Indicators and trends

Monitoring climate change adaptation

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Indicator name				Version
BT26 Road and rail bridges vulnerable to scour				**14/03/16**
Indicator type:	**Risk/opportunity**	**Impact**	**Action**	
	X			

SCCAP Theme	**SCCAP Objective**	**CCRA risk/opportunity**
Buildings and infrastructure networks	B1; B2; B3	TR6 Scouring of road and rail bridges

At a glance

- Climate change predictions suggest that the magnitude and frequency of river flood flows will increase, and this will increase scour risk in scour susceptible bridges
- Only a small proportion of trunk road and rail bridges are currently highly susceptible to scour, though this proportion is higher for road bridges
- Over half (~ 57%) of rail bridges have been assessed as medium susceptibility to scour
- The large majority of road bridges are currently low susceptibility to scour

Latest Figure	Trend
• 3.52% of trunk road bridges have been assessed as high priority (or highly susceptible to scour). • 1.33% of underline rail bridge assets have been assessed as high priority (or highly susceptible to scour).	N/A

Why is this indicator important?

Transport is a means to an end supporting many different social and economic functions. Scouring of road and rail bridges can cause disruption to road and rail transport (e.g. as a result of speed restrictions, closures etc.) with knock-on consequences for these functions – e.g. delaying deliveries, preventing or delaying people from accessing employment, disrupting vital healthcare services, delaying rail freight etc. Scour risk to road and rail bridges is driven by the force exerted on foundations by river flood flows and also the river bed and sediment properties specific to the site. Therefore although scour risk is inherently site specific, the projected increases in peak flood flows as a result of climate change are expected to increase scour risk to bridge assets.

Related indicators:
BT4 Flood events affecting the trunk road network
BT12 Flood events affecting the railway network

What is happening now?

Tables 1 and 2 and Figures 1 and 2 present current data on scour susceptibility of rail and trunk road bridges[1]. This includes data for the two metrics assessed which focus on the proportion of road and rail bridges that are high priority or highly susceptible to scour. See Appendix 1 Table 4 Indicator Methodology for further information on scour classification of road and rail bridges.

Table 1 Scour assessment of rail bridges (April 2015)

Priority ranking	Rail bridge assets (%)
1 High	**1.33**
2	11.73
3	24.08
4	15.92
5	5.20
6 Low	41.73

Table 2 Scour assessment of trunk road bridges (April 2015)

Priority ranking	Trunk road bridge assets (%)
1 High	**3.52**
2	4.69
3	2.27
4	0.31
5 Low	89.21

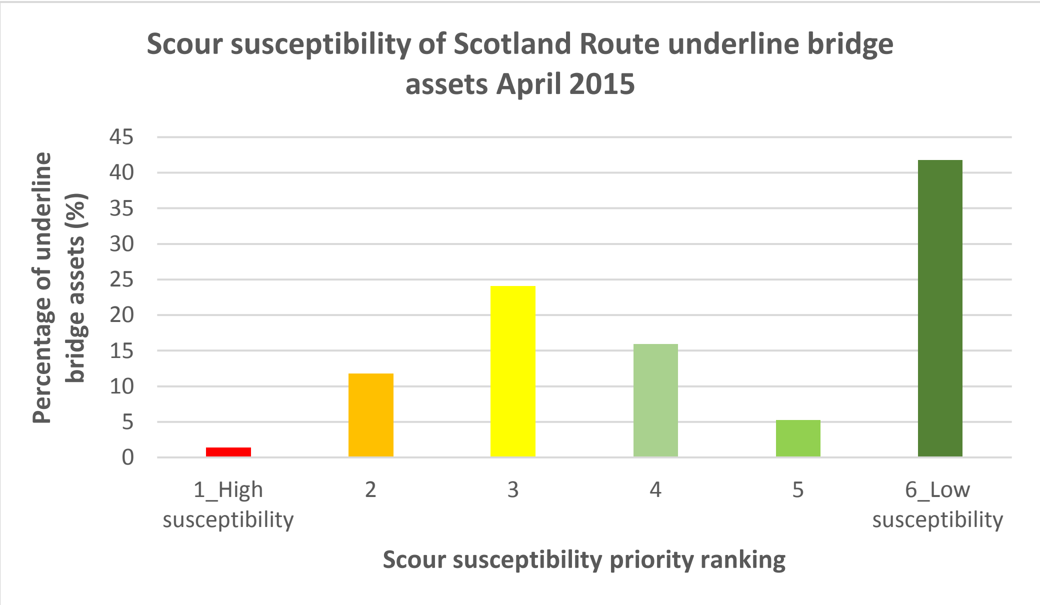

Figure 1. Scour susceptibility of Scotland Route (rail) underline bridge assets (April 2015)
Note: The Network Rail assessment includes five culvert assets though the vast majority of the assessment is on underline bridge assets (975 assets).

[1] It should be noted that this assessment has been undertaken for trunk road bridges only

In the respective scour assessments of their bridge assets, Transport Scotland assessed 1,279 assets (trunk road bridges) and Network Rail 980 assets. In both assessments, only a small proportion of all assets were assessed as high priority or highly susceptible to scour: 3.52% in the case of trunk road bridges and 1.33% for rail.

In the case of road bridges, a large majority of assets (89.21%) were assessed as low priority or low susceptibility to scour (scour priority score 5) requiring no action to be taken (see Table 4).

For rail bridges, the distribution of scour priority scores is more even – only 41.73% of assets were assessed as low priority or low susceptibility (scour priority score 6) and 56.93% of assets fell within the middle scour priority or susceptibility categories (scour priority score of 2, 3, 4 or 5).

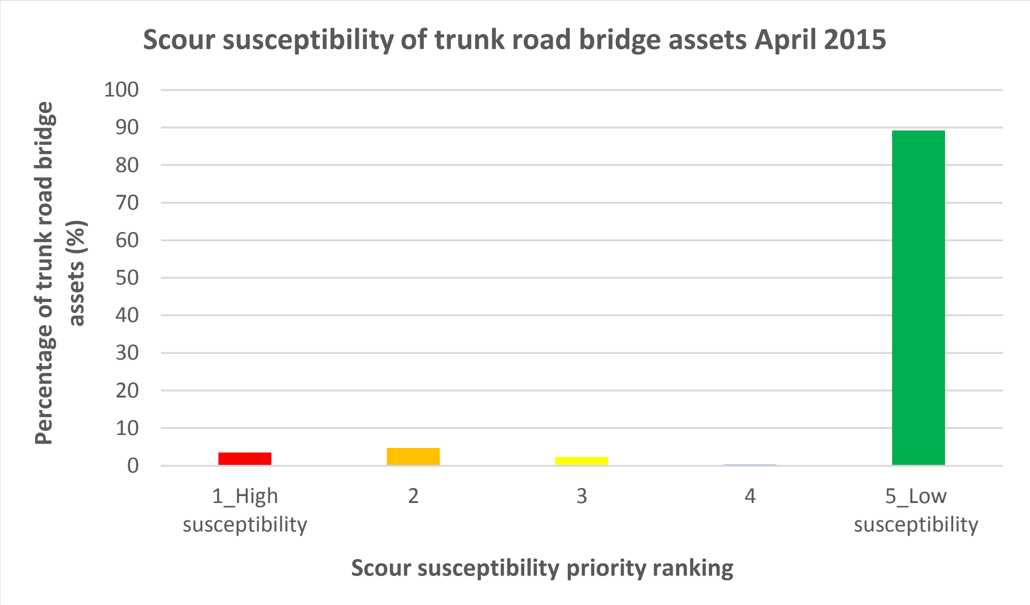

Figure 2. Scour susceptibility of trunk road bridge assets (April 2015)

What has happened in the past?

Historic bridge scour assessment data is not available. 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. scouring of road and rail bridges caused by increased magnitude and frequency of flood flows). Overall there is a clear upward trend in winter precipitation as well as increasing heavy rainfall in winter (Sniffer, 2014). It is likely that these climatic changes will have led to increased magnitude and frequency of flood flows in Scotland's rivers. An additional issue with scour risk is the nature of bridge design – advances in structural design and understanding of scour mean that major modern bridges are rarely susceptible to scour (Thornes et al, 2012), especially where susceptibility is a function of foundation design (see Table 4). Indeed it is suggested that pre-20th Century bridges are most susceptible to scour as they generally have shallower foundations and are of variable and often unknown construction (ibid). As a result, the scale and magnitude of scour risk across the portfolio of road and rail bridge assets in Scotland will have changed with time and most modern bridges will exhibit very low scour susceptibility.

What is projected to happen in the future?

The UK Climate Change Risk Assessment (HR Wallingford et al., 2012; Thornes et al., 2012) assessed changes in scour risk to road and rail bridges as a result of anticipated climate change. The contributory natural hazard in scour risk is river flows. Natural site conditions (river bed / sediments) play a part as well but these are not influenced by climate change. The CCRA estimated percentage increases in scour from present day conditions as a result of increased flow (flow increases of 10%, 20% and 30%). For all types of river bed (sediment) conditions (see Table 4), increases in river flow are expected to increase scour. For sand beds this may be anywhere between 2% and 9% and for gravel beds, anywhere between 2% and 65% (ibid). Furthermore, the CCRA and other research have assessed flow increases as a result of climate change in Scotland. For a medium emissions scenario, flow increases of 5-10% are expected by the 2020s, 15-20% by the 2050s and 20-30% by the 2080s (Kay et al., 2011). Given this, it is anticipated that climate change will contribute to increased scour risk in the future, particularly for older bridge assets that have not been designed to withstand scouring. The CCRA did not attempt to quantify the overall increase in scour risk to all bridge assets due to the site specific nature of the risk (susceptibility) and an absence of data on bridge assets and river bed conditions.

Patterns of change

No patterns of change have been identified.

Interpretation of indicator trends

No trends identified due to lack of historical data.

Limitations

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

1. Within the scope of the project (time and resource) it was not possible to gain full details from Transport Scotland and Network Rail on the methodology used in scour assessments. In particular, it is unclear if or how information on river flow has been incorporated into the assessment – e.g. does the assessment just consider the susceptibility of the bridge assets or does it consider flow conditions at the site as well? Does the assessment consider scour susceptibility under a variety of flow conditions (return periods) and has the impact of climate change on river flow regimes been accounted for?
2. The compatibility of the Transport Scotland and Network Rail bridge asset scour assessments is uncertain. For example the exact methodology adopted in the assessments is unknown and the assessments use a different scoring system (the road bridge assessment has a five point system whereas the rail assessment uses six points). Given this, comparing like for like as per the two BT26 metrics may not be appropriate.

References

Highways Agency, Transport Scotland, Welsh Government, and The Department for Regional Development Northern Ireland (2012). *Design Manual for Roads and Bridges: Volume 1 Highway Structures – Approval Procedures and General Design* [online]. Available at: http://www.standardsforhighways.co.uk/dmrb/vol1/section1/bd212.pdf [accessed 16/07/15]

HR Wallingford, AMEC Environment and Infrastructure, The Met Office, Collingwood Environmental Planning, Alexander Ballard Ltd, Paul Watkiss Associates, & Metroeconomica (2012). *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]

Kay, A.L., Crooks, S.M., Davies, H.N., and Reynard, N.S. (2011). *An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change*. Work Package 1 Report (Draft). Report produced for SEPA, April 2011

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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]

Further information

ClimateXChange (2016) Adaptation to Climate Change: Context and Overview for Transport Infrastructure Indicators. Available online at: http://www.climatexchange.org.uk/adapting-to-climate-change/indicators-and-trends/

Acknowledgements

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Network Rail provided data on Scotland Route bridge asset scour assessments.

Transport Scotland provided data on trunk road bridge asset scour assessments.

Katherine Beckmann, Heriot-Watt University / CXC contributed to this indicator.

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	BT26 Road and rail bridges vulnerable to scour
Indicator contact: Organisation or individual/s responsible for the indicator	ClimateXChange
Indicator data source	**Transport Scotland:** trunk road bridge asset scour assessment data **Network Rail:** Scotland Route bridge asset scour assessment data
Data link: URL for retrieving the indicator primary indicator data.	N/A – data available by arrangement only

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	Single data point April 2015
Frequency of updates: Planned or potential updates	
Spatial coverage: Maximum area for which data is available	Scotland-wide
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	The exact methodology adopted in the scour assessments is uncertain meaning that it is not possible to directly compare the scour assessment of trunk road and rail scour assessment
Spatial resolution: Scale/unit for which data is collected	N/A
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	Transport Scotland and Network Rail data available by request only

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.
Transport Scotland trunk road bridge asset scour assessment data Network Rail Scotland Route bridge asset scour assessment data

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
There is no methodology as such for BT26 beyond obtaining the scour susceptibility data from Transport Scotland and Network Rail. *Introduction to the approach* Scour can be defined as *"the movement of the riverbed sediment as a response to the shear forces associated with flowing water in the presence of a hydraulic structure such as a bridge"* (Thornes et al, 2012 p.57). All bridges that have footings in rivers and estuaries are at some risk of scour occurring around these foundations – where scour becomes significant, the stability of the foundations may be threatened which can lead to structural damage or failure in severe cases (ibid). Transport Scotland and Network Rail carry out scour assessments of bridges and other structures (e.g. culverts, retaining walls) within their management. These assessments focus on the vulnerability element of risk. Specifically, the susceptibility of the bridge to scouring is assessed on the basis of what is known about its foundations (e.g. form, depth, geotechnical setting) and the nature of the river bed sediments (e.g. gravel, sand). The contributory natural hazard in the case of scour risk is high river flows, which may be exacerbated by climate change (see the 'what is projected to happen in the future' section). Both the Transport Scotland and Network Rail assessments categorise structures on the basis of 'scour priority' – high priority structures are those that may require some further action in order to reduce scour susceptibility to an acceptable level. For example, Transport Scotland define high priority bridges (Priority Rating 1) as *"Bridges need[ing] further consideration, including possible monitoring and scour protection measures"* (Transport Scotland, undated). It follows therefore that scour susceptibility is dynamic – bridges could have some measure put in place (e.g. foundation strengthening works, monitoring) that reduces susceptibility for a time though the priority rating may increase thereafter under continued scour conditions (e.g. as the strengthening works are damaged by continued scour). The approach to scour susceptibility assessment and priority setting adopted by Transport Scotland and Network Rail differ. Network Rail produce an overall risk score that is then used to assign priorities (McLuskey, 2015). Transport Scotland include suggested actions for each priority category as per the table below:

Transport Scotland scour assessment priority ranking

Priority rating	Suggested action
1	Bridge needs further consideration including possible monitoring and scour protection measures
2	
3	No immediate action. Re-inspections, both as part of regular bridge inspections and after major floods should examine for signs of scour and bank erosion. If conditions at bridge change then reassessment should be carried out
4	
5	No action required

Both Transport Scotland and Network Rail have provided scour susceptibility data for a single data point – i.e. the status of scour susceptibility across all relevant bridge assets for a given moment in time. In this current iteration of BT26, this is April 2015. Given the dynamic nature of scour susceptibility, the proportion of bridge assets that are highly susceptible to scour / high scour priority will change with time – this will be picked-up in future iterations of this indicator.

Scope of Indicator

Transport Scotland and Network Rail manage a range of structures that sometimes come into contact with / have foundations in flowing water and that may therefore be susceptible to scour. For example, Network Rail manage underline bridges, overline bridges, footbridges, culverts, tunnels, retaining walls and coastal / estuarial / river defences (McLuskey, 2015). Underline bridges are bridges with a span of >1.8m carrying the railway over an obstruction, such as water (ibid). Transport Scotland define bridges as structures that support the highway with a clear span of >0.9m (Highways Agency et al, 2012).

This assessment has focussed primarily on bridge structures as per the definitions above. In addition however, Network Rail's routine (i.e. not conditions led) assessment of scour includes consideration of five culverts with a span of between 0.45m and 1.8m (McLuskey, 2015) and these structures have also been incorporated within this assessment. Network Rail has provided data on 980 bridge assets (includes five culvert assets). Transport Scotland has provided data on 1,279 trunk road bridge assets. This scope for BT26 is fully in line with the relevant risk from the CCRA – *TR6 Scouring of road and rail bridges*.

Metrics assessed under BT26

Box 1. Metrics assessed under indicator BT26

- **BT26a:** Proportion of rail bridges that are highly susceptible to scour
- **BT26b:** Proportion of trunk road bridges that are highly susceptible to scour