# Indicators and trends

## Monitoring climate change adaptation

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| **Indicator name** | | | | **Version** |
|---|---|---|---|---|
| **BT8 Railway network at risk of flooding** | | | | **31/03/16** |
| **Indicator type:** | **Risk/opportunity** | **Impact** | **Action** | |
| | **X** | | | |

| **SCCAP Theme** | **SCCAP Objective** | **CCRA risk/opportunity** |
|---|---|---|
| Buildings and infrastructure networks | B1; B2 | FL8b Railways at significant risk of flooding |

## At a glance

- Scotland's rail network is at risk of flooding from fluvial, pluvial and coastal sources
- Climate change predictions suggest that flooding of rail infrastructure in Scotland will become more extensive and more frequent
- Flood risks to rail infrastructure are spread across the Scottish rail network and the greatest flood risk is posed by pluvial source flooding
- Only small sections of Scotland's rail network are exposed to fluvial and coastal flood risk

## Latest Figure

| | Latest Figure |
|---|---|
| BT8a: Percentage of rail network at risk of fluvial flooding | 2.62% |
| BT8b: Percentage of rail network at risk of pluvial flooding | 8.41% |
| BT8c: Percentage of rail network at risk of coastal flooding | 0.61% |

Note: All the above metrics are based on 0.5% probability (1:200 year) flood events

## Trend

*Insufficient data to show trend information*

## Why is this indicator important?

Transport supports many social and economic functions. In 2013/14, 86.3 million passenger journeys were made by rail in Scotland which represents 16% of all public transport journeys. Rail patronage has increased by 35% since 2004/05 and constitutes a growing share of public transport journeys. In contrast, there has been a decline of 8.2% in the amount of freight (tonnes) lifted by rail between 2002/03 and 2012/13. The modal share of freight (in tonne-km) carried by rail in Scotland in 2010 was 7% (Transport Scotland, 2014).

Flooding of rail infrastructure can cause disruption to rail transport with knock-on consequences for these functions – e.g. preventing or delaying people accessing work, delaying rail freight etc. Climate change predictions suggest that flooding of rail infrastructure will become more extensive and more frequent.

**Related indicators:**
**BT9** Disruption risk to railway services as a result of flooding
**BT12** Flood events affecting the railway network
**BT16** Rail network benefitting from fluvial flood protection measures

## What is happening now?

Current figures for each of the three metrics are presented in Table 1 and Figure 1. The location of flood risk to the rail network is shown on Figure 2.

**Table 1** Proportion of rail network at risk of flooding (1:200 year event)

| BT8 Metric | Latest Figure |
|---|---|
| BT8a: Proportion of rail network at risk of fluvial flooding (%) | 2.62% |
| BT8b: Proportion of rail network at risk of pluvial flooding (%) | 8.41% |
| BT8c: Proportion of rail network at risk of coastal flooding (%) | 0.61% |

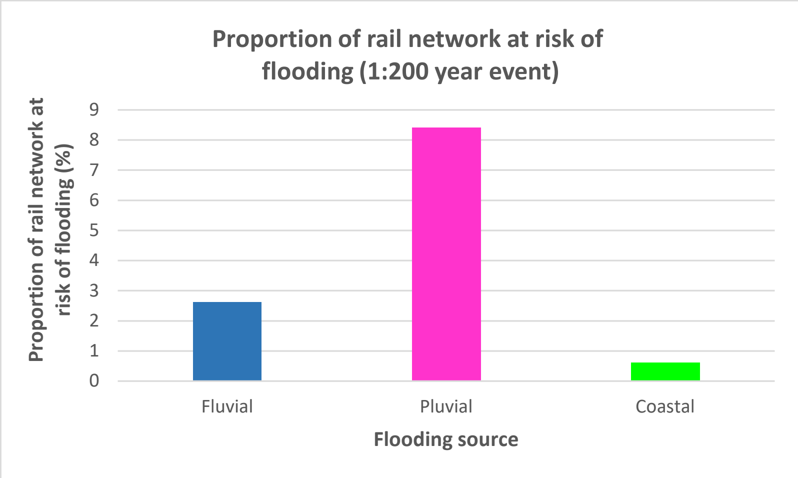


**Figure 1** Proportion of rail network at risk of flooding (1:200 year event)

Table 1 and Figure 1 show the extent to which the rail network is exposed to various flood sources. The degree of exposure varies between flooding source – e.g. 8.41% of the network is exposed to pluvial flooding compared to only 0.61% for coastal.

Figure 2 shows how flood risks to the rail network are spread across Scotland reflecting the spatial distribution of watercourses and their catchments (fluvial flood risk), impermeable features or areas with poor surface water drainage provision (pluvial flood risk) and low lying coastal areas (coastal flood risk). It should be noted that areas of fluvial, pluvial and coastal source flood risk coincide on certain lengths of the rail network which means that that the proportion of the network at risk from any form of flooding is less than the combined percentages from the individual flooding sources.

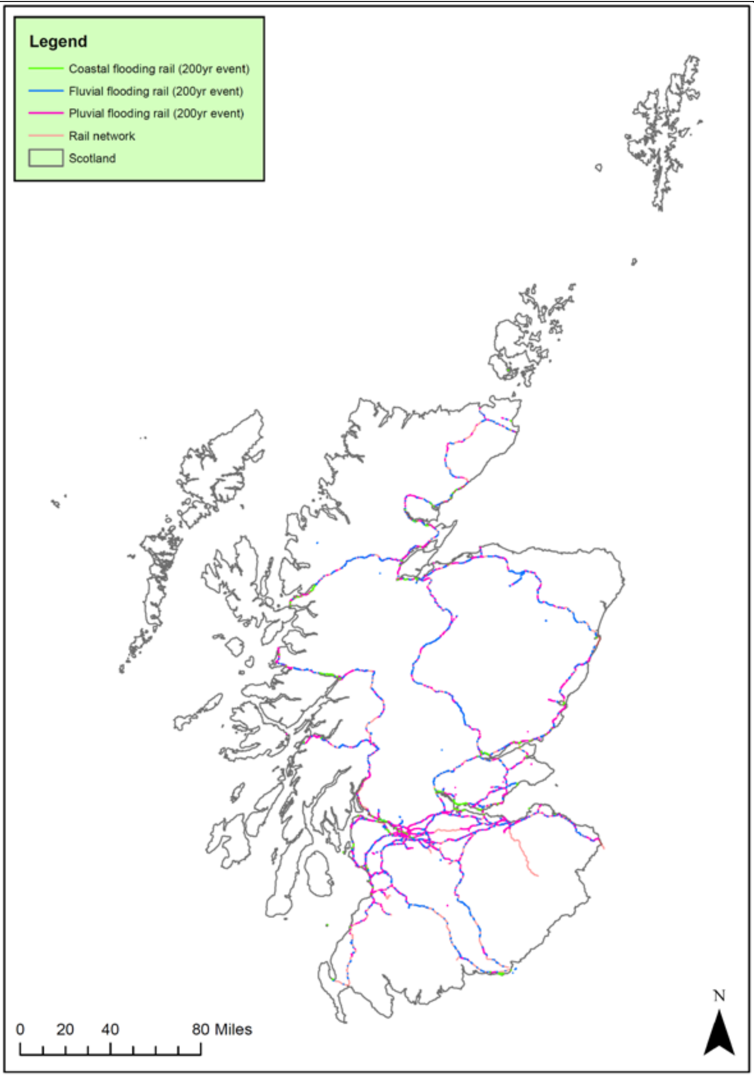


**Figure 2** Rail network at risk of flooding (1:200 year flood event) – spatial distribution of fluvial, pluvial and coastal source flood risk to the rail network in Scotland

## What has happened in the past?

Historic flood hazard and rail network data is not available to assess these metrics over time. However historic climate data shows how key aspects of climate (rainfall) have changed leading to impacts on biophysical systems (e.g. hydrological response of Scotland's catchments and watercourses) and ultimately changes to the scale and magnitude of relevant climate risks (i.e. risk of rail network flooding). Overall there is a clear upward trend in winter precipitation as well as increasing heavy rainfall in winter (Sniffer, 2014). It is expected that these climatic changes will have contributed to increased frequency and extent of pluvial and fluvial source flooding and associated impacts on the rail network.[1]

## What is projected to happen in the future?

The UK Climate Change Risk Assessment (HR Wallingford et al, 2012a; Thornes et al, 2012) assessed changes in flood risk to rail infrastructure as a result of anticipated climate changes. Whilst this assessment was only undertaken for England and Wales (due to data availability) it provides a broad indication of what might happen in Scotland in the future given anticipated climate changes. As

[1] A fuller account of historic climate trends is provided in indicator BT2 (Risk of road closures from flooding).

such, transport specific aspects from the UK CCRA can be used in conjunction with general aspects from the Scotland CCRA (HR Wallingford et al, 2012b) to understand how flooding related impacts to rail infrastructure might change in the future.[2]

The CCRA for England and Wales indicated that the projected length of railway at significant likelihood of flooding (where significant is defined as a 1.3% annual probability) would be between 2,000km and 2,600km by 2020 compared with a baseline of about 2,000km (Thornes et al, 2012). This equates to a possible increase of between 0% and 30% with the range reflecting the different climate change (emissions) scenarios considered in the assessment. The CCRA also highlighted how in addition to an increase in the overall length of infrastructure that could be affected, the frequency of flooding of infrastructure that is already located in the floodplain is expected to increase (ibid). These projections do not account for actions taken to alleviate flood risk to railways (e.g. flood defence infrastructure, enhanced maintenance regimes and so on (see indicator BT6)) which may help to reduce overall flood risk. Whilst these projections are focussed on England and Wales they provide a useful proxy of what may happen in Scotland.

The following projected changes are therefore anticipated to take place in the future:

- The proportion of the rail network located in areas at risk of flooding is projected to increase
- Rail infrastructure that is located in the floodplain is expected to be affected by flooding more frequently
- Increased incidence of intense summer rainfall events may result in more frequent pluvial (surface water) flooding

## Patterns of change

*No patterns of change have been identified.*

## Interpretation of indicator trends

*No trends identified for this indicator due to lack of historical data.*

## Limitations

There are several key limitations to the assessment as summarised below:

1. Major railways located in the floodplain are often raised above the ground surface on embankments. The difference in elevation afforded by these embankments is not always identified in flood modelling and mapping (Thornes et al, 2012). Therefore, flood risk to rail infrastructure may be over-estimated – i.e. where the embankment would raise the railway out of the inundated area and this is not reflected in the modelling due to the granularity of SEPA's flood hazard modelling process.
2. The consideration of what might happen in the future in terms of flooding-related climate risks to the rail network are based on English and Welsh data from the UK CCRA and so must be interpreted with caution for the Scottish rail network.
3. Network Rail's Network Links Layer which was used in this analysis includes double sections of track at many locations as well as railway siding etc. Thus that the total length of track used in this analysis does not correspond with the length of track published by Transport Scotland (2014) which counts one kilometre of single or double-track as one kilometre of route length.
4. This assessment was only undertaken for 0.5% probability (1:200 year) modelled flood events. These are low probability events located at the more severe end of the flood event spectrum.

[2] Indicator BT2 provides a more detailed description of the assessment of climate projections and associated impacts on biophysical systems (the precursor of risks and impacts to socio-economic systems).

Higher probability events (e.g. 1:10, 1:50) can be expected to affect a smaller extent of the network than 1:200 year events but on a more frequent basis. The he flood hazard modelling is based on historic data. As a result of climate change, the magnitude of a 1:200 year event may be greater than represented in this analysis.

5. Given the nature of the modelled data used for these metrics it is not possible to compare either the likelihood or the potential consequences of flood events in relation to other types of disruptive event (such infrastructure problems or other extreme weather events).

## References


HR Wallingford, AMEC Environment and Infrastructure, The Met Office, Collingwood Environmental Planning, Alexander Ballard Ltd, Paul Watkiss Associates, & Metroeconomica (2012a). *UK Climate Change Risk Assessment* [online]. Available at: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report [accessed 22/05/15]

HR Wallingford, AMEC Environment and Infrastructure, The Met Office, Collingwood Environmental Planning, Alexander Ballard Ltd, Paul Watkiss Associates, & Metroeconomica (2012b). A *Climate Change Risk Assessment for Scotland* [online]. Available at: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report [accessed 22/05/15]

Sniffer (2014). *Scotland's Climate Trends Handbook* [online]. Available at: http://www.environment.scotland.gov.uk/climate_trends_handbook/index.html [accessed 21/05/15]

SEPA (2015) *Flood Risk Management Strategy Characterisation Data*

Thornes, J., Rennie, M., Marsden, H., & Chapman L (2012). *Climate Change Risk Assessment for the Transport Sector* [online]. Available at: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report [accessed 22/05/15]

Transport Scotland (2014) Scottish Transport Statistics, No. 33, 2014 Edition. Available at http://www.transportscotland.gov.uk/statistics/j357783-00.htm [accessed 11/08/2015]


## Further information

Climate change adaptation indicators – transport infrastructure overview document

## Acknowledgements


SEPA provided spatial data on rail network flood risk assessment from an early version of their Flood Risk Management Strategy Characterisation Data (SEPA, 2015)

Network Rail provided spatial data for the Scotland Route.

The analysis and development of this indicator was undertaken by Dr Neil Ferguson (University of Strathclyde) and Dr Peter Phillips (Collingwood Environmental Planning Limited).

## Appendix One: Indicator meta data and methodology

### Table 1: Indicator meta data

| | |
|---|---|
| **Title of the indicator** | BT8 Railway network at risk of flooding |
| **Indicator contact:** Organisation or individual/s responsible for indicator | Katherine Beckmann, Heriot Watt University |
| **Indicator data source** | **Network Rail** – Scotland Route NetworkLinks layer (GIS polyline of the rail network in Scotland)<br>**SEPA** – Early version of SEPA's Flood Risk Management Strategy Characterisation Data (SEPA, 2015) |
| **Data link:** URL for retrieving the indicator primary indicator data. | Network Rail: data available by arrangement only<br>SEPA: data available by arrangement only |

### Table 2: Indicator data

| | |
|---|---|
| **Temporal coverage:** Start and end dates, identifying any significant data gaps. | Single point analysis using an early version of SEPA's Flood Risk Management Strategy Characterisation Data (SEPA,2015) |
| **Frequency of updates:** Planned or potential updates | Flood Risk Management Strategy data to be updated every 6 years |
| **Spatial coverage:** Maximum area for which data is available | Scotland-wide |
| **Uncertainties:** Uncertainty issues arising from e.g. data collection, data aggregation, data gaps. | See 'Limitations' section |
| **Spatial resolution:** Scale/unit for which data is collected. | • **Network Rail NetworkLinks layer:** +/- 0.5m x and y<br>• **SEPA data:** 5m |
| **Categorical resolution** Potential for disaggregation of data into categories. | By sub-national geography e.g. Local Plan District (LPD), Potentially Vulnerable Areas (PVAs), catchments etc. |
| **Data accessibility:** Restrictions on usage, relevant terms & conditions. | The SEPA Flood Risk Management Strategy Characterisation Data is available under licence<br>The Network Rail Network Links data is available by arrangement with Network Rail. |

### Table 3 Contributing data sources

| |
|---|
| **Contributing data sources:** Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data. |
| SEPA's Flood Risk Management Strategy Characterisation Data [not available online]<br>Network Rail NetworkLinks layer: [not available online] |

### Table 4 Indicator methodology

| |
|---|
| **Indicator methodology:** The methodology used to create the indicator data |

*Introduction to the approach*
This indicator assesses the railway network at risk of flooding separately for three sources of flooding – fluvial, pluvial and coastal. The assessment is based primarily on SEPA's modelled assessment of flood risk to rail infrastructure, as per SEPA's Flood Risk Management Strategy Characterisation Data (SEPA,2015). This indicator is a risk indicator based on modelled predictions of flood hazards and risks (i.e. it is not based on data from actual flood events or impacts observed on the ground – this is addressed in indicator BT12). The assessment of this indicator has been undertaken for 0.5% probability (1:200 year) flood events only.

Separate metrics are presented for each flooding source and the indicator does not attempt to produce an integrated assessment of risk based on the three sources of flooding combined.

*Metrics assessed under indicator BT8*

***Box 1. Metrics assessed under indicator BT8***

- **BT8a:** Proportion of rail network at risk of **fluvial** flooding
- **BT8b:** Proportion of rail network at risk of **pluvial** flooding
- **BT8c:** Proportion of rail network at risk of **coastal** flooding

*Methodologies adopted in the assessment of metrics*
This section provides details of the methodology adopted to assess each metric. The methodologies include steps that are undertaken in a GIS indicated in pale green and steps that are undertaken in Microsoft Excel indicated in dark green. A separate metric calculation template has been created in Microsoft Excel.

| **Assessment methodology for Metric BT8a – proportion of rail network at risk of fluvial flooding** | |
|---|---|
| **Assessment Step** | **Method** |
| **1** | Sum the SHAPE_LEN field from Network Rail NetworkLinks layer |
| **2** | Sum the FL_Length field from the rail network SEPA Baseline Appraisal fluvial output |
| **3** | Divide the output of Assessment Step **No.2** by the output of Assessment Step **No.1** and multiply by 100. This produces a figure for Metric No.1: *Proportion of rail network at risk of **fluvial** flooding* |

| **Assessment methodology for Metric BT8b – proportion of rail network at risk of pluvial flooding** | |
|---|---|
| **Assessment Step** | **Method** |
| **1** | Sum the SHAPE_LEN field from Network Rail NetworkLinks layer |
| **2** | Sum the FL_Length field from the rail network SEPA Baseline Appraisal **national** pluvial output |
| **3** | Sum the FL_Length field from the rail network SEPA Baseline Appraisal **regional** pluvial output |
| **4** | Sum the output of Assessment Step **No.2** with the output of Assessment Step **No.3** to calculate the total length of the rail network at risk of **pluvial** flooding |
| **5** | Divide the output of Assessment Step **No.4** by the output of Assessment Step **No.1** and multiply by 100. This produces a figure for Metric No.2: *Proportion of rail network at risk of **pluvial** flooding* |

| **Assessment methodology for Metric BT8c – proportion of rail network at risk of coastal flooding** | |
|---|---|
| **Assessment Step** | **Method** |
| **1** | Sum the SHAPE_LEN field from Network Rail NetworkLinks layer |
| **2** | Sum the FL_Length field from the rail network SEPA Baseline Appraisal coastal output |

| | |
|---|---|
| **3** | Divide the output of Assessment Step **No.2** by the output of Assessment Step **No.1** and multiply by 100. This produces a figure for Metric No.3:<br>*Proportion of rail network at risk of **coastal** flooding* |