Living With Water Programme
Strategic Drainage Infrastructure Plan

Belfast Sea Level Rise – A Briefing for Policy Makers

Version 3, issued 16/02/17

This paper briefly sets out the relative current rate of sea level rise in Belfast, and how this increases the risk of coastal flooding.

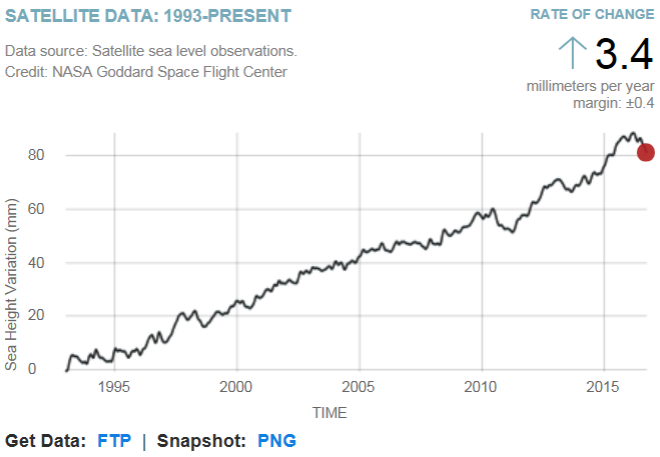
Summary:

- **Absolute sea level rise is currently 3.4mm per annum**
- **Due to isostatic rebound from the last ice age Belfast is rising by around 0.4mm per annum**
- **This gives a relative current rise of around 3mm per annum**
- **The relative sea level rise for Belfast by 2095 is projected to be between 245mm and 403mm compared to 1990.**
- **Had the peaks of the high tide and surge coincided more closely on 3 Jan 2014 the peak sea level would have been over 250mm higher.**

1) Sea Level Rise

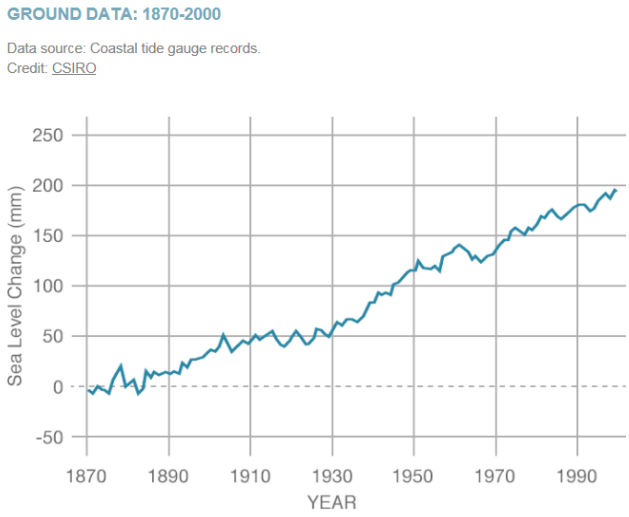
Source for this section: NASA (http://climate.nasa.gov/vital-signs/sea-level/)

Sea level rise is caused primarily by two factors related to global warming: the added water from melting land ice and the expansion of sea water as it warms. The first chart tracks the change in sea level since 1993 as observed by satellites.



LWWP Commentary: This graph states that the absolute sea level rise (not including land movement) is currently 3.4mm per annum. There will be local variations due to changed salinity etc.

The second chart, derived from coastal tide gauge data, shows how much sea level changed from about 1870 to 2000.



LWWP Commentary: This graph illustrates that sea levels rose by around 200mm between the year 1870 and 2000 (around 1.5 mm per annum). Hence the current rate of rise is more than double the average for that period.

2) Vertical Land Movement

Source for this section: UK Climate Projections (2009) science report: Marine & coastal projections — Chapter 3

During the last ice age, the mass of the Eurasian and British-Irish ice sheets (BIIS) caused isostatic deformation that resulted in vertical movement of the Earth's crust throughout Europe and NW Asia. The mantle material below the crust under the ice sheet was displaced leading to a rising of the crust around the ice sheet periphery (glacial forebulge). Melting of the ice sheets removed the load from the depressed crust and allowed the crust to rebound. The resulting vertical land movement is controlled by viscous, elastic and gravitational effects in a process termed Glacial Isostatic Adjustment (GIA). Superimposed on this is the effect of the BIIS, which leads to an uplift in Scotland due to the viscous and elastic response, and the subsidence in the BIIS forebulge in England, Wales, and Shetlands. In terms of present vertical land movement in the UK, the GIA processes generally dominate over the negligible vertical component of plate tectonics. These different processes lead to a complex pattern of uplift and subsidence throughout the UK that has implications on the sea level rise relative to the land (*relative sea level rise*).

Bradley *et al*. (2008) used the GIA model of Milne *et al*. (2006) and the ice loading of Shennan *et al*. (2006) to produce a map of vertical land movement.

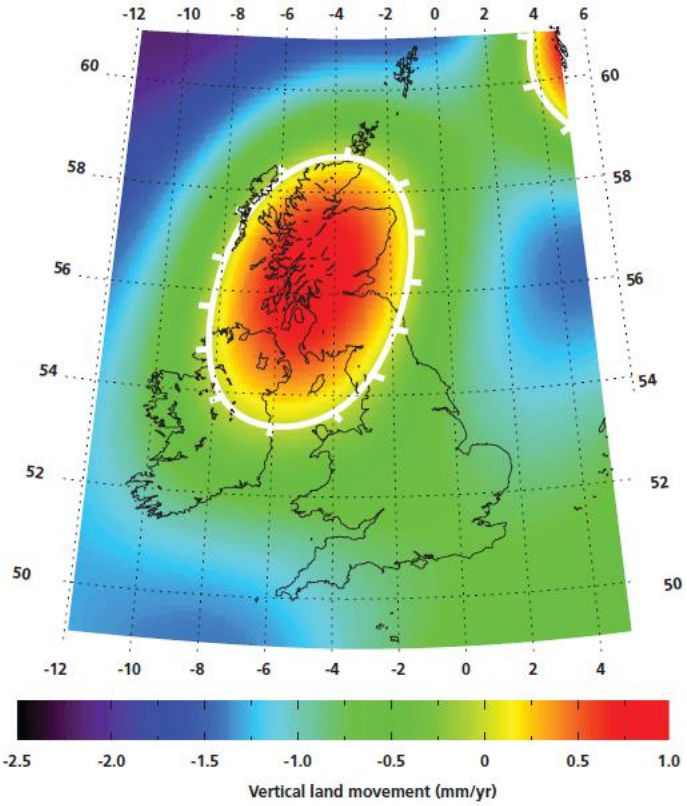


Figure 3.5: GIA map of the vertical land movement (mm/yr) for the UK. The model was constrained by time series (>3 yr since ~2000) of AG corrected CGPS (see the Annex for details). Adapted from Bradley *et al*. (2008).

LWWP Commentary: This map illustrates that the rate of rise of land around Belfast is currently around 0.4mm per annum.

3) Relative Sea Level Rise

Source for this section: UK Climate Projections (2009) science report: Marine & coastal projections — Chapter 3

In this section we combine absolute sea level changes and vertical land movements into estimates of **relative sea level rise.** This uses the absolute sea level rise estimates for the UK from Table 3.3 and the land movement estimates from Bradley *et al*. (2008) (Figure 3.5).

Assuming that the vertical land movement rates shown in Figure 3.5 will remain relatively constant over the 21st century, a yearly time series of the influence of vertical land movement on relative sea level was calculated for four sample locations (London, Cardiff, Edinburgh and Belfast). Subtracting these vertical land movement time series from the absolute sea level rise (averaged around the UK, as was done for Figure 3.4) gives time series of relative sea level rise for the low, medium and high emissions scenarios.

	London			Cardiff			Edinburgh			Belfast		
	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low
2000	3.5	3.0	2.5	3.5	2.9	2.5	2.2	1.6	1.2	2.3	1.7	1.3
2010	7.3	6.2	5.3	7.3	6.2	5.3	4.7	3.5	2.6	4.9	3.8	2.8
2020	11.5	9.7	8.2	11.5	9.7	8.2	7.5	5.7	4.3	7.8	6.0	4.6
2030	16.0	13.5	11.4	15.9	13.4	11.4	10.7	8.2	6.1	11.1	8.6	6.6
2040	20.8	17.5	14.8	20.8	17.5	14.8	14.2	10.9	8.2	14.7	11.4	8.7
2050	25.9	21.8	18.4	25.9	21.8	18.4	18.0	13.9	10.5	18.6	14.5	11.1
2060	31.4	26.3	22.2	31.4	26.3	22.2	22.1	17.1	13.0	22.9	17.8	13.7
2070	37.2	31.2	26.3	37.1	31.1	26.3	26.6	20.6	15.7	27.4	21.4	16.5
2080	43.3	36.3	30.5	43.3	36.2	30.5	31.4	24.4	18.6	32.3	25.3	19.6
2090	49.7	41.6	35.0	49.7	41.6	35.0	36.5	28.4	21.8	37.6	29.4	22.8
2095	53.1	44.4	37.3	53.1	44.4	37.3	39.2	30.5	23.4	40.3	31.6	24.5

Table 3.4 (above): Central estimates of relative sea level changes with respect to 1990 (cm). Only the central estimates of sea level rise are presented here. These data correspond to Figure 3.6, which also gives the 5th to 95th percentile range.

LWWP Commentary: This table states that the relative sea level rise for Belfast by 2095 is projected to be between 245mm and 403mm compared to 1990.

4) Risk of Tidal Flooding in Belfast

Sources for this section:

- Rivers Agency's North Eastern Flood Risk Management Plan (December 2015)
- Rivers Agency's information from the Tidal Event on 3 January 2014 (accessed by Stephen Dawson, DfI Water Drainage Policy Division)

Coastal areas of Northern Ireland are especially vulnerable if a high spring tide coincides with a tidal surge during winter months. The Northern Ireland coastline is most susceptible to surges created by deep low pressure areas passing to the north of the Province. The low pressure creates a rise in sea level and friction due to high winds on the sea surface locally exacerbates this level. The 'perfect storm' occurs when the peak of the tidal surge occurs at the time of the peak of a spring tide.

There has not been any significant flooding in Belfast within living memory that can, with certainty, be solely attributed to the sea. There have however, been a number of near misses; the most recent of which occurred on 3 January 2014. On this occasion the UK Coastal Monitoring and Forecasting Service, which provides tidal surge information and level alerts to Rivers Agency, gave advance warning of a predicted extreme tidal surge for Belfast Lough and the rest of the Northern Ireland coastline around the time of the January high spring tide. With a possible surge greater than 1m, a possible combined water level of over **3m** OD was possible which had the potential to overtop defences in Belfast and other coastal areas. In addition to the surge, the Met Office was forecasting high winds and 20 - 30 mm of rain. This situation triggered a major flood emergency response to prepare for the possibility of serious flooding from the sea.

The response was led by the PSNI (because of the potential risk to life) and involved a number of bodies, including Local Government, Rivers Agency, the Office of the First Minister and Deputy First Minister, Northern Ireland Fire and Rescue Service, Transport NI, NI Water, Belfast Health Trust, NI Electricity, British Telecom and Translink. In this instance major flooding was narrowly averted because the surge did not reach the predicted level and the peaks of the high tide and surge did not coincide. However a reduced 'double-peak' tide was still experienced at Belfast leading to a maximum tide level of around **2.75m** OD which, as can be seen from the photographs below, is only a few centimetres below the top of the various sections of the walls and embankments, which act as a form of coastal defence to low lying areas of the city centre. Although the sea did not actually overtop the quasi defence structures in Belfast on this occasion, the emergency response operation, led by the PSNI, was considered a success. However, other areas of the coastline did suffer localised flooding e.g. Ards Peninsula, South Down.

Saltwater Brig, Kircubbin

LWWP Commentary: Had the peaks of the high tide and surge coincided more closely on 3 Jan 2014 the peak sea level would have been over 250mm higher.