Glasgow City	3,500	£9.8 million
Paisley and Johnstone	1,600	£2.7million
Rutherglen	650	£2.5 million
Kirkintilloch	570	£740,000
Clydebank	290	£720,000
Giffnock and Thornliebank	270	£1.6 million
Coatbridge and Airdrie	210	£440,000
Cambuslang	190	£600,000
Hamilton	180	£980,000
Barrhead	150	£340,000

Table 1: Main areas at risk of river flooding

Economic activity and infrastructure at risk

The Annual Average Damages caused by river flooding in the Clyde catchment group are approximately £22 million. This accounts for approximately 33% of the estimated Annual Average Damages from all flooding sources within the Local Plan District. The damages are distributed as follows:

- 60% residential properties (£13 million)
- 29% non-residential properties (£6.4 million)
- 5% emergency services (£1.1 million)
- 3% vehicles (£650,000)
- 2% roads (£350,000)
- 1% agriculture (£180,000).

Figure 2 shows the Annual Average Damages throughout the catchment group.

Table 2 shows further information about infrastructure and agricultural land at risk of flooding within this catchment.

	Number at risk	Further detail
Community facilities	10	Includes: educational buildings, emergency services and healthcare facilities
Utility assets	110	Includes: electricity sub stations, telecommunications, oil refining and distribution, gas regulating and mineral and fuel extraction sites.
Roads (km)	32.7	Primary roads and Motorways include: A725 at Bothwell A726 at Renfrew, Paisley and Strathaven A737 at Kilbarchan M74 at Motherwell A-Roads include: A752 between Bargeddie and Aitkenhead in Coatbridge A723 between Motherwell and Hamilton A736 north-west of Neilston in Barrhead A8 east of Inchinnan A760 Lochwinnoch
Railway routes (km)	16.5km	Notably: Glasgow City to Whifflet in Coatbridge Carstairs to Glasgow City Elvanfoot to Carstairs Bearsden to Milngavie Glasgow City to Ayr between Kilbirnie and Johnstone Railway line at Neilson
Airports	1	
Agricultural land (km²)	92	

Table 2: Infrastructure and agricultural land at risk of river flooding

Designated environmental and cultural heritage sites at risk

Within the catchment group there are approximately 108 designated cultural heritage sites at risk of river flooding. These sites include; scheduled monuments, gardens and designed landscapes, battlefield sites, World Heritage sites and listed buildings.

There are approximately 12km² of environmental designated area at risk of river flooding within the Clyde catchment group. The majority of these are Sites of Special Scientific Interest (9km²), with smaller areas of Special Areas of Conservation (1km²) and Special Protected Areas (2km²).

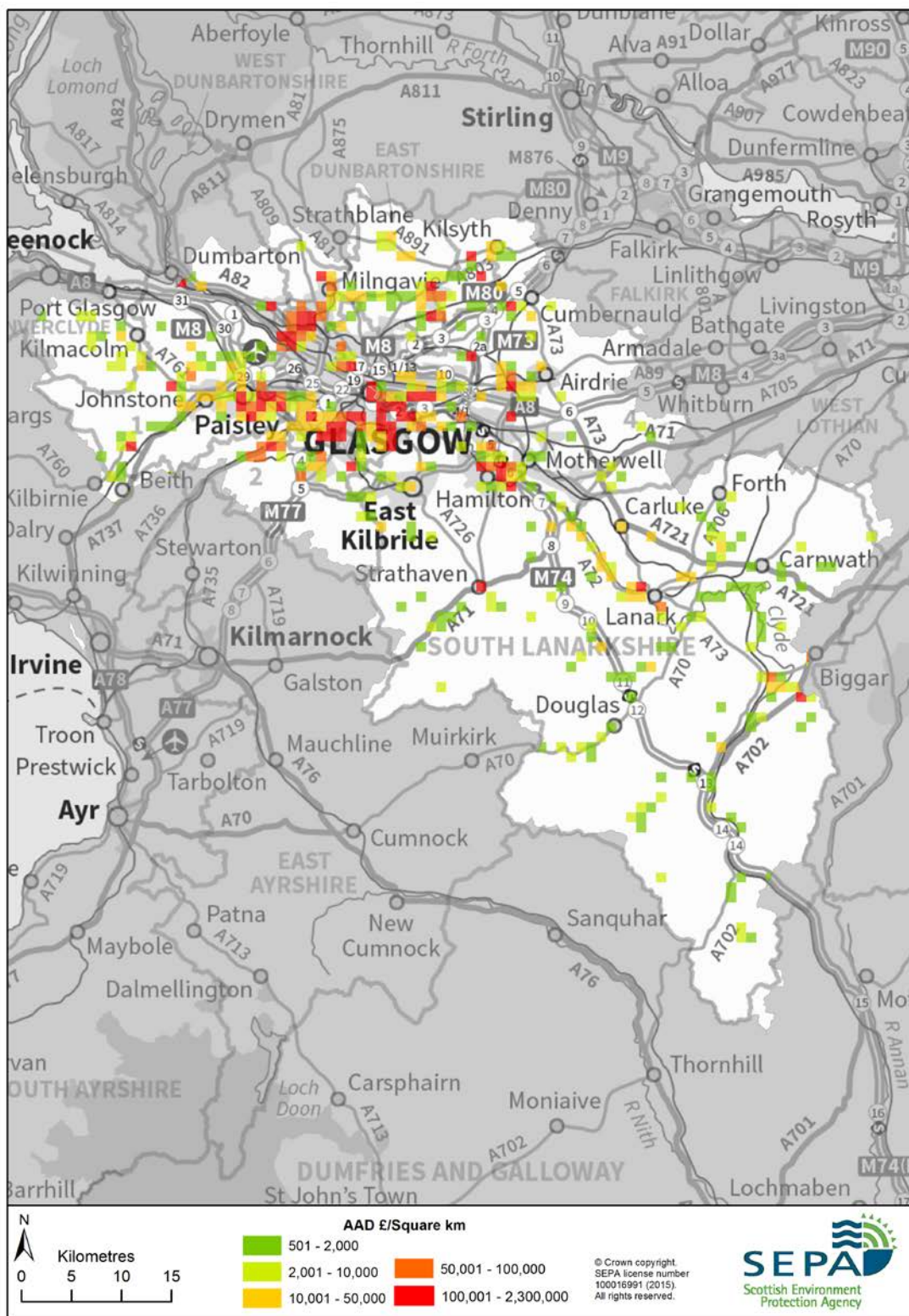


Figure 2: Annual Average Damages from river flooding

History of flooding

This area has a long history of flooding with many of these floods impacting large numbers of people and properties. The most significant modern day flooding occurred between 10 and 12 December 1994, caused by prolonged heavy rainfall over a 48 hour period. Previous peak river flows were exceeded in all major catchments. In Glasgow over 700 residential properties and many non-residential properties flooded, with major transport disruptions (roads and rail) and three fatalities. The flood peaks of the White Cart Water and Black Cart Water, and their associated tributaries, coincided resulting in flows backing up along the main channels, causing flooding within Paisley. There was also flooding on the White Cart Water in 1984 affecting over 500 properties. More recently in December 2013 flooding from the River Clyde impacted properties and roads.

Recent flooding in this area has often been caused by linked river and surface water flooding with many areas impacted by regular flooding. The north west of Glasgow was affected on 21 October 2013 and on 30 and 31 July 2002, when storms led to 500 properties flooding, businesses being damaged and transport on major roads and railways severely disrupted

The earliest flooding recorded in the area was in 738 AD when the Clyde burst its banks. There were also a number of significant events identified in the 1700s and 1800s, which caused destruction of properties and bridges and resulted in a number of fatalities.

Further detail about the history of flooding in this area is available in the relevant Potentially Vulnerable Area chapters of this document.

Managing flood risk

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

This section describes the existing actions that are in place to manage flood risk and are in addition to the information presented in the relevant Potentially Vulnerable Area chapter of this document.

Flood protection schemes

Given the historic risk of flooding within the catchment group a large number of flood protection schemes have been completed. East Dunbartonshire Council, Glasgow City Council, North Lanarkshire Council, Renfrewshire Council and South Lanarkshire Council have all completed schemes and flood mitigation works within this area. Many of these schemes aim to reduce the impact of both river and surface water due to the linked sources of flooding in this area.

In North Lanarkshire, Broadwood Loch Balancing Pond (previously known as Mosswater Pond) provides flood risk reduction benefit to the north western area of Cumbernauld.

The flood protection schemes completed by East Dunbartonshire Council in this area are:

- Lennoxtown Flood Protection Scheme (1963) included channel improvements, new culverts and a new outfall on the Rannie Burn.
- The River Kelvin Flood Protection Scheme (1998) benefits Kirkintilloch, Balmore and Torrance. It involved the construction of embankments and retaining walls, diversion of services, channel improvements, new culverts, floodgates and pumps.
- The River Kelvin (Glazerbank Lennoxtown) Flood Protection Scheme (2000) involved the construction of retaining walls and flood banks along the Glazer Water in Lennoxtown,
- In Service Street, Lennoxtown a new screen and flood defence wall were installed to manage overland flows. Maintenance, to include removal of debris at screen and inspection of flood wall, is carried out annually by East Dunbartonshire Council.
- Colquhoun Park Flood Alleviation Scheme (2015), Creation of a wetland area to reduce flooding in Bearsden.

The flood protection schemes completed by Glasgow City Council in this area are:

- White Cart Water Flood Protection Scheme, which included construction of flood storage areas upstream in East Renfrewshire and defences along parts of the river and tributary corridors. This scheme also benefits East Renfrewshire Council and Renfrewshire Council.
- Brock Burn / Lavern Water flood defence, which is a series of on-line flood defences.
- Camlachie Burn Overflow involved the construction of an overflow pipe.

The flood protection schemes completed by South Lanarkshire Council in this area are:

- Cityford Burn Culvert Flood Protection Scheme (2006), included culvert and embankments in Rutherglen.
- Dalmarnock Flood Bund Flood Protection Scheme (1999), included embankments in Rutherglen.
- Backmuir Road (culvert bypass) Flood Protection Scheme (2007), included culvert and embankments in Hamilton.
- Kenmar Terrace Culvert Flood Protection Scheme (2005) included culvert and embankments in Hamilton.
- Clydesmill Stage 1 and 2 Flood Protection Scheme (2001), included embankments in Cambuslang.
- Meadowbank Flood Bund Flood Protection Scheme, included a flood bund in Uddingston.
- Golf Gardens Flood Protection Scheme (2006), included a culvert upgrade in Larkhall.

The flood protection schemes completed by Renfrewshire Council in this area are:

- The flood protection scheme on the River Gryfe at Crosslee Park, Crosslee

- The flood protection scheme on the Black Cart Water at Collier Street / Rankine Street, Johnstone
- Flood protection scheme on the Espedair Burn at Moredun Playing Fields

Renfrewshire Council also has a flood protection scheme under construction at Renfrew, including embankments, land raising, the installation of two demountable flood barriers, construction of a pumping station and partial infilling of a tidal dock in the Clyde. Scheme construction is anticipated to be complete in early 2016.

River flood warning schemes

SEPA operates 17 river flood warning schemes in the Clyde catchment group. Flood Warnings are issued when river flooding is forecast for these areas. The river flood warning schemes in this catchment are shown in Figures 3 and 4 and Table 3.

Table 3 shows the total number of properties in the flood warning area and the percentage of those properties that have signed up to receive flood warnings. Note that this is not the number of properties at risk of flooding.

Flood warning area (FWA)	River	Number of properties within FWA	% of properties registered May 2014
Alyth Crescent (Thornliebank)	White Cart Water	158	20%
Cambuslang Road and Morrision Park (Glasgow)	River Clyde	162	28%
Carmyle (Glasgow)	River Clyde	47	43%
Cleveden Park (Glasgow)	River Kelvin	128	15%
Crossford	River Clyde	48	31%
Dalbeth (Glasgow)	River Clyde	0	N/A
Dalmarnock Bridge (Rutherglen, Glasgow)	River Clyde	1,046	11%
Dalserf	River Clyde	12	58%
Goyle Bridge (Kirkintilloch)	River Kelvin	4	0%
Hamilton Services (Hamilton)	River Clyde	3	33%
Kelvinbridge Underground (Glasgow)	River Kelvin	92	5%
Pollok (Glasgow)	White Cart Water	115	17%
Pollok Country Park (Glasgow)	White Cart Water	10	40%
Pollokshaws (Glasgow)	White Cart Water	139	60%
Rosebank	River Clyde	15	47%
Shawlands, Langside and Cathcart (Glasgow)	White Cart Water	4	100%
Watersports Centre at Strathclyde Loch (Motherwell)	River Clyde	86	100%

Table 3: Flood warning areas

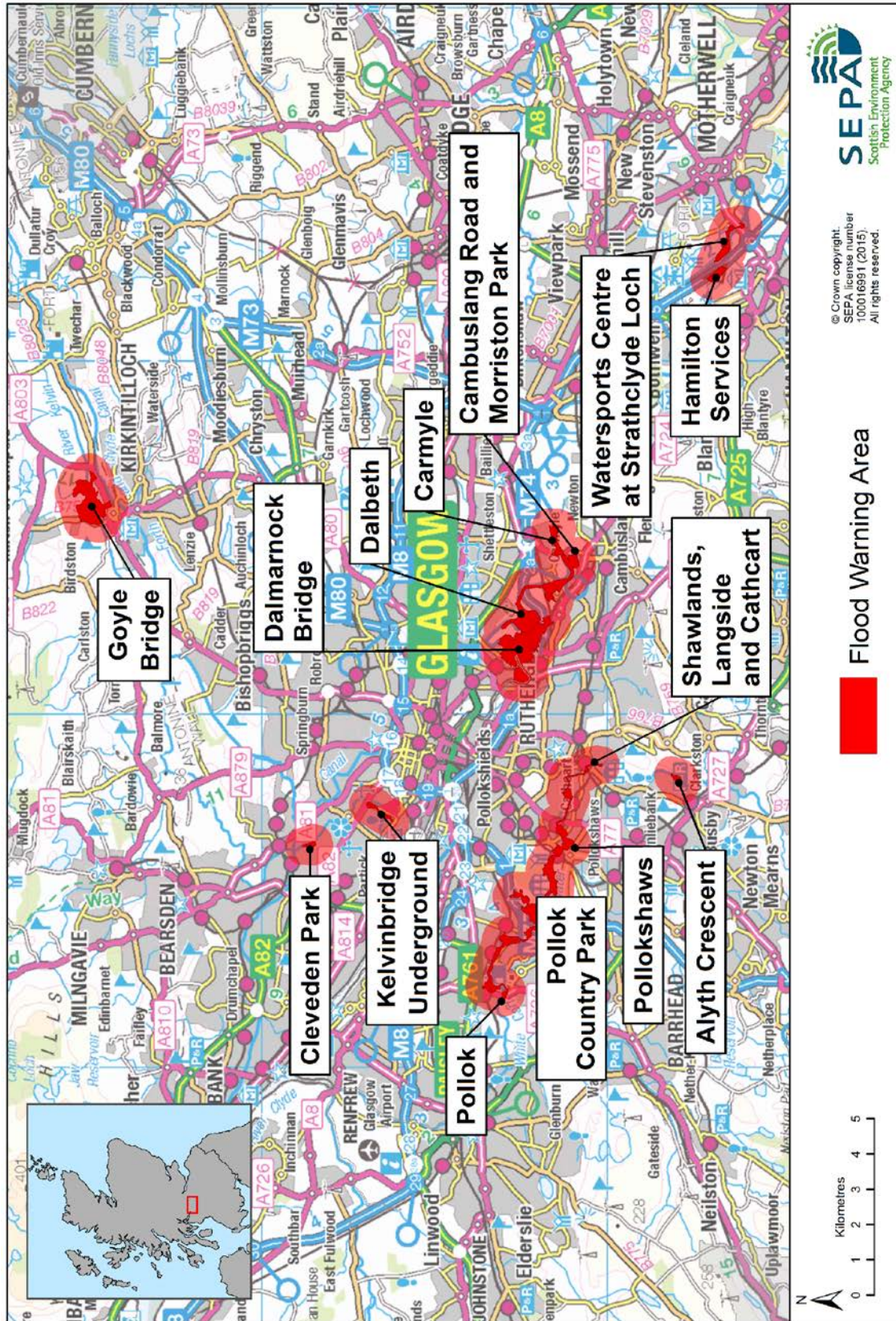


Figure 3: Flood warning areas – Clyde North

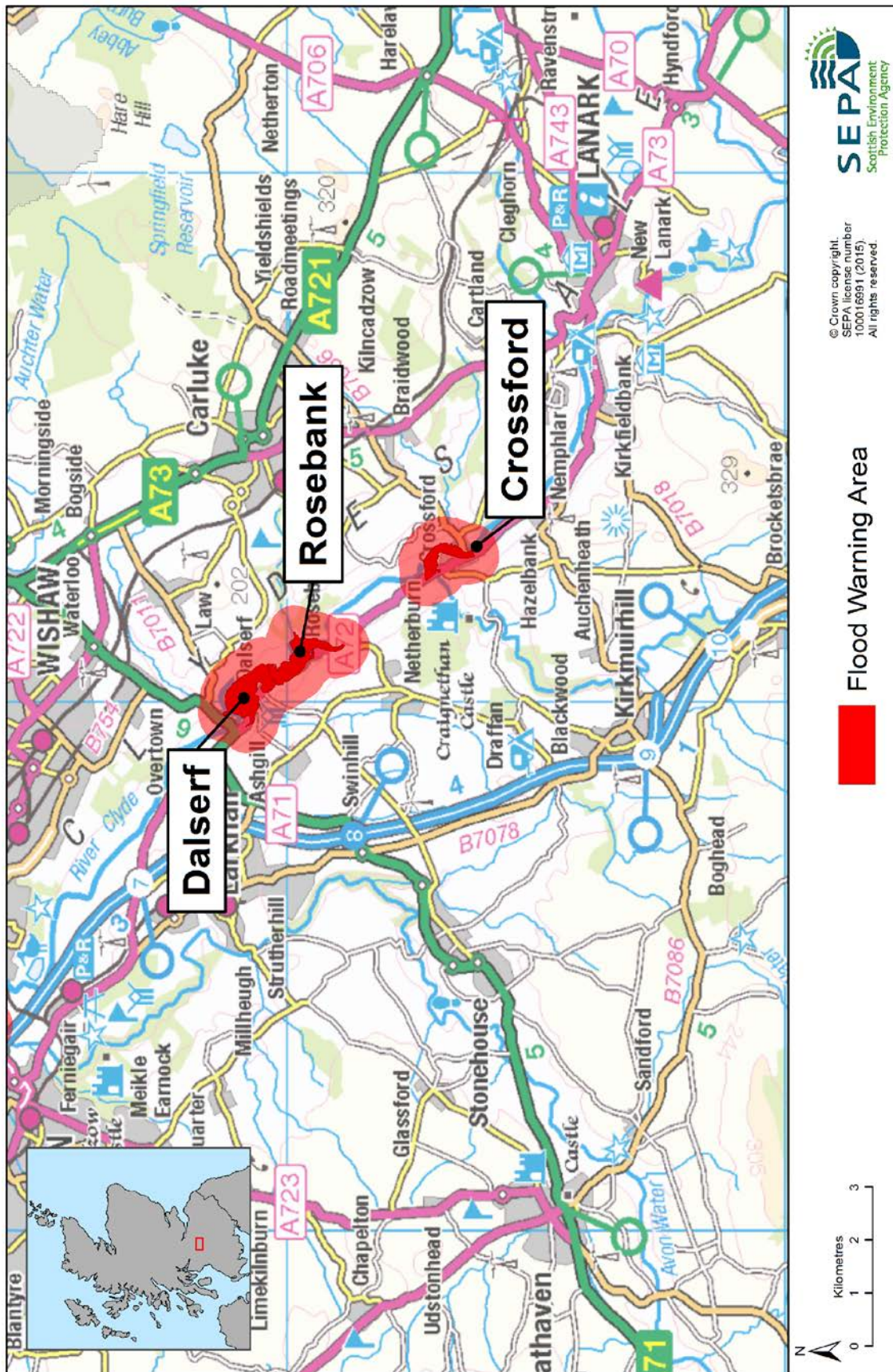


Figure 4: Flood warning areas – Clyde South

Climate change and future flood risk

The UK Climate Projections (UKCP09) predicts that climate change may lead to warmer and drier summers, warmer and wetter winters with less snow, and more extreme temperature and rainfall. The predicted increase in rainfall and river flows may increase the potential for river flooding.

Under the UKCP09 high emissions scenario for 2080, average peak river flows for the Clyde basin may increase by 44%¹. This would potentially increase the number of residential properties at risk of river flooding from approximately 7,800 to 12,000 and the number of non-residential properties from approximately 1,800 to 2,900.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.

Potential for natural flood management

The assessment of the potential for natural flood management is shown on SEPA's flood maps (<http://www.sepa.org.uk/environment/water/flooding/flood-maps/>). The maps indicate the potential for wave attenuation and estuarine surge attenuation. They show areas where natural flood management could be effective and where further detailed assessment should take place. This information was used to identify where local authorities could include natural flood management as part of flood risk management schemes and studies. The proposed schemes and studies are listed in the relevant Potentially Vulnerable Area chapters of this document.

Runoff reduction

The assessment identifies a very large area with high potential for runoff reduction in the northern part of the River Kelvin catchment. Further areas with high potential for runoff reduction are scattered throughout the catchment group, with large areas of medium potential in the south of the White Cart Water catchment and between Milngavie and Dumbarton.

Floodplain storage

Areas identified with the greatest potential for floodplain storage are in the vicinity of existing lochs and reservoirs. Some of these are impounding reservoirs and therefore subject to control regimes which regulate their levels and may restrict their suitability to provide additional flood storage. Potential floodplain storage areas are also identified along the Mouse Water, which contributes to flood damages in Lanark. An area with medium potential for additional storage exists along the River Kelvin, near Balmore Haughs

Sediment management

¹ From the study 'An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change' (CEH, 2011)

The River Clyde shows signs of alternating between lengths of high deposition and high erosion. Several of the River Clyde tributaries also present similar areas of unbalance. Incorporating sediment management measures in these areas may help to reduce the significant damages relating to the rivers in this catchment group.

River flooding River Leven (Dunbartonshire) catchment group

Catchment overview

The Leven catchment group is within the Clyde and Loch Lomond Local Plan District and covers over 830km². The catchment group is over 97% rural and almost 3% urban, with an approximate population of 58,000.

This river catchment group contains three local authorities; Argyll and Bute Council, Stirling Council and West Dunbartonshire Council.

The majority of the catchment group is within the Loch Lomond and the Trossachs National Park. This area is dominated by Loch Lomond and has high and steep mountains to either side of it. The maximum elevation is on Ben More in the north, at 1,029m. In the south of the catchment group are towns along the Vale of Leven including Alexandria and Dumbarton, which have hills either side to elevations of approximately 300m, falling to sea level. In the east are the Campsie Fells, with elevations of over 500m and some steep sloping hillsides.

The River Leven flows south from Loch Lomond through Alexandria and Dumbarton before entering the Firth of Clyde. The River Falloch flows into Loch Lomond from the Highlands in the north. Loch Lomond is located in the centre of the catchment group and stretches for almost 36km. A number of tributaries discharge to Loch Lomond including the Arklet Water, Endrick Water, Douglas Water, Luss Water, Finlas Water and the Fruin Water.

The average annual rainfall for this area is given as 2,015mm, which is high for Scotland.

Flood risk in the catchment

There are approximately 990 residential properties predicted to be at risk of river flooding in this area, 98% of which are located within a Potentially Vulnerable Area. Approximately 160 non-residential properties are predicted to be at risk of river flooding in this area, 86% of which are located within a Potentially Vulnerable Area. There are two Potentially Vulnerable Areas in this catchment as shown in Figure 1:

- Loch Lomond and Vale of Leven (11/01)
- Strathblane (11/03).

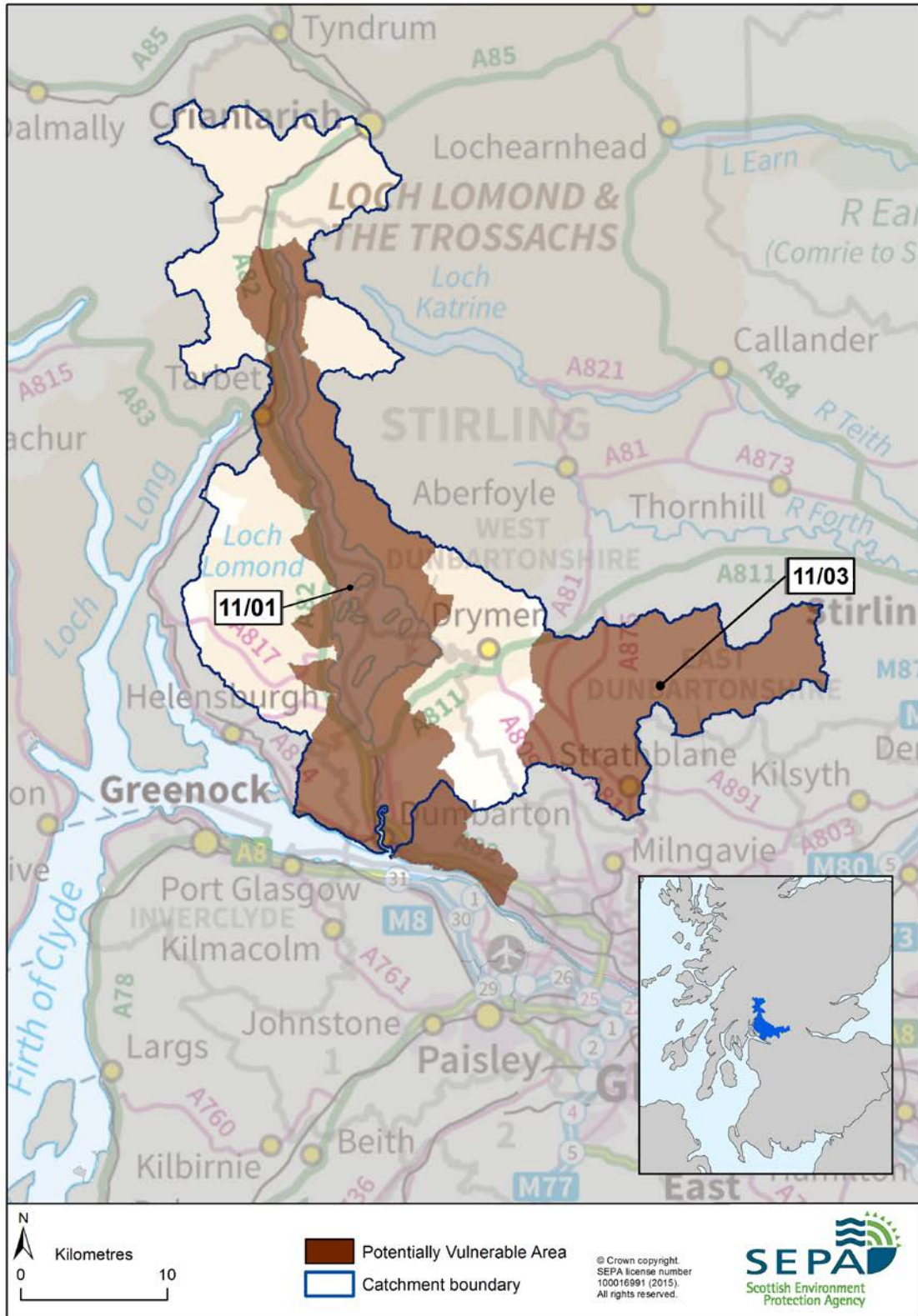


Figure 1: River catchment for the Leven catchment group

Main areas at risk

The main areas at risk of river flooding can be seen in Table 1, which shows the number of properties at risk and the Annual Average Damages caused by river flooding. This includes damages to residential and non-residential properties, transport and agriculture. The two principal areas at risk are Alexandria and Balloch and Dumbarton.

	Residential and non-residential properties at risk of river flooding	Annual Average Damages
Alexandria and Balloch	610	£2.4 million
Dumbarton	360	£1.3 million
Strathblane	30	£90,000
Geilston	10	£23,000

Table 1: Main areas at risk of river flooding

Economic activity and infrastructure at risk

The Annual Average Damages caused by river flooding in the Leven catchment group are approximately £4.2 million. This accounts for approximately 7% of the estimated Annual Average Damages from all flooding sources within the Local Plan District. The damages are distributed as follows:

- 52% residential properties (£2.2 million)
- 38% non-residential properties (£1.6 million)
- 5% emergency services (£210,000)
- 3% vehicles (£130,000)
- 2% roads (£76,000)
- <1% agriculture (£27,000).

The damage calculations do not include any wider, indirect impacts flooding may have, including the impact to tourism in the area.

Figure 2 shows the Annual Average Damages throughout the catchment group.

Table 2 shows further information about infrastructure and agricultural land at risk of flooding within this catchment.

	Number at risk	Further detail
Community facilities	<10	Includes: educational buildings
Utility assets	<10	Includes: electricity sub stations
Roads (km)	3	Notably the A82 primary road running along the west bank of Loch Lomond, (the road is currently being redesigned)
Railway routes (km)	1.4	Notably between Crianlarich and Inveruglas and in Dumbarton
Agricultural land (km ²)	15	

Table 2: Infrastructure and agricultural land at risk of river flooding

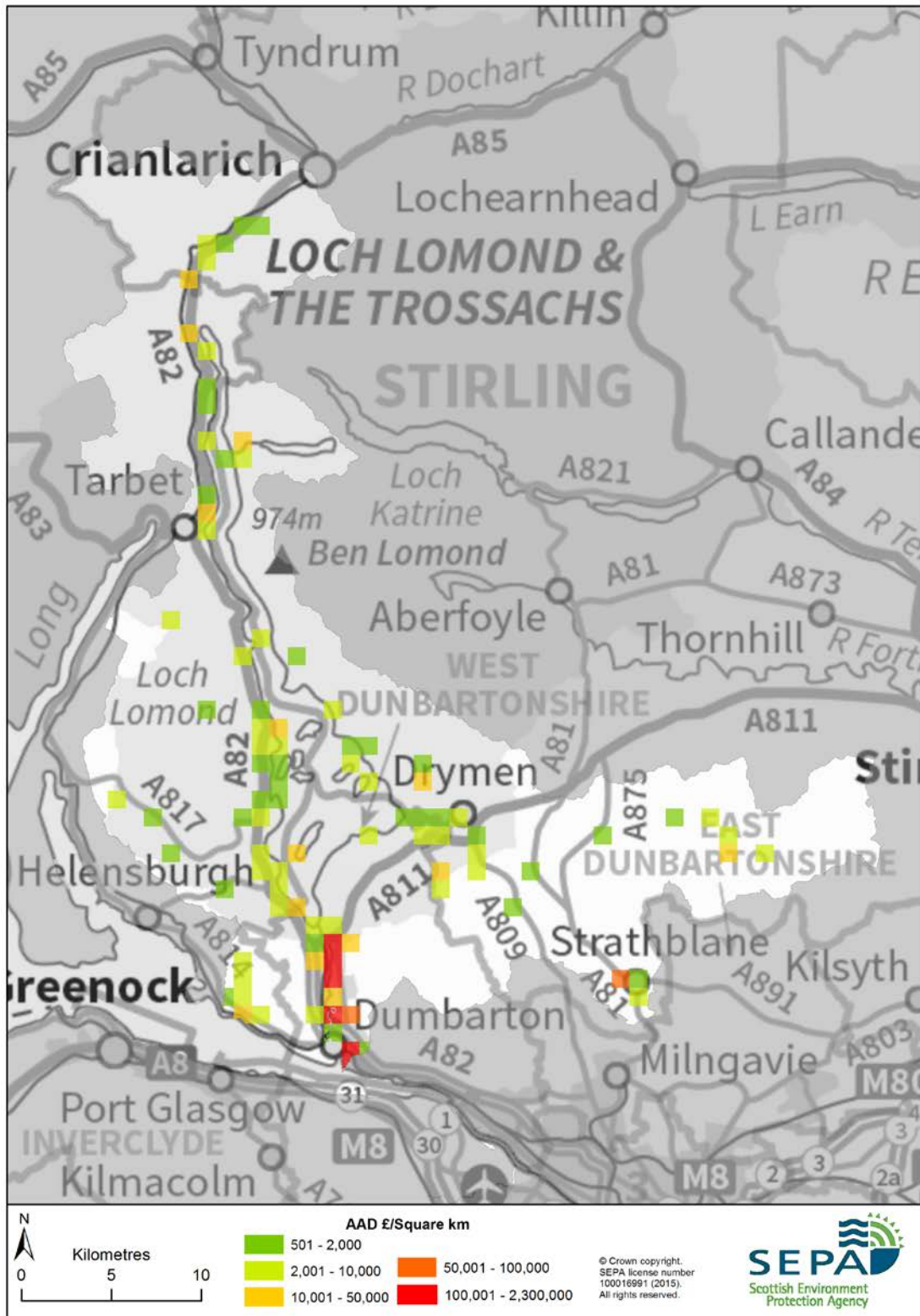


Figure 2: Annual Average Damages from river flooding

Designated environmental and cultural heritage sites at risk

Within the catchment there are approximately 24 designated cultural heritage sites at risk of river flooding. These sites include scheduled monuments, gardens and designed landscapes and listed buildings.

There are approximately 16km² of environmental designated area at risk of river flooding within the Leven catchment group. The majority of these are Special Protected Areas (<7km²) and Sites of Special Scientific Interest (<6km²), with smaller areas of Special Areas of Conservation (<2km²).

History of flooding

There is a long history of flooding in this area, although floods have tended to have relatively localised impacts to people and properties. They have become more frequent over the last 15 years with 10 floods recorded since 2000.

Early records of flooding in the area mostly impacted crops during harvest, the earliest of which was in 1782. Records of flooding to properties from the Leven start in 1846 with six further floods between 1880 and 1903. More recently on 11 March 1990, heavy rain caused Loch Lomond to rise, flooding individual properties around the Loch. Furthermore, in October and December 2006 the River Leven overtopped its banks.

The most recent recorded flooding occurred on 29 November 2011, when high tide coincided with high river flow within the Gruggies Burn. This resulted in transportation disruption and homes in Wallace Street being badly affected. There were similar conditions which led to flooding on the same river in 1909. The Gruggies Burn has also flooded in July 2002, August 2004 and September 2005 with flooding to properties and roads. The Knowle Burn in Dumbarton has also experienced recent frequent flooding with incidents in June 2010, July and August 2005, September and October 2005 and July 2002, which have impacted properties and disrupted transport.

Further detail about the history of flooding in this area is available in the relevant Potentially Vulnerable Area chapters of this document.

Managing flood risk

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

This section describes the existing actions that are in place to manage flood risk and are in addition to the information presented in the relevant Potentially Vulnerable Area chapter of this document.

Flood protection schemes

West Dunbartonshire Council completed a scheme on the Knowle Burn in 2015. The scheme helps to protect nearly 70 residential properties and includes flood storage pond with inlet & outlet control structures near Garshake Road with a series of downstream channel improvements and flood embankments.

While not a formal flood protection structure, a barrage across the River Leven in Alexandria maintains levels within Loch Lomond at a maximum of 8m Above Ordnance Datum. The operation of the barrage is regulated by an Act of Parliament

Climate change and future flood risk

The UK Climate Projections (UKCP09) predicts that climate change may lead to warmer and drier summers, warmer and wetter winters with less snow, and more extreme temperature and rainfall. The predicted increase in rainfall and river flows may increase the potential for river flooding.

Under the UKCP09 high emissions scenario for 2080, average peak river flows for the Leven catchment may increase by 44%¹. This would potentially increase the number of residential properties at risk of river flooding from approximately 990 to 1,230 and the number of non-residential properties from approximately 160 to 230.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.

Potential for natural flood management

The assessment of the potential for natural flood management is shown on SEPA's flood maps (<http://www.sepa.org.uk/environment/water/flooding/flood-maps/>). The maps indicate the potential for wave attenuation and estuarine surge attenuation. They show areas where natural flood management could be effective and where further detailed assessment should take place. This information was used to identify where local authorities could include natural flood management as part of flood risk management schemes and studies. The proposed schemes and studies are listed in the relevant Potentially Vulnerable Area chapters of this document.

Runoff reduction

The assessment shows large areas with high potential for runoff reduction around Loch Lomond, encompassing a number of tributaries north of Loch Lomond (River Falloch, Allt Fionn Ghlinne and Dubh Eas) as well as Loch Lomond itself and areas as far south as Blairglas and Balmaha.

Floodplain storage

The assessment also indicates a high potential for floodplain storage exists at Loch Lomond, however further work would be required to assess any potential. The barrage at Alexandria, which regulates loch levels and the varied uses of the loch may limit the potential for significant additional storage.

Sediment management

Areas of high erosion and high deposition exist along the River Leven south of Loch Lomond, and along the flood risk areas of the Vale of Leven. Other notable areas of high erosion and moderate deposition also exist along Endrick Water and Gourlays Burn in the east of the catchment group. Incorporating sediment management

¹ From the study 'An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change' (CEH, 2011)

measures in these areas may reduce damages downstream in areas such as Drymen.

River flooding Firth of Clyde catchment group

Catchment overview

The Firth of Clyde catchment group is located within the Clyde and Loch Lomond Local Plan District and covers over 980km². The catchment group is over 94% rural and almost 6% urban, with a population of approximately 120,000.

This river catchment group contains three local authorities; Argyll and Bute Council, Inverclyde Council and North Ayrshire Council.

The main river catchment within this area is the River Eachaig which is located on the Cowal Peninsula. The Eachaig flows out of Loch Eck, which is surrounded on all sides by steep hills rising to over 700m. The Eachaig flows from the loch down to sea level and discharges into Holy Loch. The remainder of watercourses in the area are characteristically steep burns which flow directly from the numerous hills in the area in to the various sea lochs of the Firth of Clyde.

In the north of the catchment group the River Cur flows from its origin in Monevechadan, southeast of Ardnò and meets the River Shellish, before discharging to Loch Eck at Invernòaden.

The average annual rainfall for the area is 2,515mm, which is very high for Scotland.

Flood risk in the catchment

Within the catchment group there are approximately 540 residential properties predicted to be at risk of river flooding, 92% of which are located within a Potentially Vulnerable Area. There are also approximately 380 non-residential properties predicted to be at risk of river flooding, 77% of which are located within a Potentially Vulnerable Area. There are four Potentially Vulnerable Areas in this catchment (Figure 1):

- Helensburgh to Loch Larg (11/02)
- Isle of Bute (11/06)
- Dunoon (11/07)
- Greenock to Gourock (11/08).

Main areas at risk

The main areas at risk of river flooding can be seen in Table 1, which shows the number of properties at risk and the Annual Average Damages caused by river flooding. This includes damages to residential and non-residential properties, transport and agriculture.

	Residential and non-residential properties at risk of river flooding	Annual Average Damages
Gourock / Greenock / Port Glasgow	380	£440,000
Rothesay	280	£630,000
Dunoon	100	£270,000

Table 1: Main areas at risk of river flooding

Economic activity and infrastructure at risk

The Annual Average Damages caused by river flooding in the Firth of Clyde catchment group are approximately £1.8 million. This accounts for approximately 3% of the estimated Annual Average Damages from all flooding sources within the district. The damages are distributed as follows:

- 45% residential properties (£810,000)
- 41% non-residential properties (£730,000)
- 7% emergency services (£130,000)
- 4% roads (£67,000)
- 2% vehicles (£40,000)
- 1% agriculture (£17,000).

Figure 2 shows the Annual Average Damages throughout the catchment.

Table 2 shows further information about infrastructure and agricultural land at risk of flooding within this catchment.

	Number at risk	Further detail
Community facilities	<10	Includes: educational buildings and emergency services
Utility assets	20	Includes: electricity sub stations, telecommunications, gas production and distribution and mineral and fuel extraction
Roads (km)	6	Notably: A78 between Greenock and Ardgowan A83 through Ardgartan forest
Railway routes (km)	0.7	Notably in Greenock
Agricultural land (km²)	9.4	

Table 2: Infrastructure and agricultural land at risk of river flooding

Designated environmental and cultural heritage sites at risk

Within the catchment there are approximately 10 designated cultural heritage sites at risk of river flooding. These sites include; scheduled monuments, gardens and designed landscapes and listed buildings.

There are approximately 7km² of environmental designated areas at risk of river flooding within the catchment group. The majority of these are Sites of Special Scientific Interest (<6km²) with Special Protected Areas (<1km²).

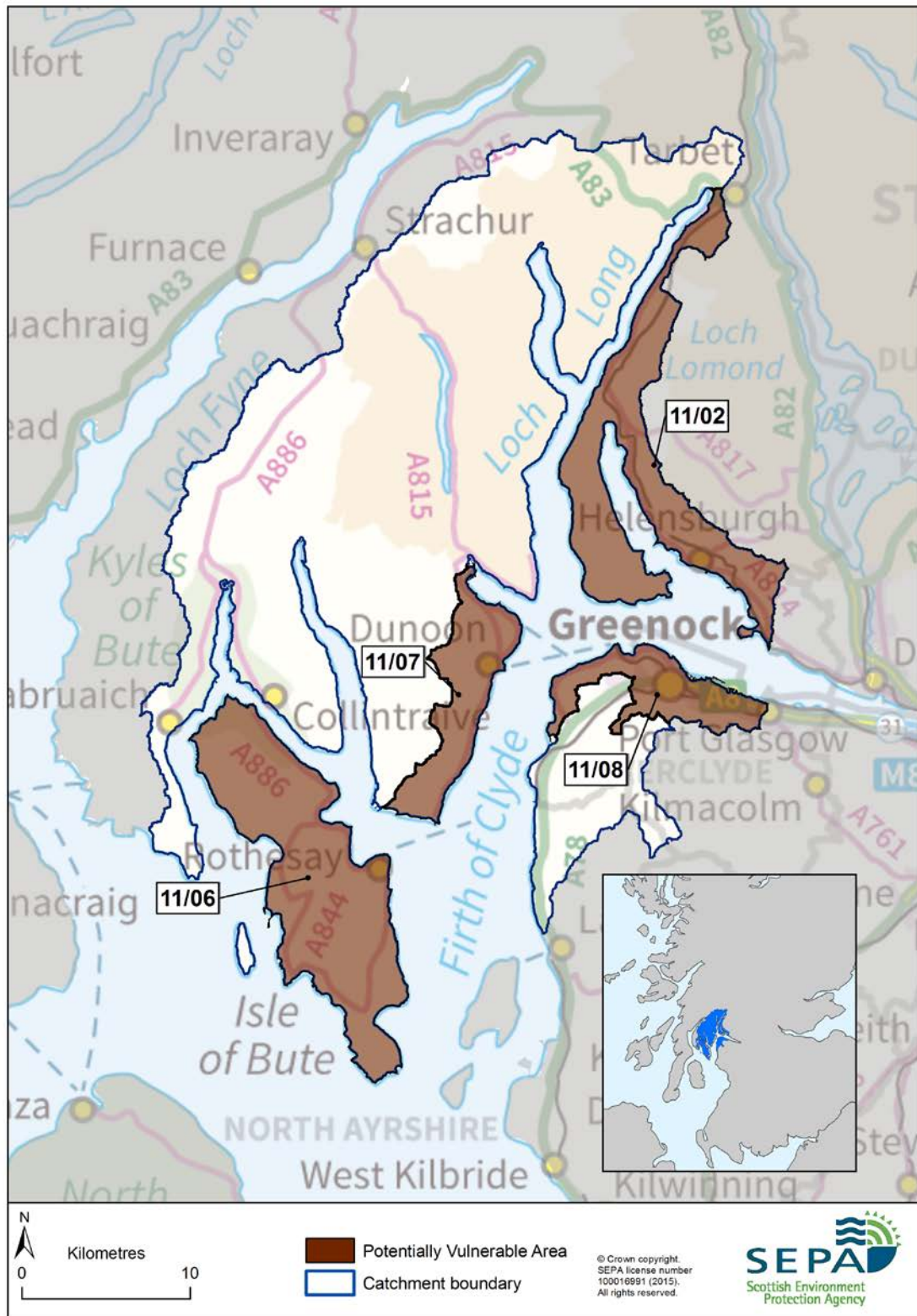


Figure 1: River catchment for the Firth of Clyde catchment group

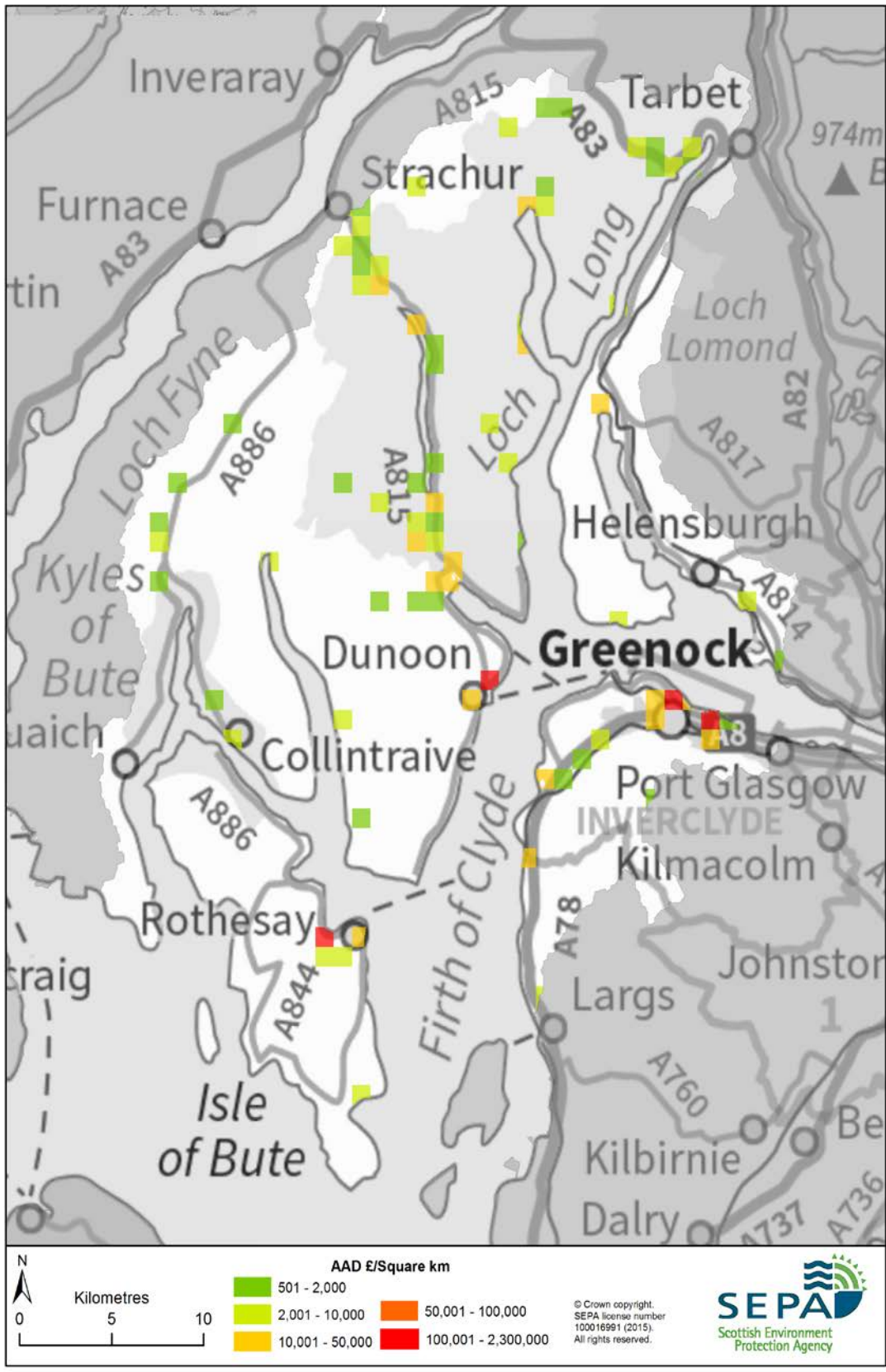


Figure 2: Annual Average Damages from river flooding

History of flooding

There have been few recorded river floods to have impacted properties in the area. As a result of the characteristics of the catchment most flooding is combined with other sources. This can be surface water flowing down the steep hillsides or coastal interaction in the flatter lower catchments. The most significant floods in the area occurred in Greenock in 2014, 2013 and 2011. These floods resulted in several streets in the town centre, including shops, being impacted and the closure of roads causing major traffic disruption.

The earliest recorded flooding in the area was in 1780 with flooding to the north of Loch Eck destroying properties in a small community. Flooding to Rothesay and Greenock have been reordered from 1852.

Further detail about the history of flooding in this area is available in the relevant Potentially Vulnerable Area chapters of this document.

Managing flood risk

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

This section describes the existing actions that are in place to manage flood risk and are in addition to the information presented in the relevant Potentially Vulnerable Area chapter of this document.

Flood protection schemes

Argyll and Bute Council has a number of relevant flood protection schemes within this area. These help to reduce surface water and river flooding:

- Kilbride Road Flood Protection Scheme (2009) consists of overland flow, ditches and pipe.
- In Kilcreggan (2011) flood defence works to reduce the risk of flooding were constructed. This provides additional storage capacity to roadside ditches.
- Milton Burn Flood Protection Scheme (2012) consists of walls, embankments and an overflow pipe.

In addition to the above schemes the spillways of five reservoirs above Greenock have been altered to provide attenuation during high flows and help to reduce the impact of flooding to the town.

Climate change and future flood risk

The UK Climate Projections (UKCP09) predicts that climate change may lead to warmer and drier summers, warmer and wetter winters with less snow, and more extreme temperature and rainfall. The predicted increase in rainfall and river flows may increase the potential for river flooding.

Under the UKCP09 high emissions scenario for 2080, average peak river flows for the Firth of Clyde may increase by 44%¹. This would potentially increase the number of residential properties at risk of river flooding from approximately 540 to 810 and the number of non-residential properties from approximately 380 to 500.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.

Potential for natural flood management

The assessment of the potential for natural flood management is shown on SEPA's flood maps (<http://www.sepa.org.uk/environment/water/flooding/flood-maps/>). The maps indicate the potential for wave attenuation and estuarine surge attenuation. They show areas where natural flood management could be effective and where further detailed assessment should take place. This information was used to identify where local authorities could include natural flood management as part of flood risk management schemes and studies. The proposed schemes and studies are listed in the relevant Potentially Vulnerable Area chapters of this document.

Runoff reduction

Almost all of the catchment has high or medium potential for runoff reduction. Incorporating runoff reduction measures could help to reduce flood impacts in areas such as Greenock and Rothesay.

Floodplain storage

There are areas with the potential for additional flood storage throughout the catchment. Many of these are lochs located upstream including; Loch Thom upstream of Ardgowan, Loch Fad upstream of Rothesay and Loch Eck upstream of Benmore. Some of the lochs are impounding reservoirs and therefore subject to control regimes which regulate their levels and may restrict their suitability to provide additional flood storage. Attenuation storage on the reservoirs above Greenock has previously been installed.

¹ From the study 'An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change' (CEH, 2011).

3.3 Coastal flooding

Clyde and Loch Lomond Local Plan District

This chapter provides supplementary information on flooding for coastal areas. It provides an overview of the natural characteristics of the coast, a summary of flood risk within the coastal area and a brief history of flooding. It also outlines the likely impact of climate change and the potential for natural flood management.

Information about the objectives and actions to manage flood risk are provided in in Section 2.

Coastal overview

The coastal area of the Clyde and Loch Lomond Local Plan District covers approximately 500km of the Firth of Clyde coastline.

There are seven local authorities in this area; Argyll and Bute Council, Glasgow City Council, Inverclyde Council, Renfrewshire Council, North Ayrshire Council, South Lanarkshire Council and West Dunbartonshire Council.

A high percentage of the Inner Firth of Clyde coastline is protected by some form of coastal defence works reflecting the highly developed nature of the coastal area.

Flood risk

There are estimated to be approximately 3,600 residential properties and approximately 1,300 non-residential at risk of coastal flooding. This risk has been calculated from the inland projection of still water levels. Additionally, there is potential impact from locally generated wave mechanisms affecting the coastline. In the Inner Firth of Clyde fetch lengths are relatively small in most directions therefore locally generated waves are the most common. Waves generated from the south are less common; however, wave heights can be double those experienced from other directions. These larger waves could result in additional flooding to some areas.

There are 13 Potentially Vulnerable Areas in this Local Plan District at risk of coastal flooding as listed below. One further Potentially Vulnerable Area (11/17/1) is crossed by the coastal area however there are no damages identified from coastal flooding (Figure 1).

- Loch Lomond and Vale of Leven (11/01)
- Helensburgh to Loch Larg (11/02)
- Kilsyth to Bearsden – north of Glasgow City (11/04)
- Yoker catchment – Clyde (Clydebank to Partick) (11/05)
- Isle of Bute (11/06)
- Dunoon (11/07)
- Greenock to Gourock (11/08)
- Clyde south - Port Glasgow to Inchinnan (11/09)
- Bishopton (11/10)
- Black Cart Water catchment – Lochwinnoch to Johnstone (11/12)
- White Cart Water catchment (11/13)
- Rutherglen (11/14)
- Glasgow City centre (11/16).

Main areas at risk

The main areas at risk of coastal flooding can be seen in Table 1. This shows the number of properties at risk and the total Annual Average Damages caused by coastal flooding for each of these areas. This includes damages to residential and non-residential properties, transport and agriculture.

	Residential and non-residential properties at risk of coastal flooding	Annual Average Damages
Dumbarton	1,700	£11 million
Glasgow City	1,000	£2.4 million
Renfrew	660	£1.2 million
Rothesay	490	£870,000
Gourock/Greenock/Port Glasgow	400	£360,000
Renton	110	£410,000
Clydebank	70	£1.8 million
Port Bannatyne	70	£150,000
Kilchattan Bay	20	£90,000
Ardnadam	10	£60,000
Geilston	10	£50,000
Helensburgh	10	£40,000

Table 1: Main areas at risk of coastal flooding

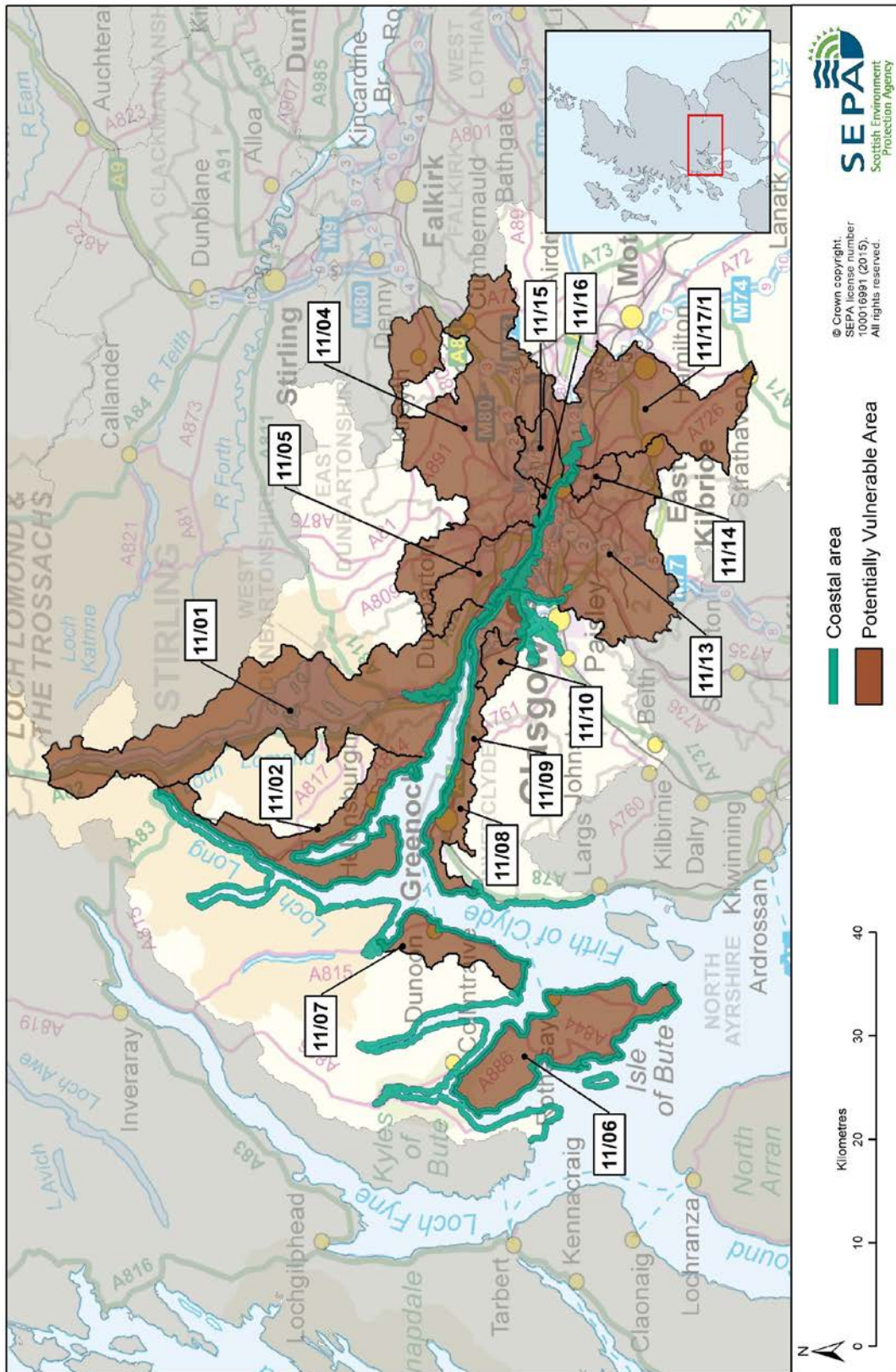


Figure 1: Local Plan District coastal area and Potentially Vulnerable Areas with a risk of coastal flooding

Economic activity and infrastructure at risk

The Annual Average Damages caused by coastal flooding within this catchment are approximately £19 million. The damages are distributed as follows:

- 59% non-residential properties (£11 million)
- 27% residential properties (£5.2 million)
- 5% emergency services (£1.0 million)
- 5% roads (£940,000)
- 3% vehicles (£540,000)
- 1% agriculture (£16,000).

The highest damages are predicted to occur around Clydebank, Dumbarton, Renfrew and Rothesay. High damages can also be seen in Glasgow City (along the Clyde), Port Glasgow, Gourock and Renton. This is due to the density of businesses in the area and the impact on entertainment services, commercial services and industrial properties. Figure 2 shows the Annual Average Damages throughout the coastal area.

Please note that economic damages to rail were not assessed as information on damages at a strategic scale is not available.

Table 2 shows further information about infrastructure and agricultural land at risk of coastal flooding.

	Number at risk	Further detail
Community facilities	<10	Includes: educational buildings and healthcare facilities.
Utility assets	50	Includes: electricity substations, fuel extraction sites, energy production sites and telecommunications sites
Roads (km)	53	Includes: 1.2km of the M8 1km Primary roads 23km A roads 7.5km B roads 12km minor roads
Railway routes (km)	2.8	
Agricultural land (km²)	9	

Table 2: Infrastructure and agricultural land at risk of coastal flooding

Designated environmental and cultural heritage sites at risk

It is estimated that approximately 40 designated cultural heritage sites are at risk of coastal flooding within the catchment. These sites include; scheduled monuments, gardens and designed landscapes, World Heritage Sites and listed buildings.

There are approximately 10 environmental designated areas at risk of coastal flooding, including two Special Protection Areas and eight Sites of Special Scientific Interest. These notably include the Ruel Estuary, the north end of Bute, the Inner Clyde and the Largs coast.

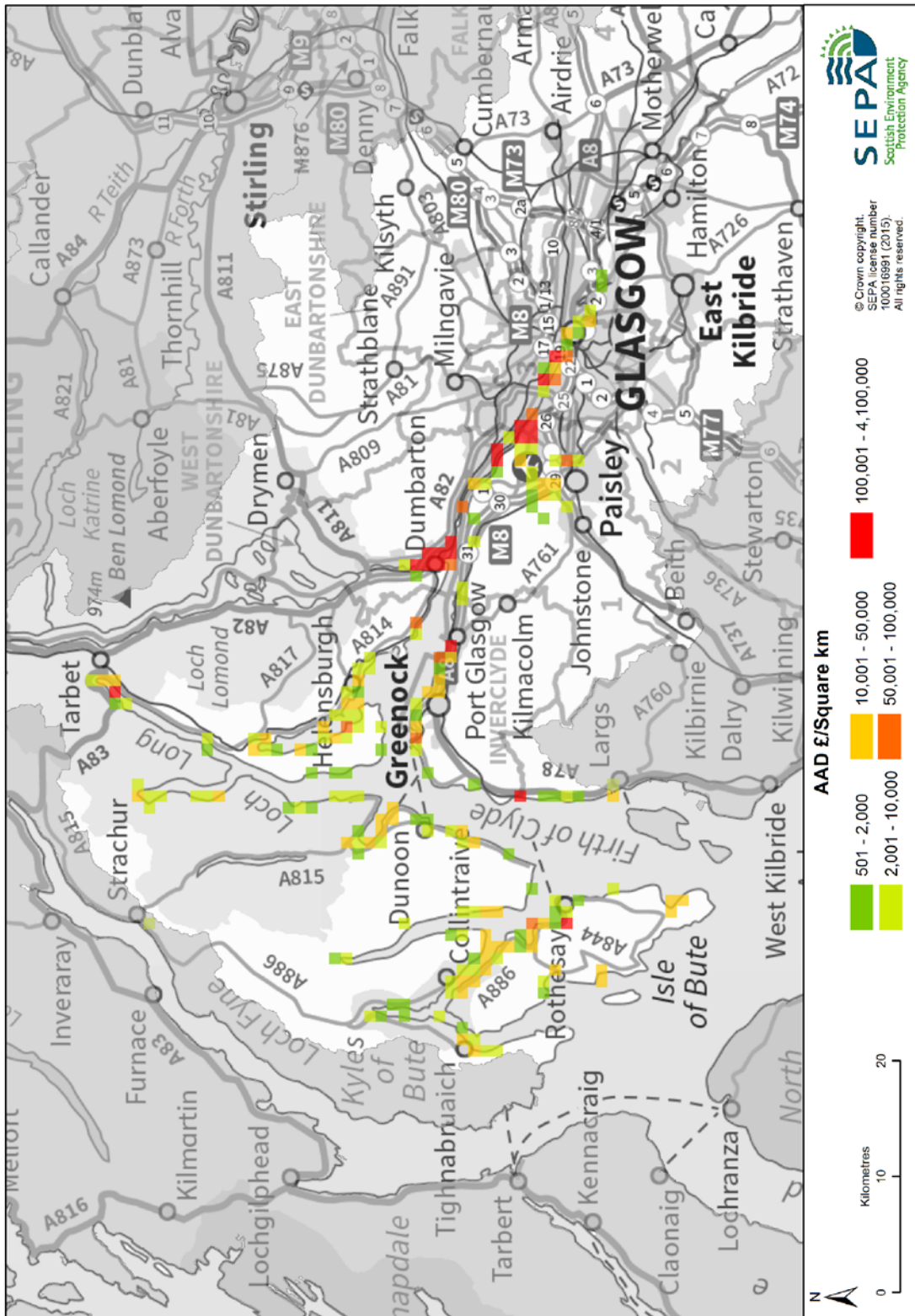


Figure 2: Annual Average Damages from coastal flooding

History of flooding

Recent and notable coastal floods were reported in January 2014, when the entire west coast of Scotland experienced major coastal flooding. Areas that were affected include Helensburgh, Dumbarton, Rothesay, Greenock, Port Glasgow and Gourock. Incidences of coastal flooding have also been reported in Gourock since 1930 with similar flooding on 11 January 1974 affecting access roads to the ferry terminal.

A report in 2001 stated that the highest sea level recorded at Helensburgh was experienced on 5 January 1991. This tidal flood also affected Dumbarton when an extreme high tide coincided with a moderately high river flow and resulted in over £500,000 of damages. Rothesay suffered an estimated £4 million of damages from this coastal flood.

Further detail about the history of flooding in this area is available in the relevant Potentially Vulnerable Area chapters of this document.

Managing flood risk

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

This section describes the existing actions that are in place to manage flood risk and are in addition to the information presented in the relevant Potentially Vulnerable Area chapter of this document.

Flood protection schemes

The coastal flood protection schemes that have been identified in this area are summarised below:

- Rothesay Flood Protection Scheme (2002) involved the construction of new coastal floodwalls and raising of the existing walls of the Mill Lade.
- North Renfrew Flood Protection Scheme, at the time of publication is under construction. The purpose of this scheme is to prevent and/or mitigate flooding in Renfrew from the River Clyde. The operations consist of flood embankments, retaining walls, demountable barriers, river basin remediation and infill and pump station construction on the existing Mill Burn culvert.
- Additionally there are flood protection schemes, within the tidal limit of the Clyde, that are designed to protect principally against river flooding. However, they also offer protection against coastal flooding.

In addition to the formal flood protection schemes there are large areas of this coastline that have hard shoreline, which includes reinforcement structures. Reinforcement structures use materials, such as rock armour, man-made armour, revetments, retaining walls, gabion baskets, seawalls and sheet piling to protect vulnerable coastlines or harbours from erosion.

The location and type of all existing coastal defences in this coastal area are shown in Figure 4 overleaf.

Coastal flood warning schemes

There are 15 coastal flood warning areas within this Local Plan District as shown in Table 3 and Figure 3. Table 3 shows the total number of properties in the flood warning area and the percentage of those properties that have signed up to receive flood warnings. Please note that this is not the number of properties at risk of flooding.

Flood warning area (FWA)	Properties within FWA	% of properties registered May 2014
Dumbarton Common (Dumbarton)	235	13%
Dumbarton Central (Dumbarton)	379	10%
Dumbarton East (Dumbarton)	994	17%
Kames Bay Pointhouse Crescent (Port Bannatyne)	85	36%
Helensburgh	415	22%
Rothesay Town Centre (Rothesay)	407	19%
Dunoon Pier (Dunoon)	104	23%
Hunters Grove (Dunoon)	4	0%
Renfrew	2,410	11%
Glasgow Quay Walls	410	13%
Largs Seafront (Largs)	70	35%
Skelmorlie A78 Shore Road (Skelmorlie)	0	N/A
Gourock Cove Road (Gourock)	150	31%
Largs Fort Street	210	3%
Greenock and Port Glasgow	300	18%

Table 3: Flood warning areas

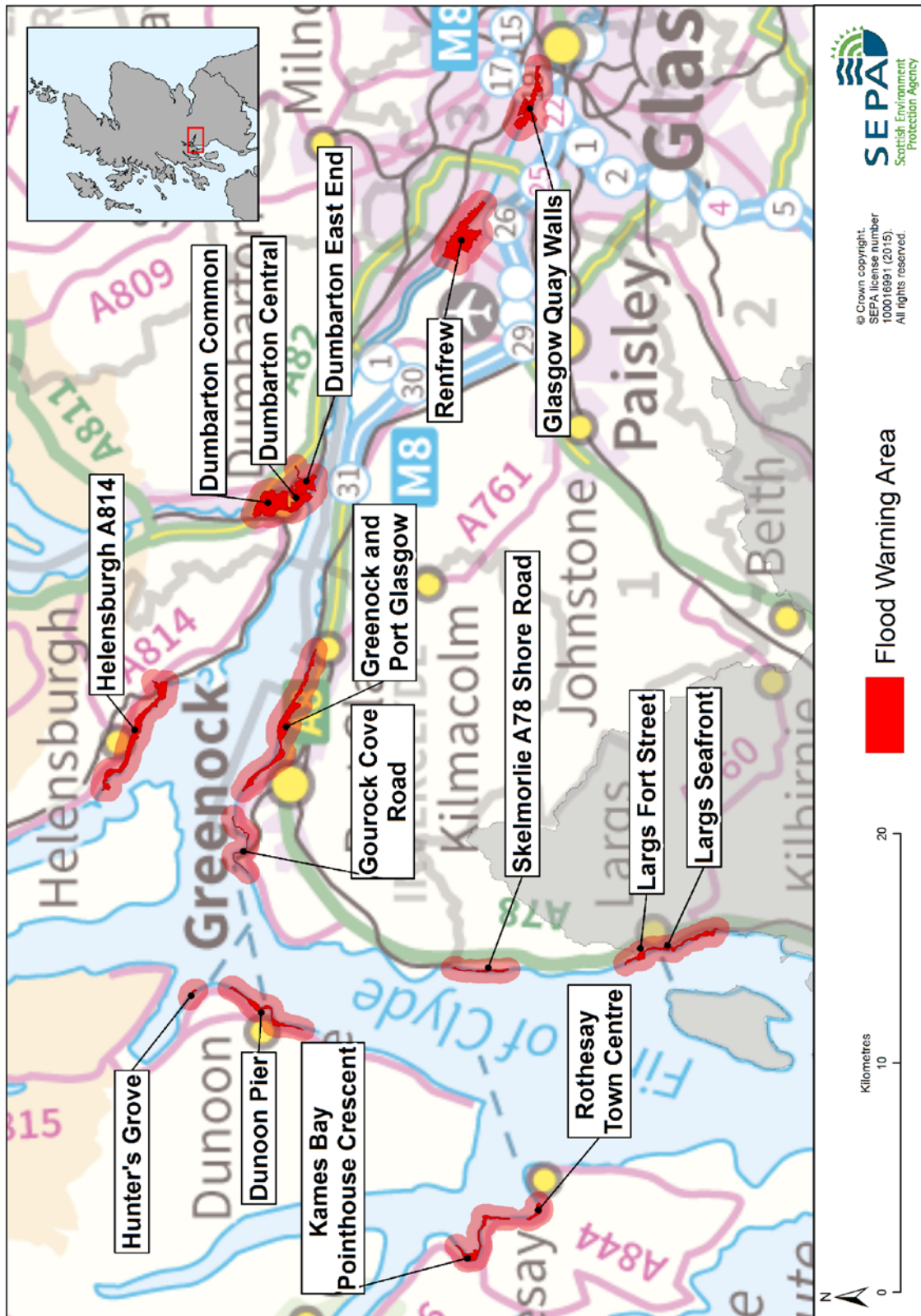


Figure 3: Coastal flood warning areas

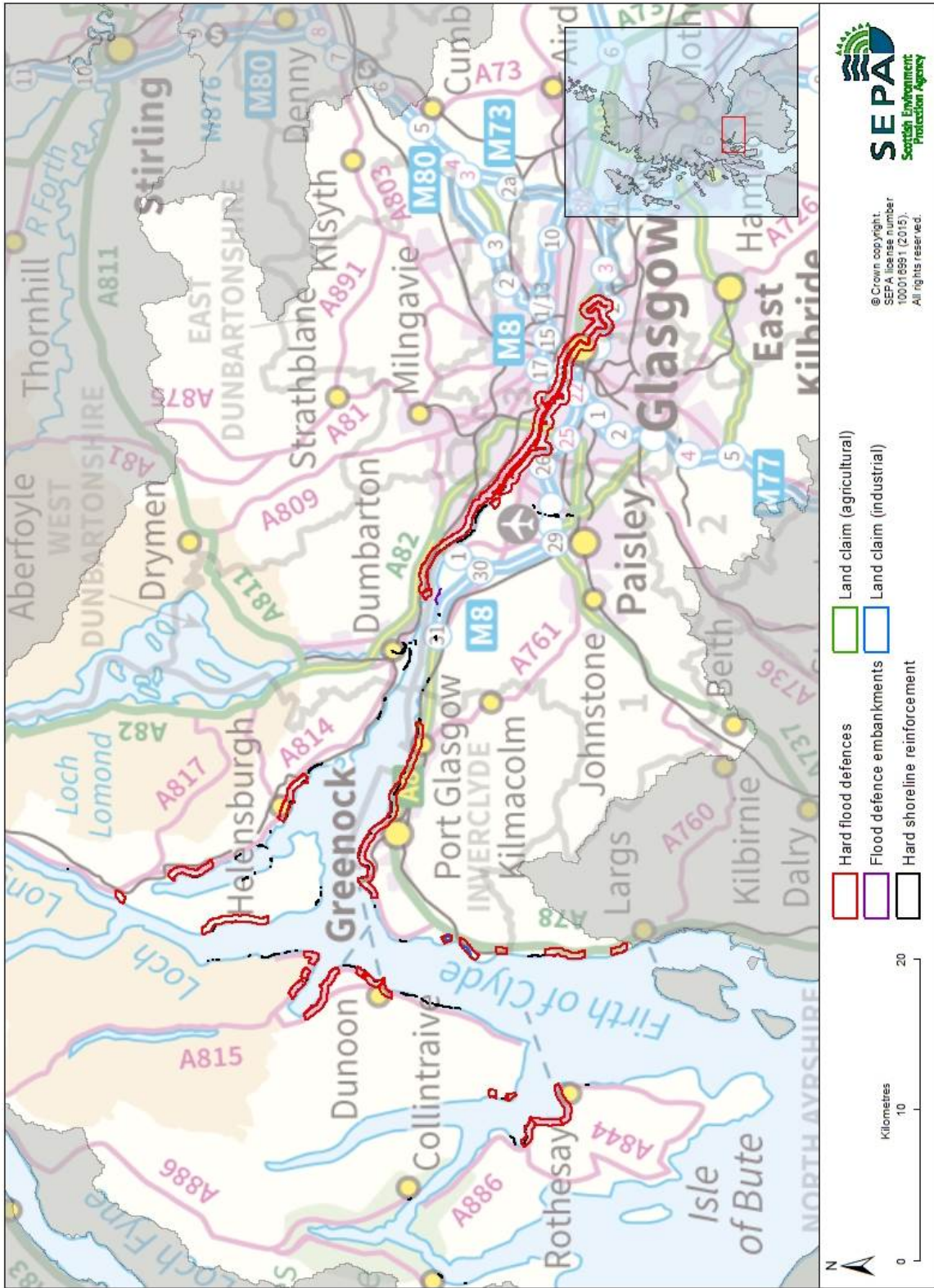


Figure 4: Coastal protection for coastal area

Climate change and future flood risk

UK Climate Projections (UKCP09) predicts that climate change may increase sea levels. The magnitude of sea level rise varies around the coastline.

For the UKCP09 high emissions scenario, the predicted average sea level increase for the Clyde and Loch Lomond Local Plan District is approximately 0.47m by 2080. This may increase the number of residential properties at risk of coastal flooding from approximately 3,700 to 7,500 and the number of non-residential properties from approximately 1,300 to 2,400. Coastal flood modelling by SEPA has not taken into account the impacts of future climate change on wave overtopping or storminess, which could increase the number of people affected by coastal flooding.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.

Potential for natural flood management

The assessment of the potential for natural flood management is shown on SEPA's flood maps (<http://www.sepa.org.uk/environment/water/flooding/flood-maps/>). The maps indicate the potential for wave attenuation and estuarine surge attenuation. They show areas where natural flood management could be effective and where further detailed assessment should take place. This information was used to identify where local authorities could include natural flood management as part of flood risk management schemes and studies. The proposed schemes and studies are listed in the relevant Potentially Vulnerable Area chapters of this document.

Wave energy dissipation

The assessment shows that there are generally areas of high potential for wave energy dissipation along the Firth of Clyde, notably along the Isle of Bute coast, Kames Bay, Lunderston Bay and Ettrick Bay.

Estuarine surge attenuation

Some significant areas with potential for estuarine surge attenuation are present along the Firth of Clyde, including between Erskine Bridge and Milton, Gare Loch and Cove Bay, as well as areas along Loch Long. There are medium potential areas scattered along the majority of the coastline.

3.4 Surface water flooding

Clyde and Loch Lomond Local Plan District

This chapter provides supplementary information on surface water flooding across the Local Plan District. It provides an overview of the main areas at risk and the history of surface water flooding. The predicted impacts on infrastructure are also identified. The impacts on environmental sites and agricultural land have not been assessed.

Information about the objectives and actions to manage flood risk are provided in Section 2.

Flood risk

Within Clyde & Loch Lomond Local Plan District there are approximately 13,000 residential and 6,300 non-residential properties at risk of surface water flooding. Approximately 98% of all properties at risk from surface water flooding are located within Potentially Vulnerable Areas.

Main areas at risk

Glasgow and surrounding areas are highly urbanised and have the greatest risk from surface water flooding in the Clyde and Loch Lomond Local Plan District. Outside of Glasgow, there are 11 areas that have more than 100 residential properties at risk of surface water flooding. Table 1 shows ten areas with the greatest number of properties at risk and the associated Annual Average Damages caused by surface water flooding. The damages include impacts to residential and non-residential properties, vehicles, emergency services and roads. Surface water flooding within these heavily urbanised areas is often associated to flooding from urban watercourses. In many areas, flooding of this type presents the greatest flood risk.

The level of flood risk due to surface water flooding in the greater Glasgow area led to the establishment of the Metropolitan Glasgow Strategic Drainage Partnership (MGSDP). The MGSDP is formed from organisations that are involved in the operation of the sewerage and drainage network within the Greater Glasgow area, including among others: local authorities; Scottish Water; SEPA and Scottish Canals. It provides a forum for the organisations to work in an integrated, collaborative partnership. The MGSDP remit spans from strategic to project level scale. Its objectives are flood risk reduction, river water quality improvement, enabling economic development, habitat improvement and integrated investment planning.

	Residential and non-residential properties at risk of surface water flooding	Annual Average Damages
Glasgow City	8,400	£4.4 million
Paisley and Johnstone	1,700	£1.1 million
Gourock / Greenock / Port Glasgow	890	£1.5 million
Clydebank	540	£440,000
Dumbarton	480	£410,000
Coatbridge / Airdrie	390	£330,000
Rutherglen	380	£260,000
East Kilbride	340	£560,000
Alexandria and Balloch	320	£900,000
Giffnock and Thornliebank	250	£110,000

Table 1: Main areas at risk of surface water flooding

Economic activity and infrastructure at risk

The Annual Average Damages caused by surface water flooding are approximately £20 million. The damages are distributed as follows:

- 47% residential properties (£9.4 million)
- 44% non-residential properties (£8.8 million)
- 7% roads (£1.4 million)
- 2% vehicles (£400,000).

Figure 1 shows the distribution of Annual Average Damages from surface water flooding across the Local Plan District. The figure shows a high concentration of damages in and around Glasgow.

Please note that economic damages to airports and rail were not assessed as information on damages at a strategic scale is not available.

Table 2 shows the approximate numbers of further infrastructure assets that are at risk of flooding within this catchment.

	Number at risk	Further detail
Community facilities	60	Includes; educational buildings and emergency services.
Utility assets	570	Includes; electricity substations, fuel extraction sites and gas regulation sites.
Roads (km)	391	Includes; M73, M8, M80 and M74
Railway routes (km)	127	Includes; West coast line and Glasgow to Edinburgh routes.
Airports	1	

Table 2: Infrastructure at risk of surface water flooding

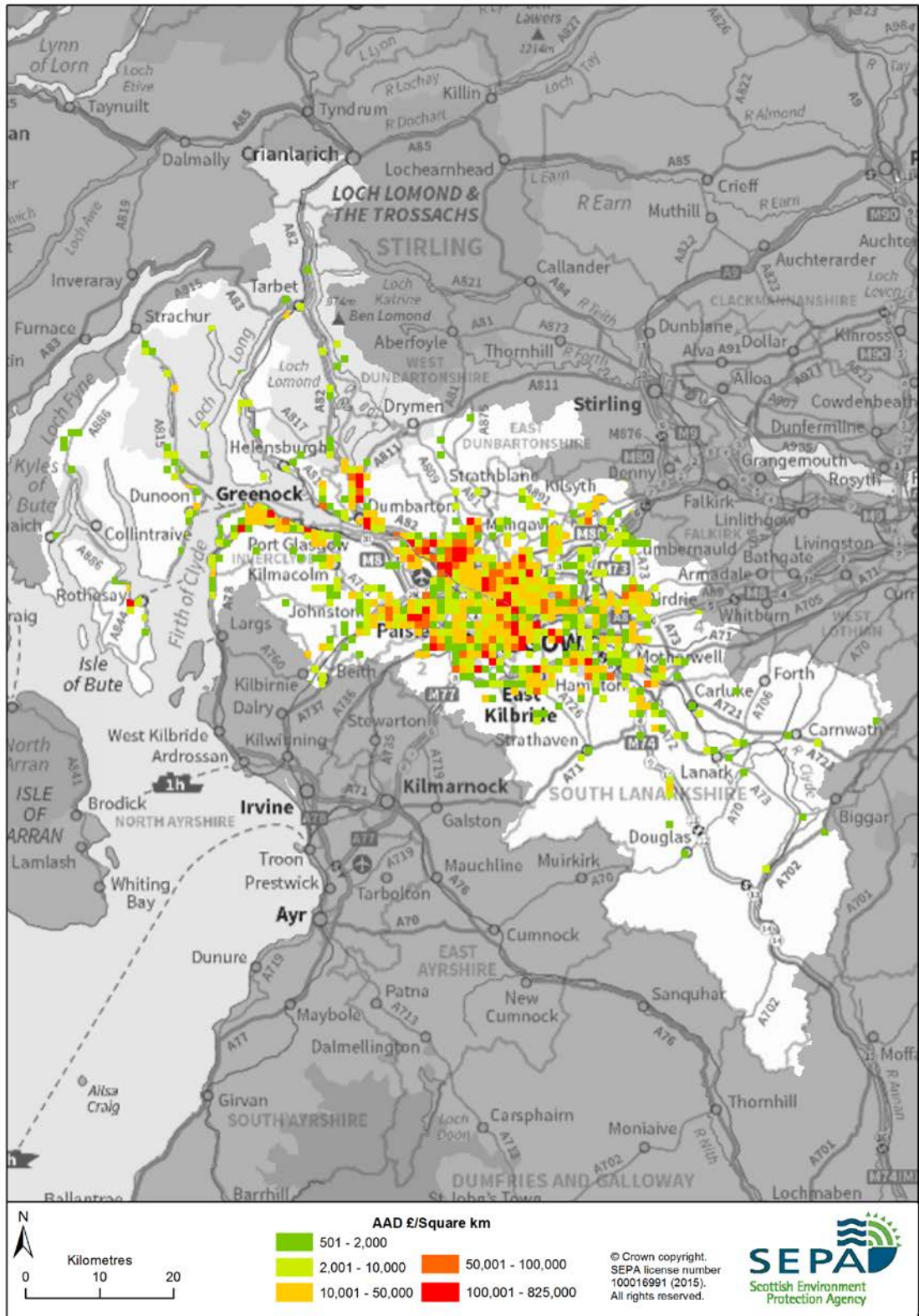


Figure 1: Annual Average Damages from surface water flooding

Designated environmental and cultural heritage sites at risk

Within the Local Plan District it is estimated that 184 designated cultural heritage sites have a risk of surface water flooding. These sites include; scheduled monuments, gardens and designed landscapes, battlefield sites, World Heritage sites and listed buildings.

The impact of surface water flooding on environmental sites has not been assessed and is assumed to be relatively low.

History of surface water flooding

There has been a long history of surface water related floods within the Clyde and Loch Lomond Local Plan District. The most notable of these floods occurred on the 30 July 2002 in Glasgow, when an estimated 1 in 100 year flood resulted in 500 properties being flooded along with serve disruption to road and rail services. The estimated cost of damages was in the region of £100 million.

The earliest recorded flooding in Glasgow was in 1926, and since this time there have been many flood events reported in the city.

The earliest recorded flooding within the Clyde and Loch Lomond Local Plan District was in Hamilton in 1871, with a number of further floods over the next decade in Carluke, Coatbridge, Airdrie, Kilsyth, Wishaw, Kirkintilloch and Paisley, with Coatbridge and Airdrie flooding regularly during this period.

More recently surface water floods have occurred regularly over the last ten years causing flooding to roads and properties across the region including flooding in Greenock, Dumbarton and Bearsden, which have all flooded multiple times during this period. The most recent flooding was in July 2015 with localised flooding impacts in Glasgow and surrounding towns.

Managing flood risk

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

Surface water management priority areas

The areas at highest risk from surface water flooding have been prioritised. These priority areas were identified using SEPA flood models, supplemented with historical flood information and, where available, more detailed modelling from local authorities. These priority areas require the preparation of surface water management plans, the details of which can be found in Section 2.

Since 2002 substantial work has been carried out in the metropolitan Glasgow area to identify those areas that are at highest risk from surface water flooding. Much of this has been helped by the Metropolitan Glasgow Strategic Drainage Partnership

(MGSDP). As a consequence many of these areas have already had surface water management plans established. The priority areas for surface water management studies do not include those areas where a surface water management plan has already been carried out and options for mitigation are being established.

Flood protection schemes

Due to the risk posed by surface water flooding in this Local Plan District many flood protection schemes and works carried out to date have taken surface water flooding into account, including:

- Argyll and Bute – Kilcreggan: Ditches constructed in 2011 to reduce surface water flood risk from overland flow.
- Argyll and Bute – Dunoon: Ditches and pipes to reduce surface water flood risk from overland flow.
- East Dunbartonshire - Milton of Campsie: Bund created in 2013 / 2014 to reduce surface water flood risk from overland flow.
- South Lanarkshire – Blantyre, Armour Court: Swales, road drainage improvements and culvert were constructed in 2011.
- South Lanarkshire – Larkhall, Machan Road: Surface water storage tanks were constructed in 2012.
- South Lanarkshire – East Kilbride Flood Prevention Scheme: creation of interceptor swales, land drainage improvements and removal of surface water flows from the combined sewer drainage system, to reduce flooding to 16 properties.
- South Lanarkshire – A70 Douglas Flood Prevention Scheme: culvert upgrading works and associated flood protection measures to address localised surface water issues to reduce flooding on the A70.
- White Cart Water Flooding Project – Part of the White Cart Water scheme constructed between from 2009 to 2012 has helped to reduce surface water flooding in Glasgow.
- Toryglen Regional Sustainable Urban Drainage pond in 2009
- Ruchill Sustainable Urban Drainage pond in 2008
- Camlachie Burn Overflow project in 2012

In addition to the above, since 2013 the Scottish Water Glasgow Wastewater Strategy (GWS) has delivered:

- Colquhoun Park Flood Alleviation Scheme constructed between 2014 to 2015
- South Dalmarnock Regional Sustainable Urban Drainage pond – Clyde Gateway in 2014
- London Road / Clyde Gateway East Sustainable Urban Drainage, Clyde Gateway in 2012
- Shawfield Masterplan Culvert Works, Clyde Gateway constructed between 2013 to 2015

Surface water management studies

The organisations involved in the operation of the sewerage and drainage network within the Greater Glasgow area have carried out a number of studies to identify the level of risk from surface water flooding and potential mitigation actions. Some of the more recent studies are listed below.

- Glasgow Surface Water Management Study from 2010 to 2012
- International Financial Services District and City Centre West surface water management plan in 2012

- Gartloch / Gartcosh surface water management plan in 2009
- Yoker / Cleddans Burn Hydraulic Model from 2013 to 2014
- Spittal / Cityford Burn Hydraulic Model from 2013 to 2014
- Cardowan surface water management plan from 2013 to 2014
- City Centre surface water management plan from 2013 to 2014
- Shawfield Flood Risk Assessment in 2010

As part of the Scottish Water Glasgow Strategic Study the following have been undertaken:

- Dalmarnock Integrated Drainage Plan from 2009 to 2015
- Shieldhall Integrated Drainage Plan from 2009 to 2014
- Dalmuir Integrated Drainage Plan from 2009 to 2014
- Daldowie Integrated Drainage Plan from 2009 to 2014
- Paisley Integrated Drainage Plan from 2009 to 2014
- Glasgow Strategic Study Estuary - River WQ Optioneering Assessments in 2010
- Glasgow Strategic Study - Inner Clyde Estuary Oxygenation Pilot Trial from 2011 - 2012
- GSS - Lower River Clyde Wastewater Strategy from 2011 to 2012
- LRC3 and Overall Glasgow Strategic Study Final Water Quality Analysis in 2013

Climate Change and Future Flood Risk

UK Climate Projections (UKCP09) predicts that climate change may lead to warmer and drier summers, warmer and wetter winters with less snow, and more extreme temperature and rainfall. The surface water modelling undertaken considered climate change scenarios with a 20% increase in rainfall intensity.

Under these conditions it is estimated that the number of residential properties at risk of surface water flooding may increase from approximately 13,000 to 18,000 and the number of non-residential properties from approximately 6,300 to 8,500.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.