

# Flood Risk Management Strategy

## Ayrshire 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.

### Section 3: Supporting information

3.1	Introduction .....	237
3.2	River flooding .....	238
	• Doon catchment group .....	239
	• Irvine and Ayr catchment group.....	246
	• Isle of Arran catchment group .....	255
3.3	Coastal flooding.....	260
3.4	Surface water flooding.....	270

## 3.1 Introduction

In the Ayrshire 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 <sup>1</sup>	Annual Average Damages	Local authority
<b>River catchments</b>			
Doon catchment group	730	£1.6 million	Dumfries and Galloway Council, East Ayrshire Council, South Ayrshire Council.
Irvine and Ayr catchment group	5,900	£10 million	Dumfries and Galloway Council, East Ayrshire Council, East Renfrewshire Council, North Ayrshire Council, Renfrewshire Council, South Ayrshire Council South Lanarkshire Council.
Isle of Arran catchment group	110	£170,000	North Ayrshire Council
<b>Coastal flooding</b>			
Ayrshire coastal area	1,500	£1.3 million	East Ayrshire Council, North Ayrshire Council, South Ayrshire Council.
<b>Surface water flooding</b>			
Ayrshire Local Plan District	3,100	£3.2 million	Dumfries and Galloway Council, East Ayrshire Council, East Renfrewshire Council, North Ayrshire Council, Renfrewshire Council, South Lanarkshire Council South Ayrshire Council.

**Table 1:** Summary of flood risk from various sources within the Ayrshire Local Plan District

<sup>1</sup> Total number of residential and non-residential properties at risk of flooding.



## River flooding Doon catchment group

### Catchment overview

The River Doon catchment group is located in the Ayrshire Local Plan District and covers an area of over 1,080km<sup>2</sup>. The catchment area is over 97% rural with less than 3% of the area identified as urban and an approximate population of 46,000. This catchment group includes areas of three local authorities; Dumfries and Galloway Council, East Ayrshire Council and South Ayrshire Council.

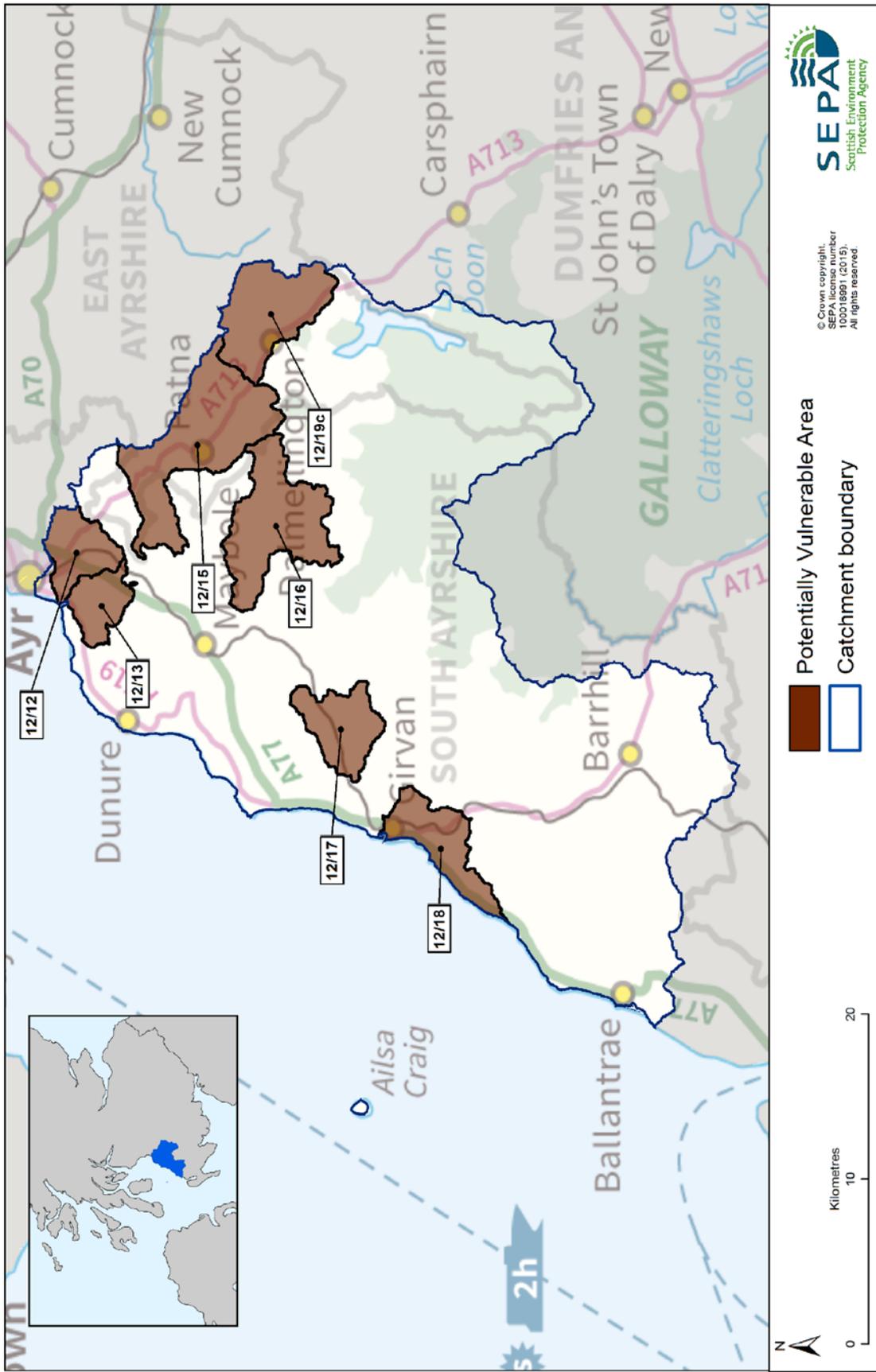
There are three main river catchments within the area: the River Doon, the Water of Girvan and the River Stinchar. The River Doon catchment is located in the north of the area where it flows through a number of small settlements and towns including Dalmellington, Patna, Dalrymple, and Alloway before discharging to the sea at Doonfoot. The Water of Girvan catchment is central in this catchment group, where it receives a number of tributaries and flows through Straiton, Kirkmichael and Dailly, before entering the sea at Girvan. The River Stinchar catchment dominates the south of the Doon catchment group, where it flows in a south westerly direction through Barr, Pinweehy and Colmonell before entering the sea at Ballantrae.

The average annual rainfall in the area broadly typical for Scotland, with values ranging between 1,359mm and 1,566mm in the lowland areas to 1,636mm and 1,803mm in the upper parts of the catchment.

### Flood risk in the catchment

Approximately 600 residential properties are predicted to be at risk of river flooding, 64% of which are located within a Potentially Vulnerable Area and an additional 10% in candidate Potentially Vulnerable Areas. Approximately 130 non-residential properties are predicted to be at risk of river flooding, 41% of which are located within a Potentially Vulnerable Area. There are seven Potentially Vulnerable Areas within this catchment area and one candidate Potentially Vulnerable Area as shown in Figure 1:

- Ayr east (12/12)
- Ayr south (12/13)
- Dalrymple to Patna (12/15)
- Straiton (12/16)
- Dailly (12/17)
- Girvan (12/18)
- Dalmellington (12/19c).



**Figure 1:** River catchment for the Doon 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. Ayr and Dalrymple are the main areas at risk from river flooding.

	Residential and non-residential properties at risk of river flooding	Annual Average Damages
Ayr	170	£370,000
Dalrymple	140	£170,000
Girvan	130	£220,000
Dalmellington	80	£110,000
Kirkmichael	40	£64,000
Barr	20	£60,000
Barrhill	10	£46,000

**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 Doon catchment group are approximately £1.6 million, which accounts for almost 13% of the estimated Annual Average Damages from river flooding within the Ayrshire Local Plan District. The damages are distributed as follows:

- 75% residential properties (£1.2 million)
- 8% non-residential properties (£120,000)
- 6% emergency services (£98,000)
- 4% roads (£65,000)
- 4% agriculture (£63,000)
- 3% vehicles (£40,000).

Figure 2 shows the distribution of Annual Average Damages throughout the catchment group. The highest concentration of damages can be seen in south of Ayr, Barr, Barrhill and Dalrymple.

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 flooding within this catchment.

	Number at risk	Further detail
<b>Community facilities</b>	<10	Includes: educational buildings and emergency services
<b>Utility assets</b>	10	Includes: electricity substations and Scottish Water assets
<b>Roads (km)</b>	6.6	Notably: A77 between Prestwick and Girvan, A713
<b>Railway routes (km)</b>	1.0	Railway between Minishant, Girvan and Wallacetown
<b>Agricultural land (km<sup>2</sup>)</b>	27	

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

### Designated environmental and cultural heritage sites at risk

Within the catchment group it is estimated that approximately 25 designated cultural heritage sites are at risk of river flooding. These sites include; scheduled monuments, gardens and designed landscapes and listed buildings.

Approximately 13 km<sup>2</sup> of environmental designated area is at risk of river flooding. This includes Special Areas of Conservation (<1km<sup>2</sup>), Special Protection Areas (<1km<sup>2</sup>) and Sites of Special Scientific Interest (11km<sup>2</sup>).

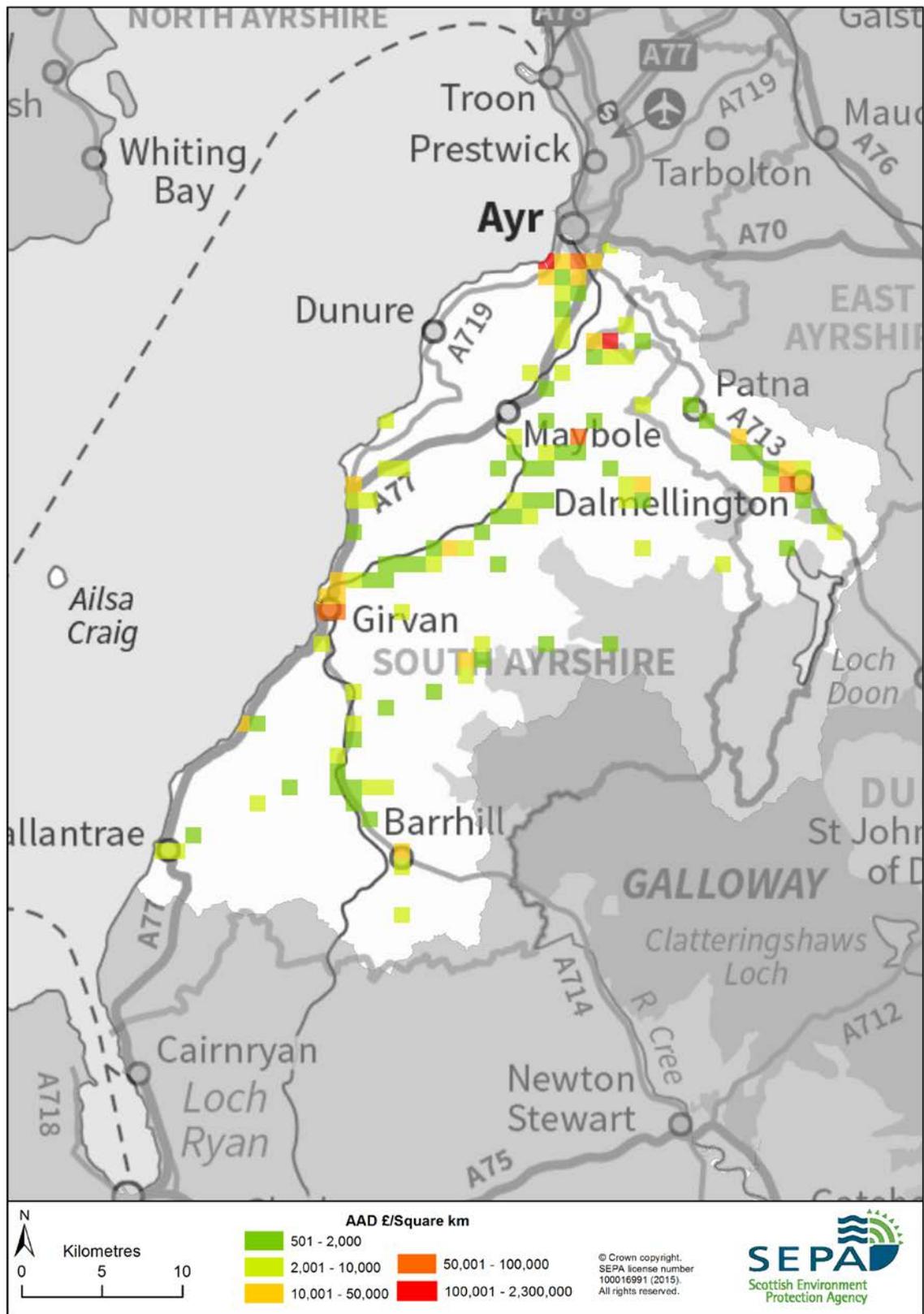
### History of flooding

There is a long history of flooding within the Doon catchment group which tends to have localised impact on properties with more widespread flooding in agricultural areas. The River Doon has been known to flood land and roads in Dalmellington and Patna, most recently in November 2009 with flooding also occurring from the Muck Water resulting in road closures.

Levels on the River Doon in October 1977 were identified as the highest recorded levels on the river at that time.

The earliest and most significant flooding recorded in the area occurred in 1814 when snow melt coincided with an already swollen River Doon to cause flooding to properties in Dalrymple with depths greater than one metre reported in some places.

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



**Figure 2:** Annual Average Damages from river flooding

## 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.

## 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 Isle of Arran catchment may increase by 44%<sup>1</sup>. This would potentially increase the number of residential properties at risk of river flooding from approximately 600 to 760 and the number of non-residential properties from approximately 130 to 150.

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

Scattered locations throughout the catchment group show potential for runoff reduction. Large areas of high potential have been identified to the east of Carrick Forest in close proximity to Barr, which is at risk from river flooding. There are also areas of potential runoff reduction in proximity upstream of Girvan and Ayr.

### Floodplain storage

There are potential areas for floodplain storage identified on the River Doon, upstream of Patna. Downstream of this area the Doon contributes to flood risk within the Dalrymple and Doonfoot areas.

---

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

The Water of Girvan has medium and high potential areas for floodplain storage between Crosshill and Girvan. Incorporating flood storage has the potential to reduce flood risk in areas such as Girvan, Old Dailly and Dailly.

Areas with floodplain storage potential are also identified along the River Stinchar between Colmonell and Pinwherry and between Asselfoot and Barr. The River Stinchar contributes to flood risk downstream in Ballantrae and Colmonell.

### **Sediment management**

Most deposition occurs along the River Doon between Dalcairney and Patna. Upstream of Girvan, which is an area identified at risk due to river flooding, the Water of Girvan appears stable with balanced areas of erosion and deposition. Other smaller tributaries in the area appear mostly balanced apart from some notable areas of erosion which occur near Carrick Forest, Macaterick, Mullwharchar, along Ness Glen and Glenalla Fell. Incorporating sediment management measures in these tributaries may potentially reduce flood risk downstream.

## River flooding Irvine and Ayr catchment group

### Catchment overview

The Irvine and Ayr catchment group is located within the Ayrshire Local Plan District, covering an area of approximately 1,500km<sup>2</sup>. The area is almost 94% rural with the remainder urban, and an approximate population of 330,000. This catchment group includes areas of seven local authorities; Dumfries and Galloway Council, East Ayrshire Council, East Renfrewshire Council, North Ayrshire Council, Renfrewshire Council, South Lanarkshire Council and South Ayrshire Council.

There are three main river catchments which are the River Garnock, the River Irvine and the River Ayr. The River Garnock is the main river catchment in the north of the catchment group, flowing south through the towns of Kilbirnie, Glengarnock, Dalry, and Kilwinning before joining the River Irvine and entering the sea at Irvine harbour. The River Irvine is the main river catchment in the centre of the catchment group, flowing east to west, passing through Newmilns, Galston, Kilmarnock and Irvine, before discharging to the sea at Irvine. The River Ayr catchment dominates the south of the catchment group and flows in the same direction as the River Irvine through Muirkirk, Catrine and Annbank before entering the sea at Ayr.

The average annual rainfall in this area is broadly typical for Scotland, ranging between 1,211mm and 1,552mm in the lowland areas to 1,294 and 1,756mm in the upper parts of the catchment.

### Flood risk in the catchment

Approximately 4,700 residential properties are predicted to be at risk of river flooding, 96% of which are located within a Potentially Vulnerable Area. Approximately 1,200 non-residential properties are predicted to be at risk of river flooding, 93% of which are located within a Potentially Vulnerable Area. There are 10 Potentially Vulnerable Areas at risk of river flooding situated within this catchment as shown in Figure 1:

- Noddsdale Water (12/01)
- Largs to Stevenston (12/03)
- Upper Garnock catchment (12/04)
- Kilwinning (12/05)
- River Irvine and Annick Water catchments (12/06)
- Irvine to Troon (12/07)
- Prestwick and Ayr (12/09)
- Pow Burn catchment (12/10)
- River Ayr catchment (12/11)
- Cumnock and Catrine (12/14).



## 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. Irvine has been identified as the main area at risk.

	Residential and non-residential properties at risk of river flooding	Annual Average Damages
Irvine (including Dreghorn)	1,700	£4.5 million
Kilmarnock (including Hurlford)	820	£940,000
Kilbirnie	790	£710,000
Prestwick / Ayr	480	£1.0 million
Galston	380	£130,000
Newmilns / Greenholm	310	£370,000
Catrine	210	£270,000
Kilwinning	90	£240,000
Lochwinnoch	90	£150,000
Troon / Barassie	90	£130,000
Stevenston	80	£120,000
Cumnock / Logan	70	£160,000
Dalry	50	£370,000

**Table 1:** Main areas at risk of river flooding

## Economic activity and infrastructure at risk

The Annual Average Damages from river flooding are estimated to be approximately £10 million, which accounts for approximately 86% of the estimated Annual Average Damages from river flooding within the Local Plan District. The damages are distributed as follows:

- 63% residential properties (£6.6 million)
- 23% non-residential properties (£2.4 million)
- 5% emergency services (£560,000)
- 4% roads (£400,000)
- 3% vehicles (£300,000)
- 2% agriculture (£100,000).

Figure 2 shows the distribution of Annual Average Damages throughout the catchment. The figure shows that the greatest concentrations of damages are in Kilmarnock, Irvine, Kilbirnie and Prestwick.

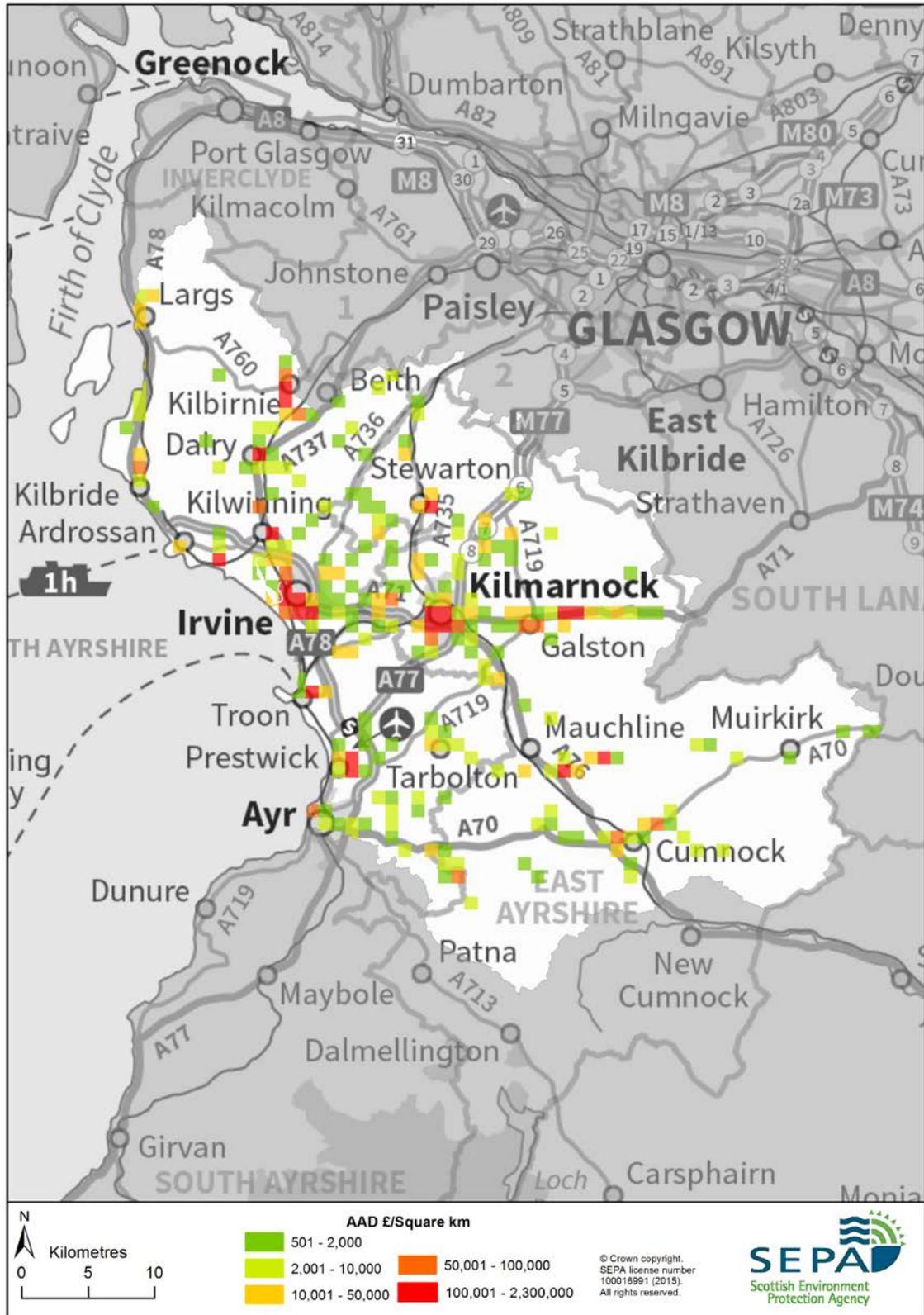
Table 2 shows further information about infrastructure and agricultural land at risk of flooding within this catchment.

	Number at risk	Further detail
<b>Community facilities</b>	20	Includes: educational buildings, emergency services and healthcare facilities
<b>Utility assets</b>	80	Includes: electricity substations, telecommunications, oil refining, gas regulating, mineral and fuel extraction and gas production and distribution
<b>Roads (km)</b>	19.7	Notably: A71 at Kilmarnock, Newmilns and Darvel A78 in Largs and Stevenston A737 in Irvine A76 between Cumnock and Kilmarnock A77 M77 to Kilmarnock from Glasgow
<b>Railway routes (km)</b>	4.7	Kilmarnock to New Cumnock Glengarnock to Stevenston West Kilbride in the north-west of the area.
<b>Agricultural land (km<sup>2</sup>)</b>	50	

**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 32 designated cultural heritage sites are at risk of river flooding. These sites include scheduled monuments, gardens and designed landscapes and listed buildings. Approximately 6km<sup>2</sup> of environmental designated areas are at risk of river flooding. This includes Special Areas of Conservation (<1km<sup>2</sup>), 1 Special Protection Area (2km<sup>2</sup>) and Sites of Special Scientific Interest (4km<sup>2</sup>).



**Figure 2: Annual Average Damages from river flooding**

## History of flooding

There has been a long history of flooding impacting properties and people in this catchment group. The greatest damage from flooding occurred in Kilbirnie and Glengarnock where on three occasions (9 August 2004, 1 August 2008 and 28 September 2010) flooding from the River Garnock and tributaries caused flooding to a large number of properties and roads, further downstream there has also been regular flooding recently. In October 2013 the Bannoch Burn flooded Kilwinning with records showing that since 2004 there have been three incidents of flooding at this location.

There is also the potential for significant infrastructure disruption due to flooding in this area as seen when Prestwick International Airport was closed on the 20 December 2012. This was due heavy rain causing the Pow Burn to burst its banks. This flooding was combined with surface water flooding.

The most recent flooding within the catchment group occurred on 22 December 2014 with flooding from the River Irvine and Kilmarnock Water caused damage to properties including a retail park in Kilmarnock.

The earliest flood was recorded in 1739 in Ayr, and there was a significant regional flooding in 1852 with flooding to towns along the River Irvine and Kilmarnock Water including, Galston, Newmills, and Kilmarnock. Water levels were reported up to horse head level. Since then flooding has occurred on a number of occasions in Kilmarnock with some of the most notable flooding reported in January 1932 when 150 families were rescued after due to flooding from the River Irvine and Kilmarnock Water.

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 more closely 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

East Ayrshire Council has completed a number of flood protection schemes within the catchment group area including:

- Formal flood defences in Galston consisting of clad sheet pile walls and earth embankments on the River Irvine in Crookedholm and the Burn Anne (2008)
- Kilmarnock is defended by clad sheet pile walls, constructed on the Kilmarnock Water, 1998, and on the River Irvine in 2000;

- Attenuation ponds at Milton and Galston were constructed to relieve localised flooding issues.

North Ayrshire Council has completed two flood protection schemes within the catchment group area including:

- A low earth bund constructed along the banks of the River Irvine to reduce the risk of flooding to Waterside to a 1 in 20 year return period, based on the Waterside flood risk management study.
- A formal defence scheme in Glengarnock constructed in 1973.

### River flood warning schemes

SEPA operates a flood warning scheme in the Irvine and Ayr catchment group area. Flood Warnings are issued when river flooding is forecast for the flood warning areas. There are two river flood warning areas which are Irvine Waterside / Low Green in Irvine and Queen's Drive, New Mill Road and Samson Avenue in Kilmarnock, as shown in Figure 3 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	Properties within FWA	% of properties registered May 2014
Irvine Waterside / Low Green (Irvine)	Irvine	30	47%
Queen's Drive, New Mill Road and Samson Avenue (Kilmarnock)	Irvine	180	12%

**Table 3:** Flood warning areas

North Ayrshire Council is currently working in partnership with SEPA to develop a flood warning scheme for the Upper Garnock. As part of its flood warning service development, SEPA aims to provide a new river flood warning scheme for the River Garnock by the end of 2016 with objectives of reducing the impact of flooding and improving the preparedness and response of communities and responders.

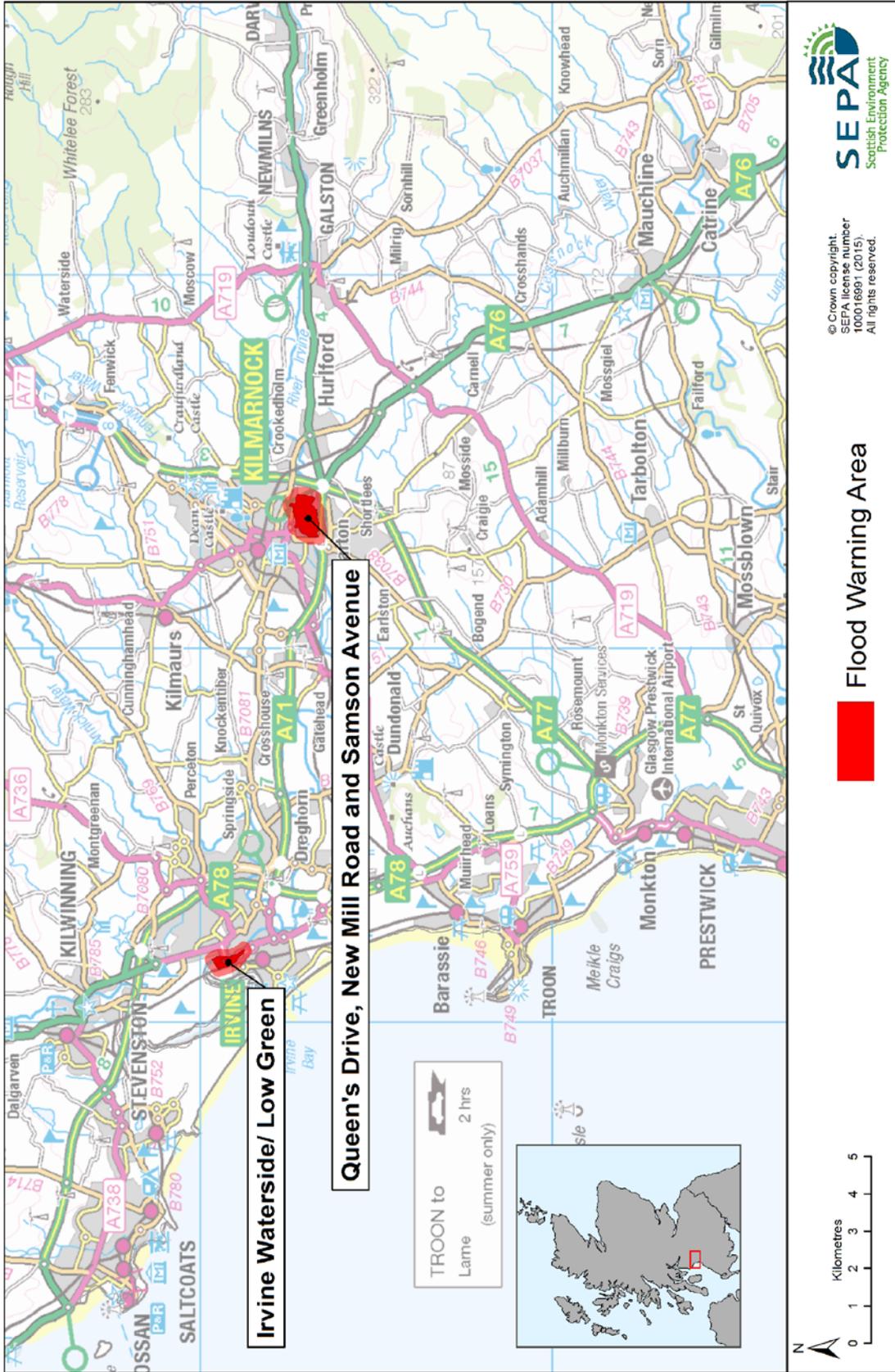


Figure 3: Flood warning areas

## 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 Irvine and Ayr catchment group may increase by 44%<sup>1</sup>. This would potentially increase the number of residential properties at risk of river flooding from approximately 4,700 to 7,000 and the number of non-residential properties from approximately 1,200 to 1,800.

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 that there are areas with potential for runoff reduction and floodplain storage throughout the River Garnock, River Irvine and River Ayr catchments. The highest density of areas for potential runoff reduction is outside of Kilmarnock. A notable area of high potential for floodplain storage is situated along the Water of Fail, a tributary of the River Ayr, close to Tarbolton. Another notable area of potential storage is identified along the River Garnock between Longbar and Dalry.

### Sediment management

The assessment for sediment management shows that the River Ayr and River Irvine have stretches of high deposition and high erosion upstream of flood risk areas. Another area of high deposition exists on the River Irvine in Irvine, where again there is flood risk. Incorporating sediment management measures in some of these rivers may potentially reduce flood risk downstream.

---

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

## River flooding Isle of Arran catchment group

### Catchment overview

The Isle of Arran is located within the Ayrshire Local Plan District. It covers an area of approximately 2,240km<sup>2</sup>, which is approximately 98% rural and 2% urban with a population of around 7,300. The Isle of Arran is within the North Ayrshire Council area.

In the north of the island there are hills with elevations of up to 874m, falling steeply to sea level. In the south of the island there are lower and more gradual slopes, with a maximum elevation of 512m.

Due to the size of the island there are no major rivers within the area. There are a series of burns leading from the upland areas to Firth of Clyde and Kilbrannan Sound.

Rainfall for this area is above the national annual average at 1,965mm.

### Flood risk in the catchment

There are approximately 90 residential properties at risk of river flooding 82% of which are located within a Potentially Vulnerable Area. Approximately 20 non-residential properties are predicted to be at risk of river flooding 65% of which are located within a Potentially Vulnerable Area. There is one Potentially Vulnerable Areas at risk of river flooding situated within this catchment as shown in Figure 1.

#### 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 properties at risk of river flooding	Annual Average Damages
Lamlash	30	£25,000
Brodick	10	£9,400

**Table 1:** Main areas at risk of river flooding

#### Economic activity and infrastructure at risk

The Annual Average Damages caused by river flooding within the Isle of Arran are approximately £170,000. The damages are distributed as follows:

- 70% residential properties (£120,000)
- 11% non-residential properties (£18,000)
- 7% emergency services (£12,000)
- 5% roads (£9,000)
- 5% agriculture (£8,000)
- 2% vehicles (£3,000).

Figure 2 shows the distribution of Annual Average Damages throughout the Isle of Arran. The figure shows the highest concentration of damages is in Lamlash. Table 2 shows further information about infrastructure and agricultural land at risk of flooding within the Isle of Arran.

	Number at risk	Further detail
<b>Community facilities</b>	0	
<b>Utility assets</b>	0	
<b>Roads (km)</b>	0.3	A841 between Lochranzra and Sannox
<b>Agricultural land (km<sup>2</sup>)</b>	5	

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

### Designated environmental and cultural heritage sites at risk

Within the Isle of Arran it is estimated that seven designated cultural heritage sites are at risk of river flooding. These sites include: scheduled monuments, gardens and designed landscapes and listed buildings.

Approximately 3km<sup>2</sup> of environmental designated areas are at risk of river flooding. This includes a Special Protection Area (1km<sup>2</sup>) and Sites of Special Scientific Interest (2km<sup>2</sup>).

### History of flooding

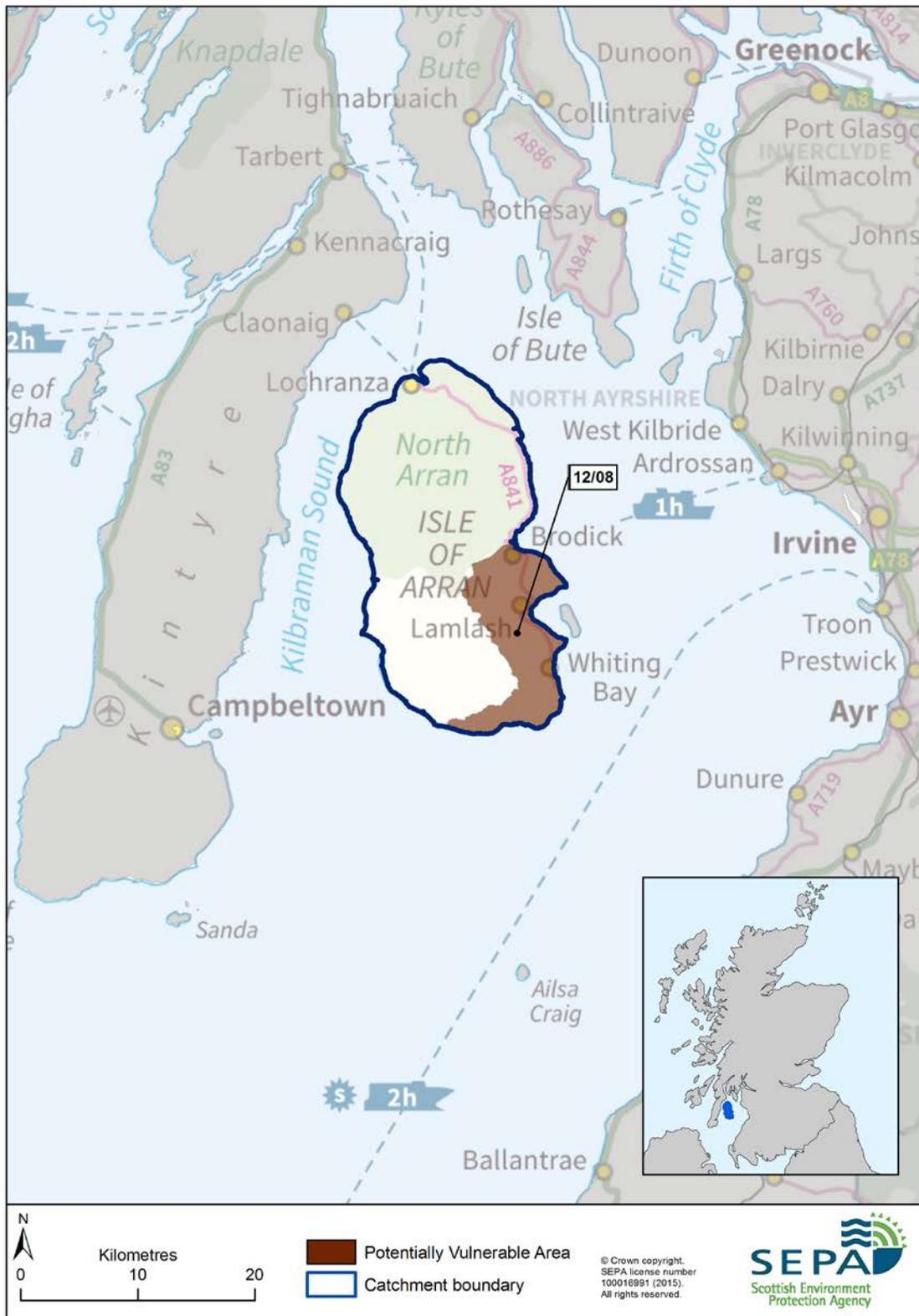
There is little recorded major river flooding to properties on the Isle of Arran. Recent river flooding includes, March 2009 at Corrie where water flowed into gardens.

On 19 June 2005 heavy overnight rain followed by thunderstorms led to flooding around Brodick. The Cloy Burn was blocked at Auchrannie Lodges by a footbridge being washed down at Kilmichael. Water from the Cloy Burn entered streets, gardens and properties.

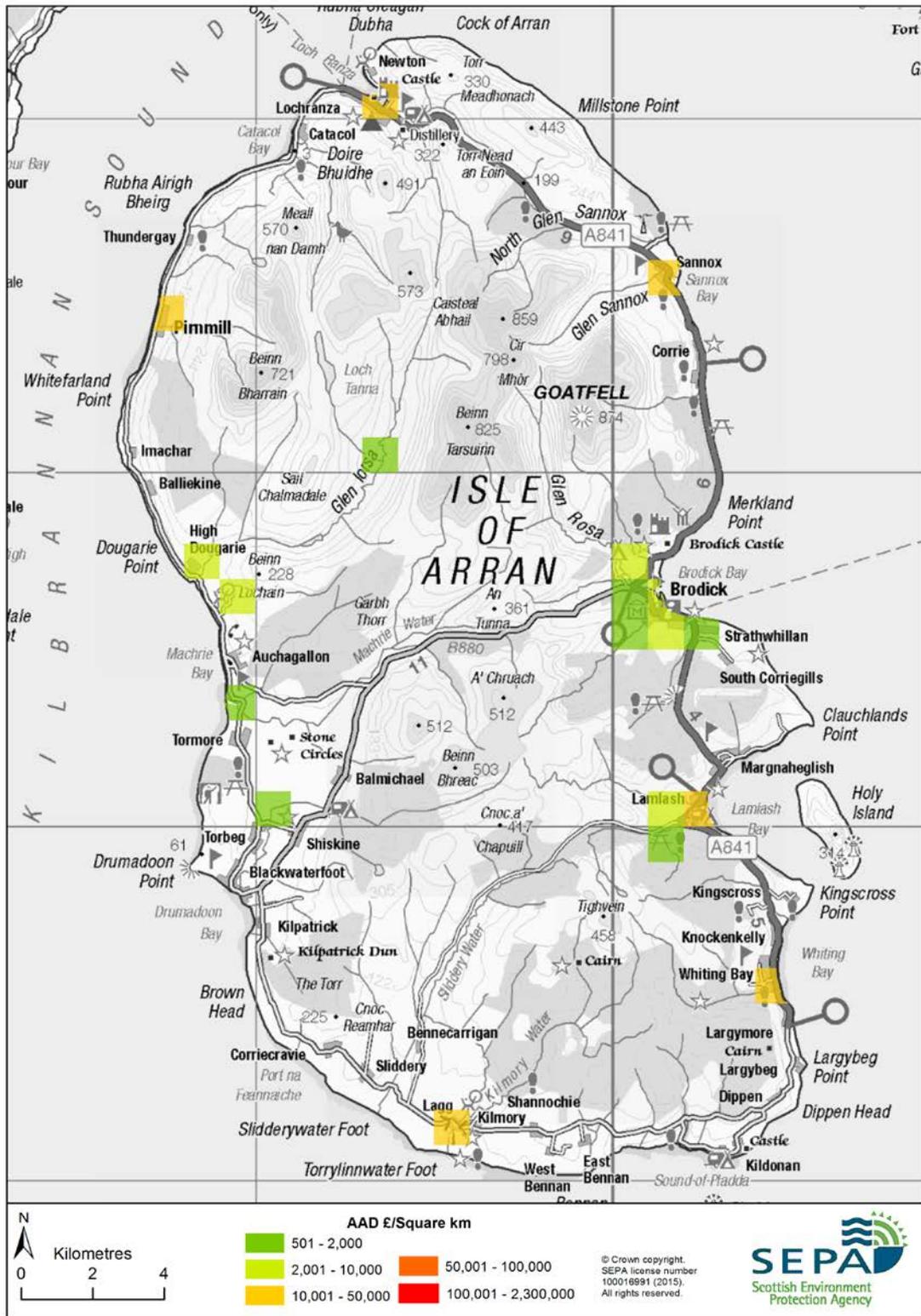
Further detail about the history of flooding in this area is available in the relevant Potentially Vulnerable Area chapters of this document.

### 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.



**Figure 1:** River catchment for the Isle of Arran catchment group



**Figure 2: Annual Average Damages from river flooding**

## 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 Isle of Arran catchment may increase by 44%<sup>1</sup>. This would potentially increase the number of residential properties at risk of river flooding from approximately 90 to 130 and the number of non-residential properties at risk of river flooding from approximately 20 to 40.

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 that almost all of the Isle of Arran has potential for runoff reduction although there may be restricted ability to alter the land cover in some of the steeper areas. There are large areas of potential for runoff reduction upstream of Brodick and Lamlash in the east, as well as Lochranza in the north.

---

<sup>1</sup> 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

### Ayrshire 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.

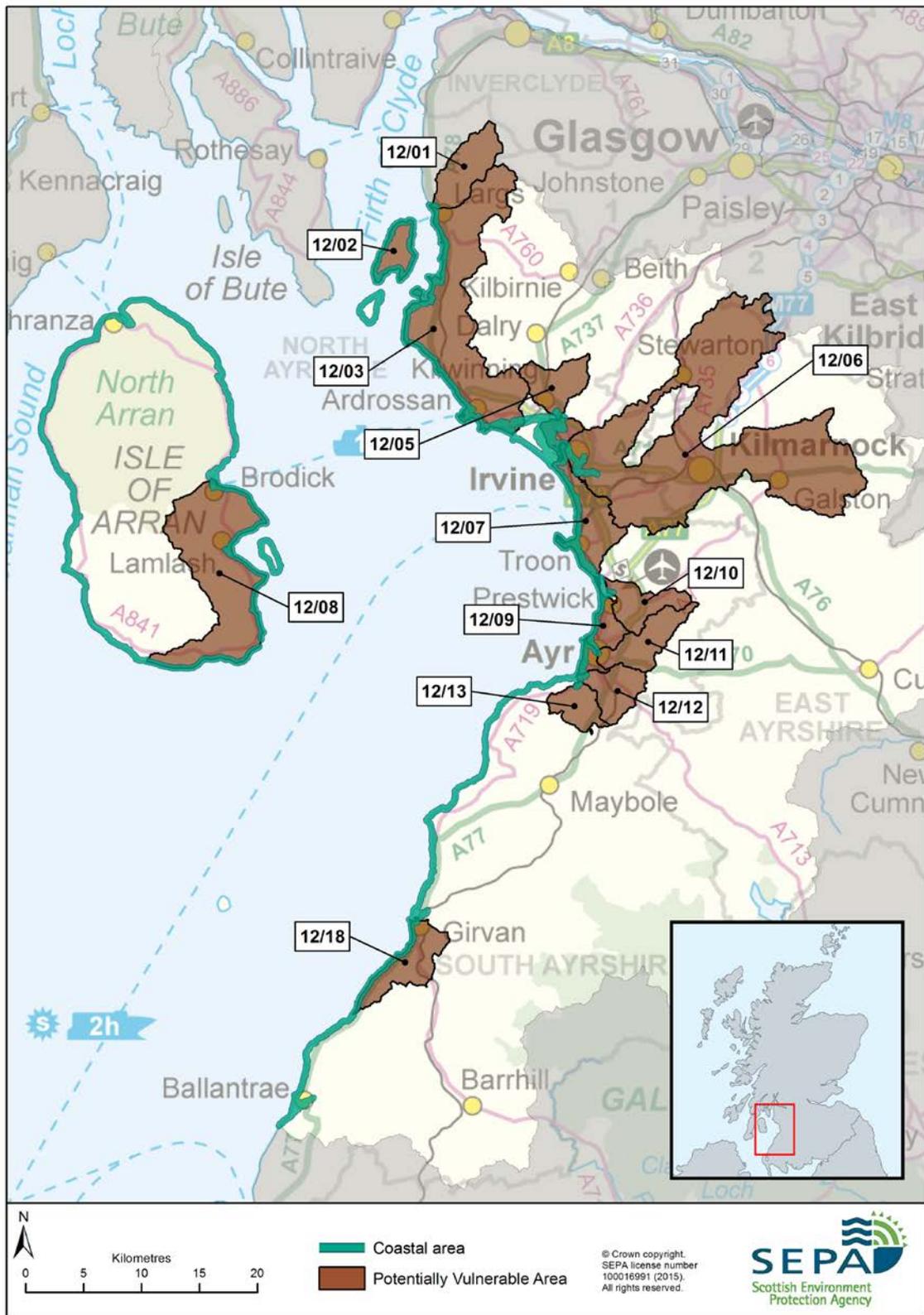
#### Coastal overview

The coastal area of the Ayrshire Local Plan District covers approximately 300km of coastline including the Firth of Clyde, Great Cumbrae and the Isle of Arran. There are several coastal communities in this area including Troon, Largs, Prestwick/Ayr, Salcoats/Ardrossan and Irvine.

#### Flood risk

There are estimated to be approximately 940 residential properties and 540 non-residential properties at risk of coastal flooding. This risk has been calculated from the inland projection of still water levels. Additionally there are potential impacts from locally generated wave mechanisms affecting the coastline. Local coastal modelling, including wave overtopping in Millport, has shown approximately an additional 780 properties at risk. There are 12 Potentially Vulnerable Areas in this Local Plan District at risk of coastal flooding as listed below. Potentially Vulnerable area 12/10 is near the coast although has no damage from coastal flooding (Figure 1).

- Noddsdale Water (12/01)
- Great Cumbrae Island (12/02)
- Largs to Stevenston (12/03)
- Kilwinning (12/05)
- River Irvine and Annick Water catchments (12/06)
- Irvine to Troon (12/07)
- Isle of Arran (12/08)
- Prestwick and Ayr (12/09)
- River Ayr catchment (12/11)
- Ayr east (12/12)
- Ayr south (12/13)
- Girvan (12/18).



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

## Main areas at risk

The ten areas at the greatest risk of coastal flooding can be seen in Table 1. Table 1 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. The property count for Millport comes from a local authority study, while all other values are from a SEPA study.

	Residential and non-residential properties at risk of coastal flooding	Annual Average Damages
Troon	780	£250,000
Millport	780	£2.2 million
Largs	240	£130,000
Prestwick/Ayr	210	£190,000
Fairlie	70	£20,000
Lamlash	30	£110,000
Brodick	30	£25,000
Irvine (including Dreghorn)	20	£220,000
Girvan	20	£20,000
Stevenston	10	£8,000

**Table 1:** Main areas at risk of coastal flooding

## Economic activity and infrastructure at risk

The Annual Average Damages caused by coastal flooding within this coastal area are approximately £1.3 million. The damages are distributed as follows:

- 48% residential properties (£630,000)
- 30% non-residential properties (£400,000)
- 16% roads (£210,000)
- 4% emergency services (£60,000)
- 1% vehicles (£30,000)
- 1% Agriculture (£10,000).

There is potential for damages all along the Ayrshire coastline with the highest damages predicted to occur to properties, shops and services in Ayr, Irvine Troon and Lamlash. Figure 2 shows the Annual Average Damages throughout the coastal area.

In addition, golf courses such as Turnberry, Prestwick and Royal Troon are potentially significant local economic drivers that could be affected by coastal erosion and flooding.

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	Educational buildings
Utility assets	20	Includes: electricity substations and telephone exchanges
Roads (km)	4	Notably: A78 between Fairlie and Largs, the A719 and the A841
Railway routes (km)	0.5	Notably between Fairlie and Largs
Agricultural land (km <sup>2</sup> )	4.6	

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

### Designated environmental and cultural heritage sites at risk

Within the catchment it is estimated that approximately 18 designated cultural heritage sites are at risk of coastal flooding. These sites include; scheduled monuments, gardens and designed landscapes and listed buildings.

Approximately 24 environmental designated areas are at risk of coastal flooding, 23 of which are Sites of Special Scientific Interest with one Special Protection Area. These include the Girvan to Ballantrae coast, south coast of Arran, Portencross coast, Ballochmartin Bay, Ardrossan to Saltcoats coast, Ballantrae shingle beach, Kames Bay, Turnberry Dunes, Troon golf links and foreshore and Bogside Flats.

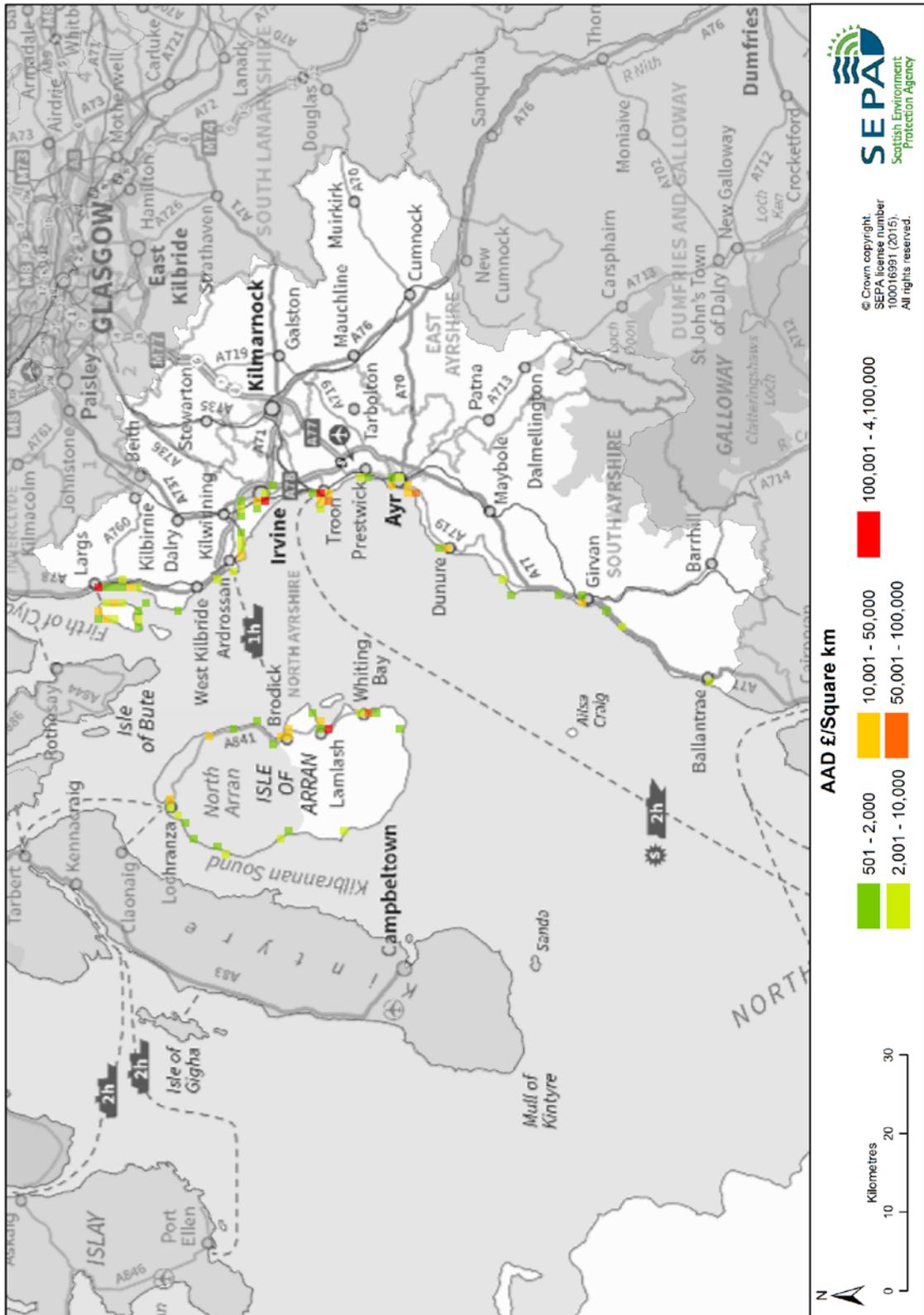
### History of coastal flooding

The most recent notable coastal flooding occurred between December 2013 and January 2014, which affected the entire south west coast of Scotland. In particular Millport, Largs, Saltcoats, Troon, Girvan, Prestwick and Fairlie were severely affected, with properties and roads affected. Some of this flooding was due to wave overtopping. On the Isle of Arran levels the levels were the highest seen since 5 January 1991.

In December 1994, incidents of coastal flooding affecting Troon were reported. Coastal floods were also reported in January 1991 and November 1991 affecting the Fairlie, Girvan and Ardrossan. Similar locations were affected by coastal floods on 5 January 1991 when high tides and storm surges caused extensive flooding to towns in the area and damaged seafront infrastructure.

The earliest coastal flood recorded happened in August 1930 which resulted in the harbour at Lamash Bay flooding due to a tidal surge in the Firth of Clyde.

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



**Figure 2:** Annual Average Damages from coastal flooding

## 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 the area are summarised below:

- Largs Flood Protection Scheme (2002) which reduces flooding from coastal sources and the Gogo Burn. The scheme also includes the installation of a rock revetment, rock groynes and the encasement of the existing sea wall.
- Saltcoats Flood Protection Scheme (2006) is designed to reduce coastal flooding including wave overtopping to Saltcoats town centre.
- Ayr South Pier Flood Protection Scheme was completed in 1825 and offers some protection to the entrance of the Harbour while minimising siltation of the navigation channel into the harbour.

In addition to the formal flood protection schemes there are large areas of this coastline that have a 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 existing coastal defences in this Local Plan District are shown in Figure 4.

## Coastal flood warning schemes

Flood warning area (FWA)	Properties within FWA	% of properties registered May 2014
Largs Seafront	65	35%
Millport Seafront	147	16%
Largs Fort Street	212	3%
Troon Coastal	1,421	17%
Troon Central	677	14%
Prestwick Links Road	20	40%
Ayr Seafield	407	15%
Girvan Esplanade	49	24%
Saltcoats Harbour	432	16%
Arran Seafront and Montrose Terrace (Whiting Bay)	21	33%
Arran Lamlash Cordon (Lamlash Bay)	19	21%

**Table 3:** Flood warning areas

There are 11 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. Note that this is not the number of properties at risk of flooding.

### 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 Solway Local Plan District is between 0.46m-0.47m by 2080. This may increase the number of residential properties at risk of coastal flooding from approximately 940 to 2,100 and the number of non-residential from approximately 540 to 860. 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 a number of areas showing high potential for wave energy dissipation. Most notably these are:

- along the coastline between Largs Bay and Little Brigurd
- along the coast of Great Cumbrae, with high potential areas for attenuation along Ballochmartin Bay in the east and Millport Bay in the south
- along the coastline at Troon
- a number of locations along the Isle of Arran coastline.



**Figure 3:** Flood warning areas



**Figure 4:** Coastal protection for coastal area

## 3.4 Surface water flooding

### Ayrshire 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 the Ayrshire Local Plan District there are approximately 1,900 residential and 1,200 non-residential properties at risk of surface water flooding. It is estimated that 95% of these properties are located within Potentially Vulnerable Areas.

#### Main areas at risk

Table 1 provides a list of the main areas at risk of surface water flooding. The damages include impacts to residential and non-residential properties, vehicles, emergency services and roads.

	Residential and non-residential properties at risk of surface water flooding	Average Annual Damages
Saltcoats / Ardrossan	560	£470,000
Kilmarnock (including Hurlford)	560	£460,000
Prestwick / Ayr	380	£280,000
Stevenston	240	£240,000
Cumnock / Logan	140	£360,000
Irvine (including Dreghorn)	140	£60,000
Galston	120	£290,000
Kilbirnie	110	£94,000
Kilwinning	110	£45,000
Newmilns / Greenholm	70	£260,000
Troon	90	£60,000
Kilmaurs	40	£10,000

**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 within this catchment are approximately £3.2 million. The damages are distributed as follows:

- 46% residential properties (£1.5 million)
- 41% non-residential properties (£1.3 million)
- 6% roads (£190,000)
- 6% emergency services (£180,000)
- 1% vehicles (£34,000).

Figure 1 shows the distribution of Annual Average Damages from surface water flooding across the Local Plan District. The highest Annual Average Damages are located in Ardrossan, Kilmarnock and Cumnock. The main type of economic activity impacted is retail.

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

Table 2 shows the approximate numbers of further infrastructure assets which are at risk of flooding within this Local Plan District.

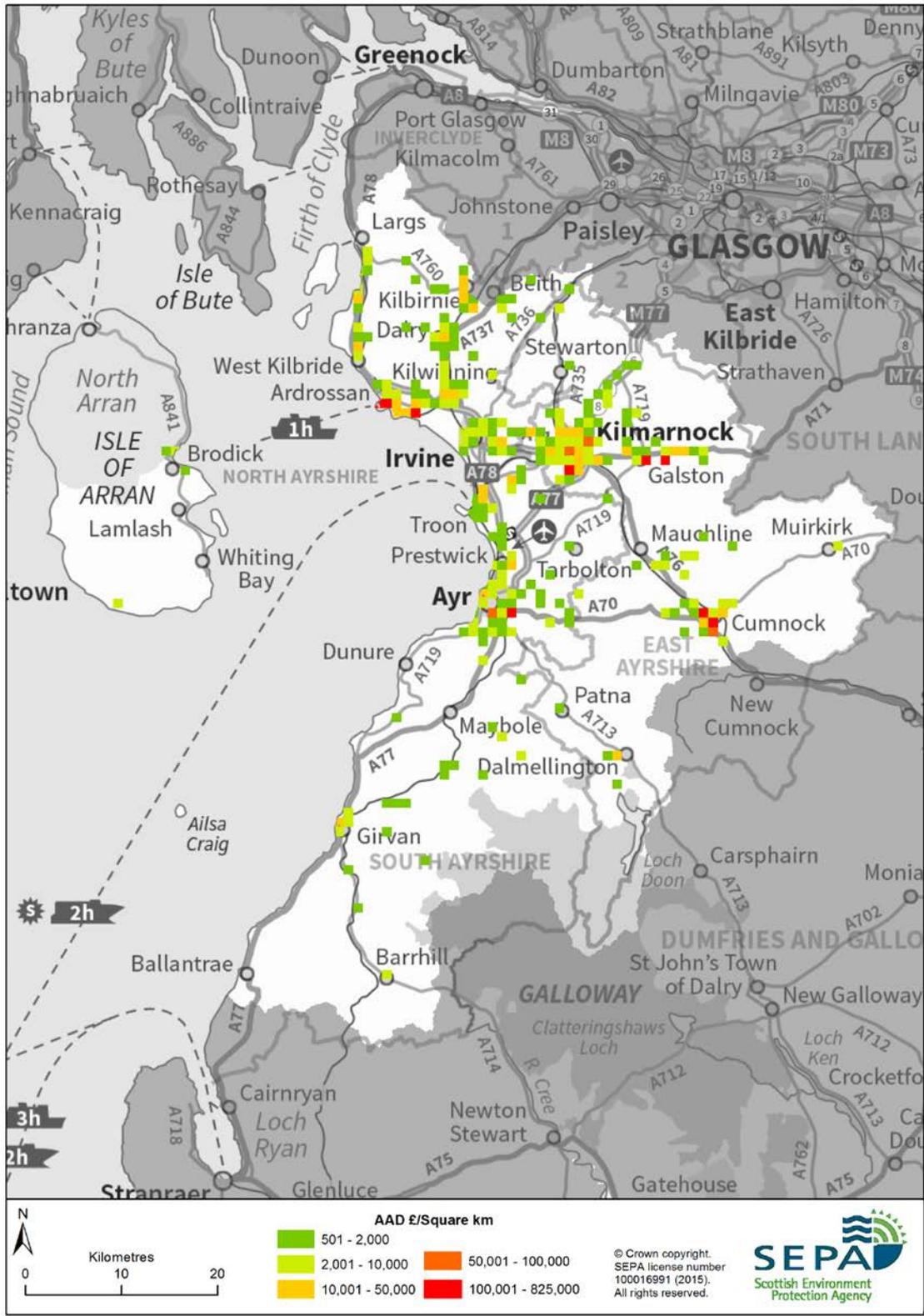
	Number at risk	Further detail
Community facilities	10	Includes; educational buildings, healthcare facilities and emergency services.
Utility assets	140	Includes; electricity substations, electricity generation and fuel extraction sites.
Roads (km)	264	Includes; A78 and A77
Railway routes (km)	39	Includes; Ayrshire coast line
Airports	1	

**Table 2:** Infrastructure at risk of surface water flooding

## Designated environmental and cultural heritage sites at risk

Within the Local Plan District it is estimated that approximately 70 designated cultural heritage sites have a risk of surface water flooding. These sites include; scheduled monuments, gardens and designed landscapes and listed buildings.

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



**Figure 1: Annual Average Damages from surface water flooding**

## History of surface water flooding

There have been 74 surface water related floods reported to SEPA within the Ayrshire Local Plan District. The most notable floods occurred on the 20 September 2012 in Ayr, Prestwick and Kilmarnock, following an estimated 1:70 year rainfall event. A combination of both river and surface water flooding resulted in the closure of Glasgow Prestwick Airport for over 12 hours. There were also several incidents of surface water flooding reported in Largs on the 29 October 2000.

There are four historic opencast mines within the district; Dunstonhill, Dalfad, Powharnal and Spireslack. Dunstonhill is situated within Potentially Vulnerable Area 12/15, Spireslack is in Potentially Vulnerable Area 12/19c, while Dalfad and Powharnal are situated upstream of Potentially Vulnerable Area 12/14. The condition of these mines is reported to be deteriorating as a result of a reduction in maintenance, including pumping to reduce water levels. This brings about an increased risk of flooding due to rising mine and lagoon water levels.

## Managing flood risk

### 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.

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.

## 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 pluvial 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 1,900 to 2,000. The number of non-residential properties at risk of surface water flooding may increase from approximately 1,100 to 1,200.

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.