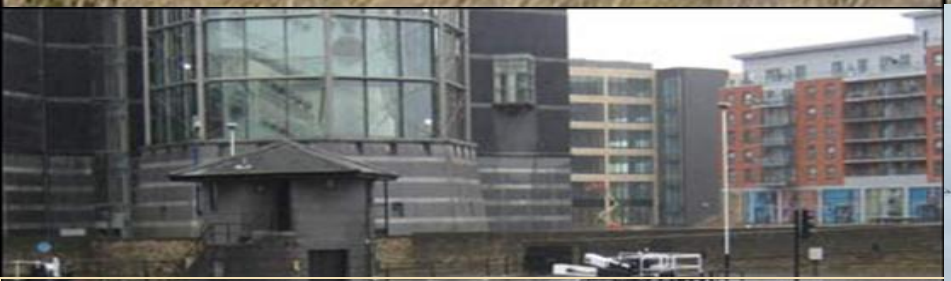
CLIMATE UK, YOUR CLIMATE & ADEPT, 15/07/13

TRANSPORT CLIMATE PROOFING IN LEEDS



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Environmental Assessment Manager
Transport Policy, City Development
Leeds City Council

Contents of Presentation

- Fluctuations in Local Weather
- Use of LCLIPS
- Climate Proofing Template for Transport
- UKCP's & Influence of the Jet Stream!
- Examples of Transport Climate Resilience:-
  - Cleansing of watercourse/culverts
  - Integrated flood protection measures
  - Winter maintenance procedures
  - Chloride damage to bridges
  - Water scour on bridges
  - The Leeds Flood Alleviation scheme

Two Methods of Tackling Climate Change

- **Climate Change Mitigation**
  - Slow down global warming/climate change by reducing GHG's
- **Climate Change Adaptation**
  - Adapt to likely impacts of unavoidable climate change (Climate proofing/Climate resilience)
  - CC Resilience will lead to GHG savings, due to reduced infrastructure damage.
  - Lord Stern quote, 'The cost of CC Inaction will be 10X cost of CC mitigation measures!

How to Prevent 'Dangerous' Climate Change

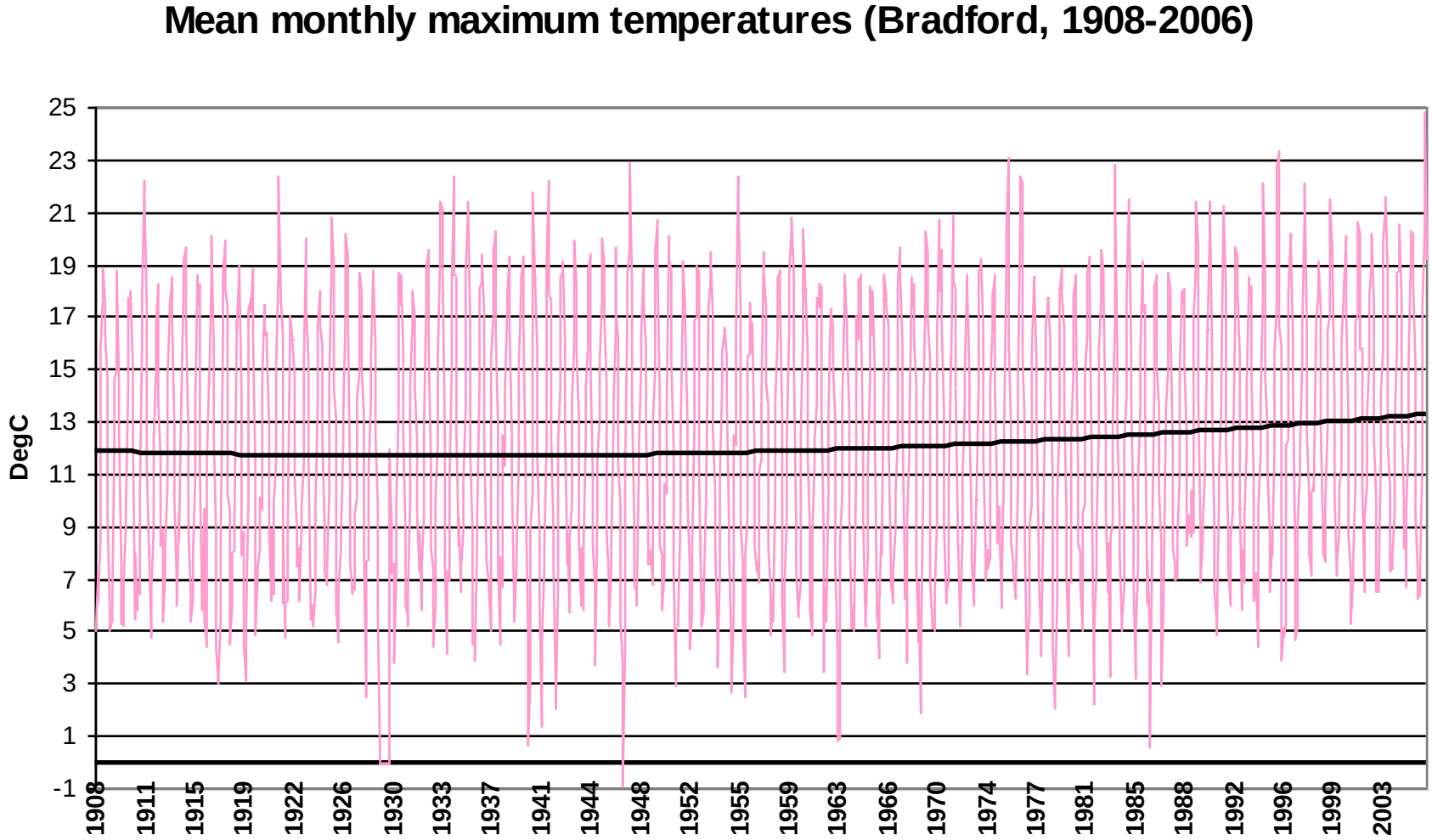
CO_2(e) (ppm)	2°C	3°C	4°C	5°C	6°C	7°C
450	78	18	3	1	0	0
500	96	44	11	3	1	0
550	99	69	24	7	2	1
650	100	94	58	24	9	4
750	100	99	82	47	22	9

Strategic Drivers for Climate Proofing

- **The Proposed WYLTP3 (2011-26)**
  - Supporting economic growth & carbon reduction, by ensuring future resilience of the transport networks
  - Started well, W Yorks Transport based Local Climate Impact Profile (LCLIP) & supporting risk assessment
  - Eg. Increased risk of landslides affecting road/rail
  - Frustrated there is no coordinated LTP approach at present!
- **The Leeds Strategic Plan**
- **The Leeds Climate Change Strategy**
- **The Leeds Environmental Policy**

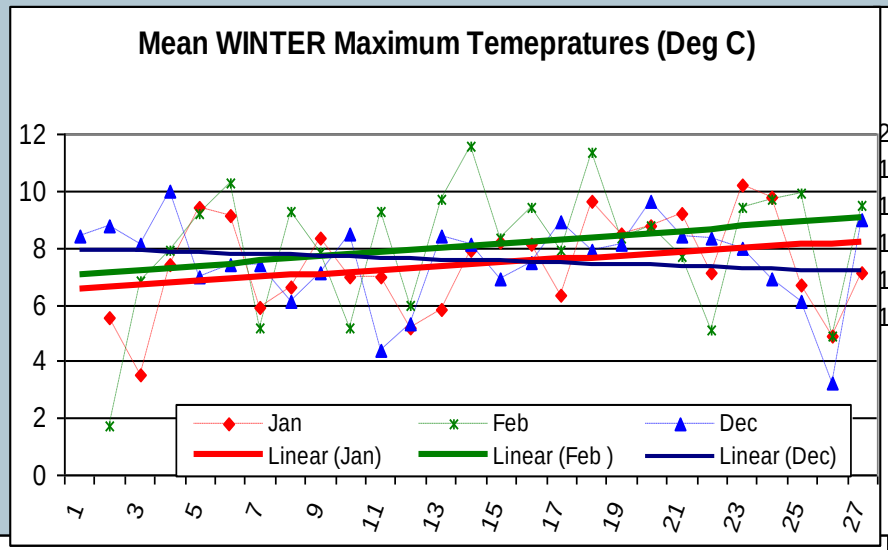
HAS THE LOCAL WEATHER OR CLIMATE CHANGED IN LEEDS?

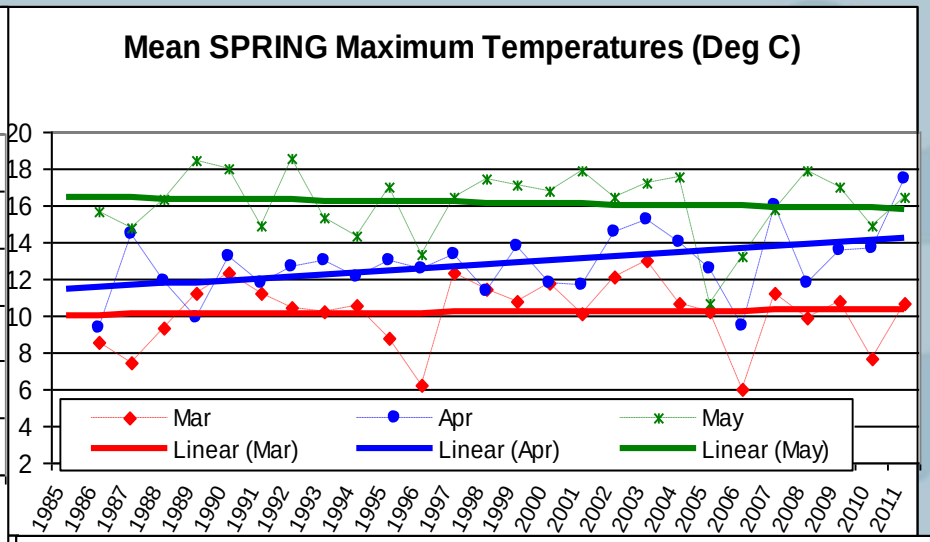
- Climate refers to average weather over >30 years
  - Observed 28 years for central Leeds (Not fully robust!)
- Identified 'Fluctuations' or 'Signals' in average Leeds weather for:-
  - **Historic & present temperatures.**
  - **Rainfall intensities & distribution.**
  - **Frequency of snowfall & frost.**
  - **Frequency of gales.**
  - Initial trends consistent with Climate Change (More chaotic in last 5 years!)

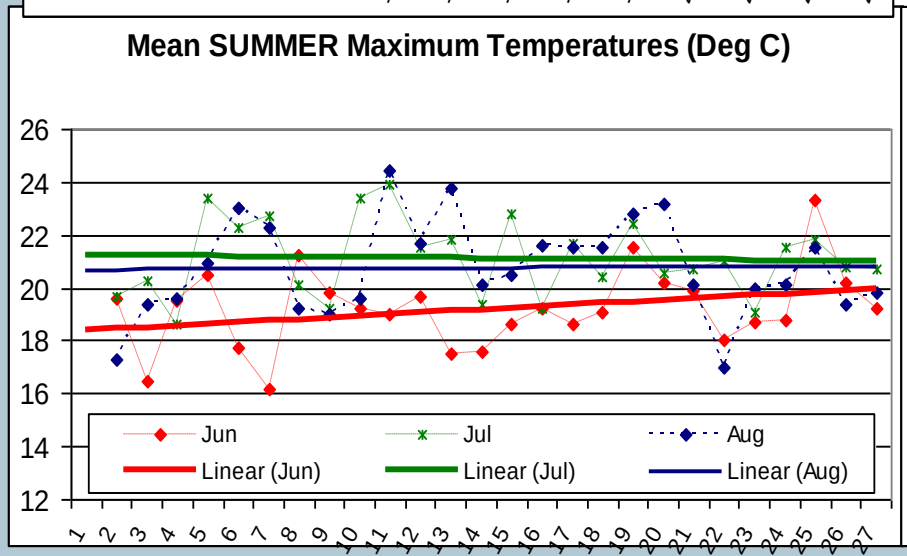


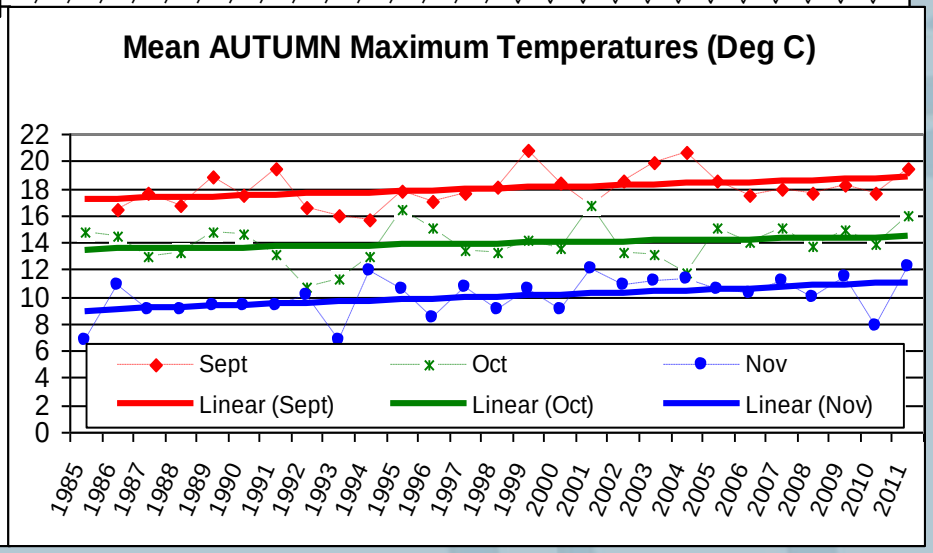
- Historical data (1908-2006) obtained from the Met Office's Bradford weather station

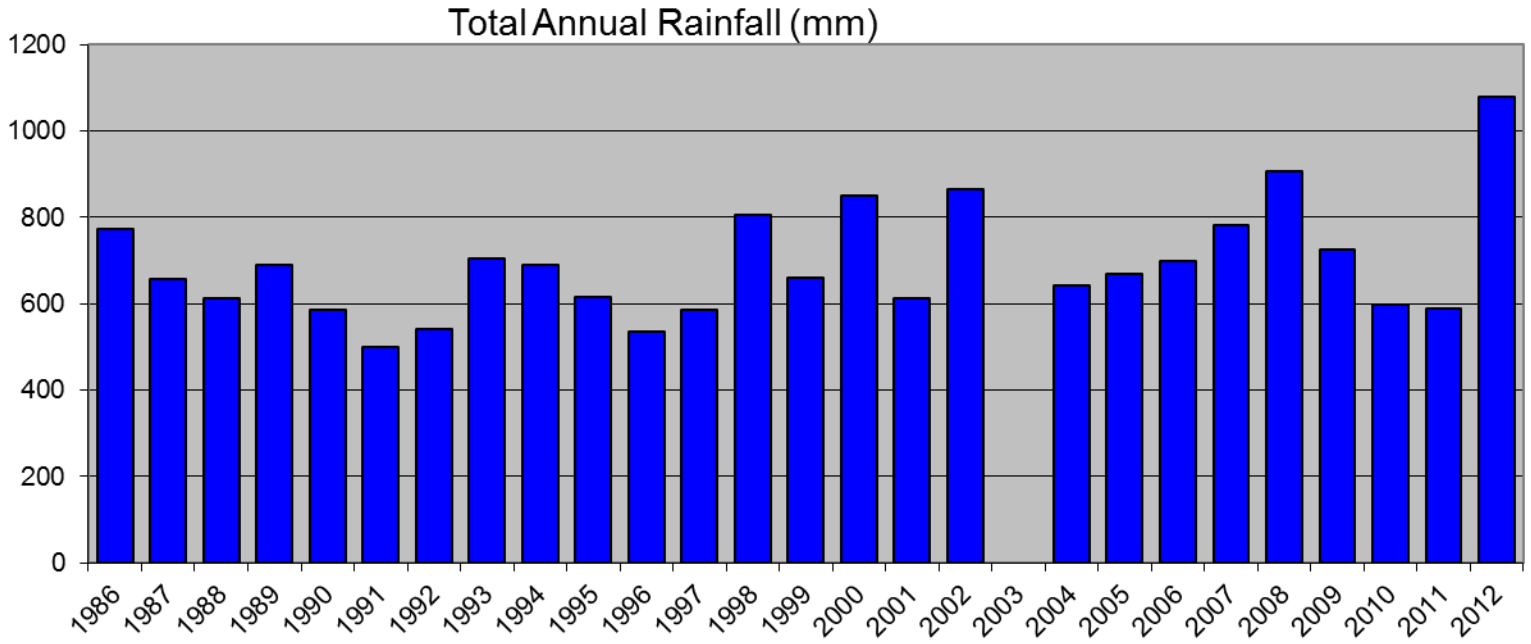
SEASONAL TEMPERATURE TRENDS

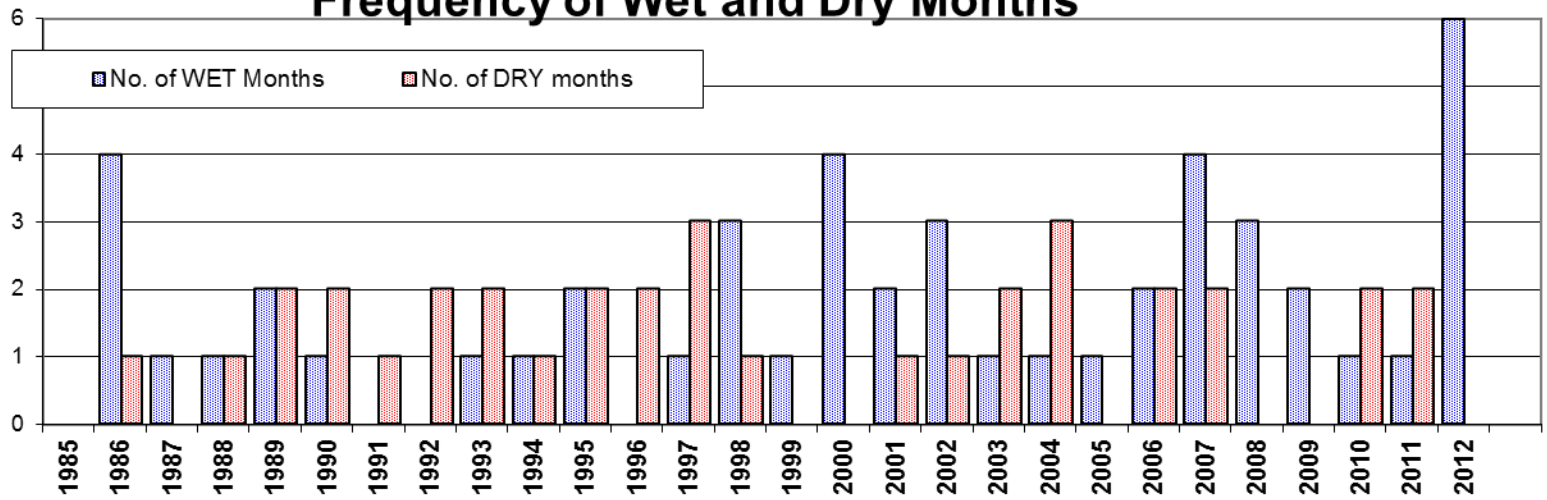




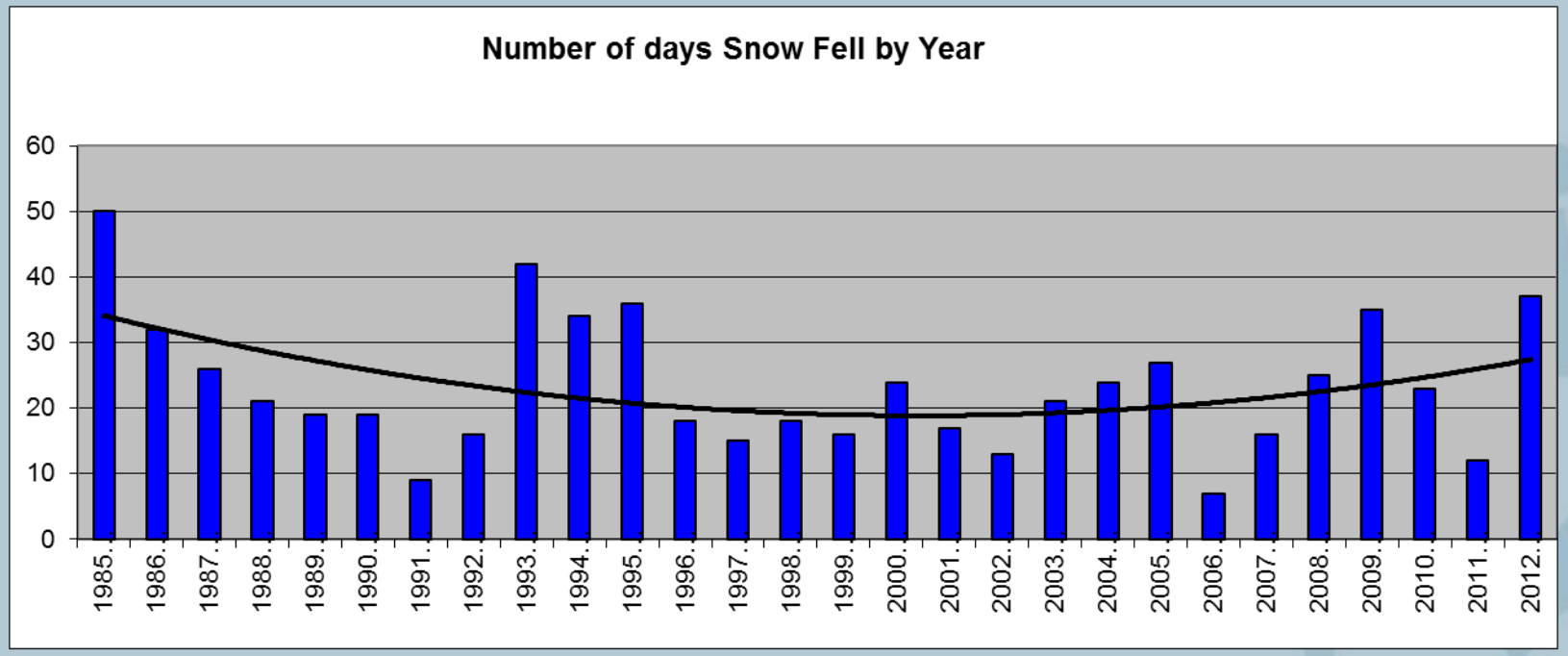








Wet Month = > 165% of Monthly Average Rainfall


Number of days Snow Fell by Year
60
50
40
30
20
10
0
1985.
1986.
1987.
1988.
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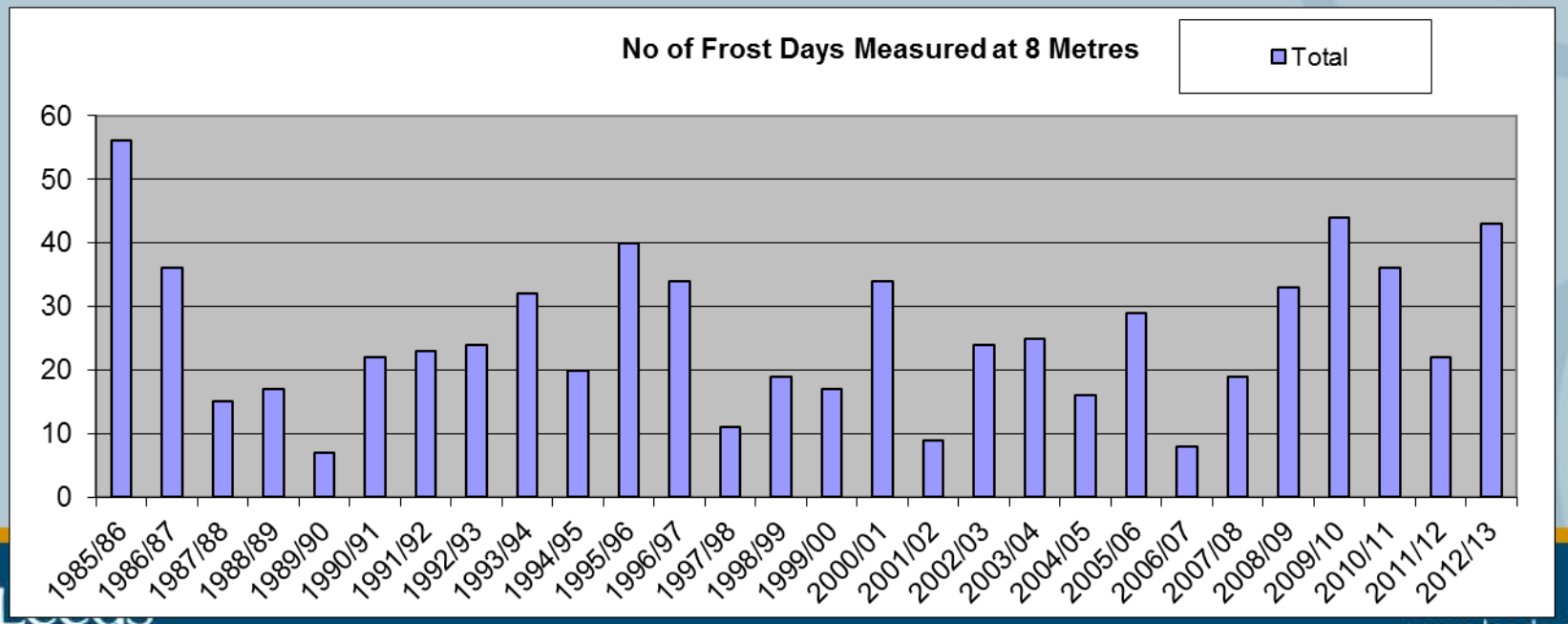
No of Frost Days Measured at 8 Metres
Total
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50
40
30
20
10
0
1985/86
1986/87
1987/88
1988/89
1989/90
1990/91
1991/92
1992/93
1993/94
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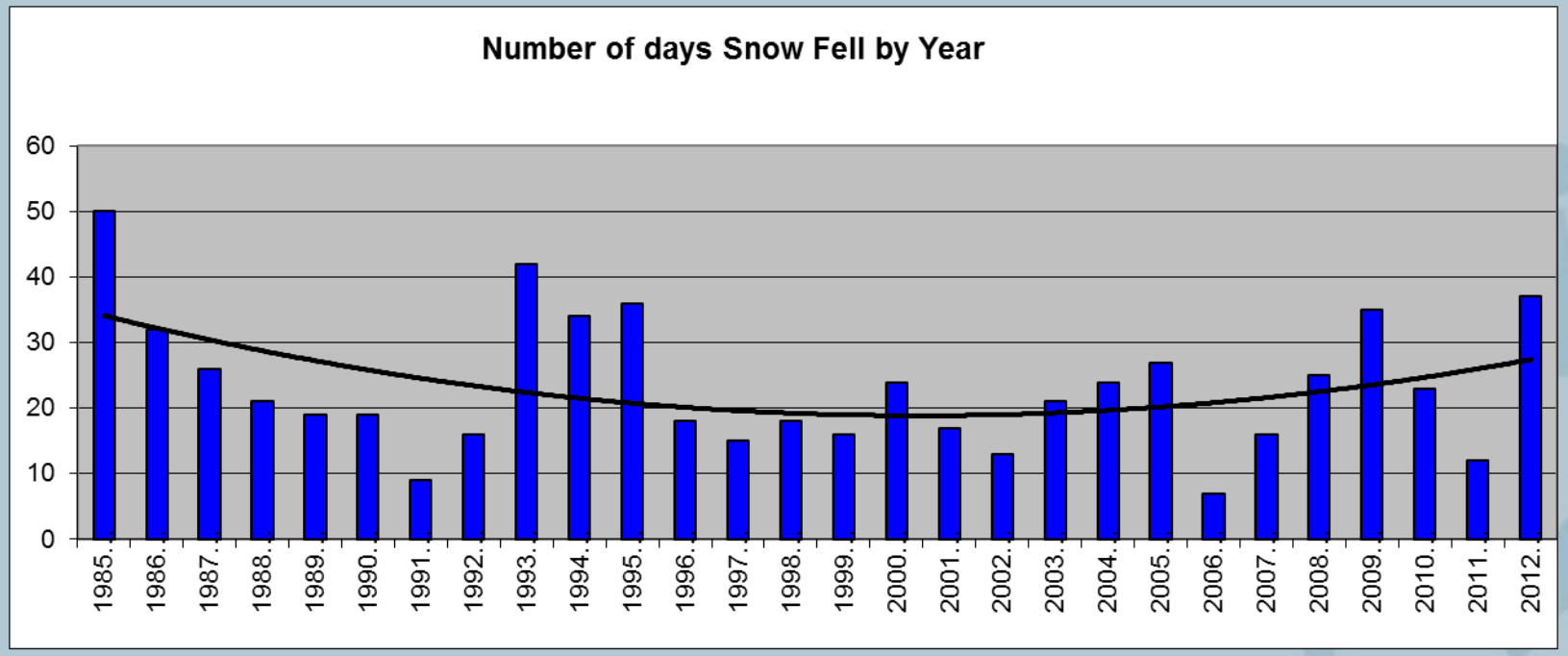
2000/01
2001/02
2002/03
2003/04
2004/05
2005/06
2006/07
2007/08
2008/09
2009/10
2010/11
2011/12
2012/13

Rainfall Intensity

- Short dataset, since 1997
- Indications of higher rainfall intensities
- Indications of greater daily rainfall totals, during anytime of year
- Previous graph: Increasing variability of rainfall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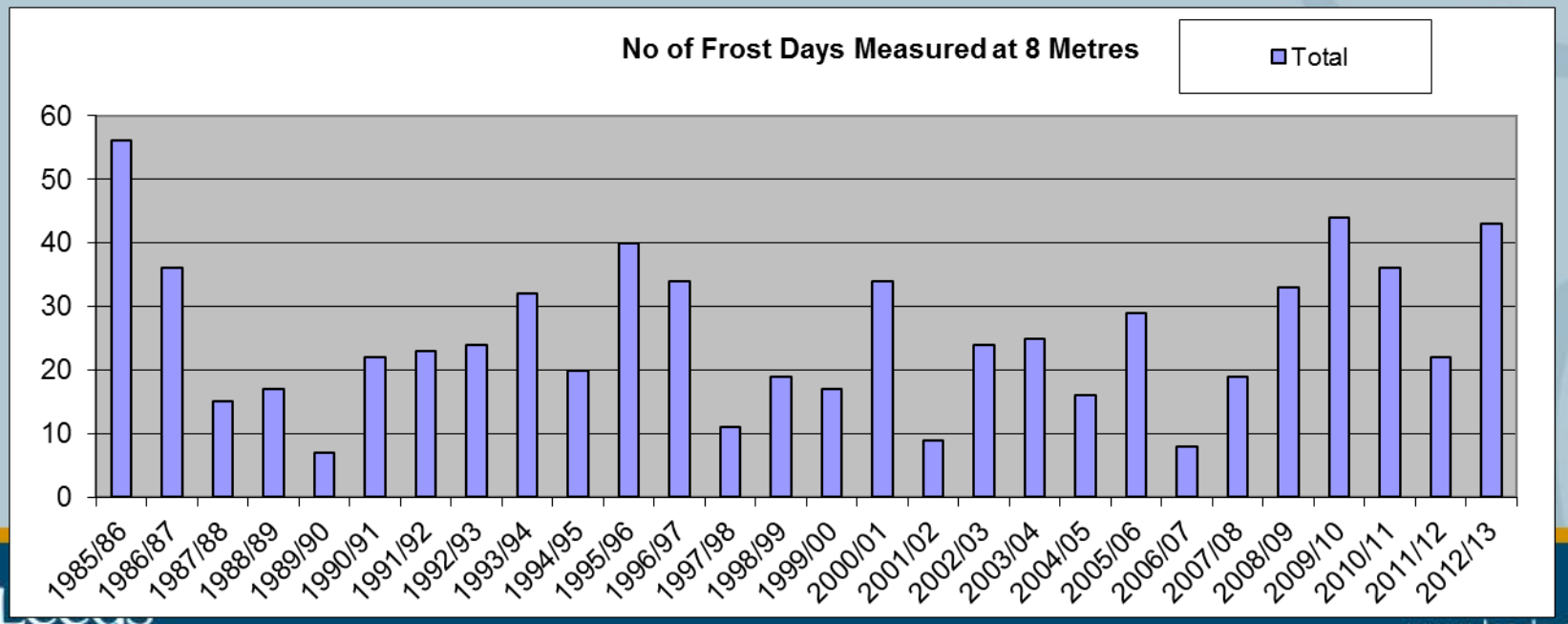
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2001/02
2002/03
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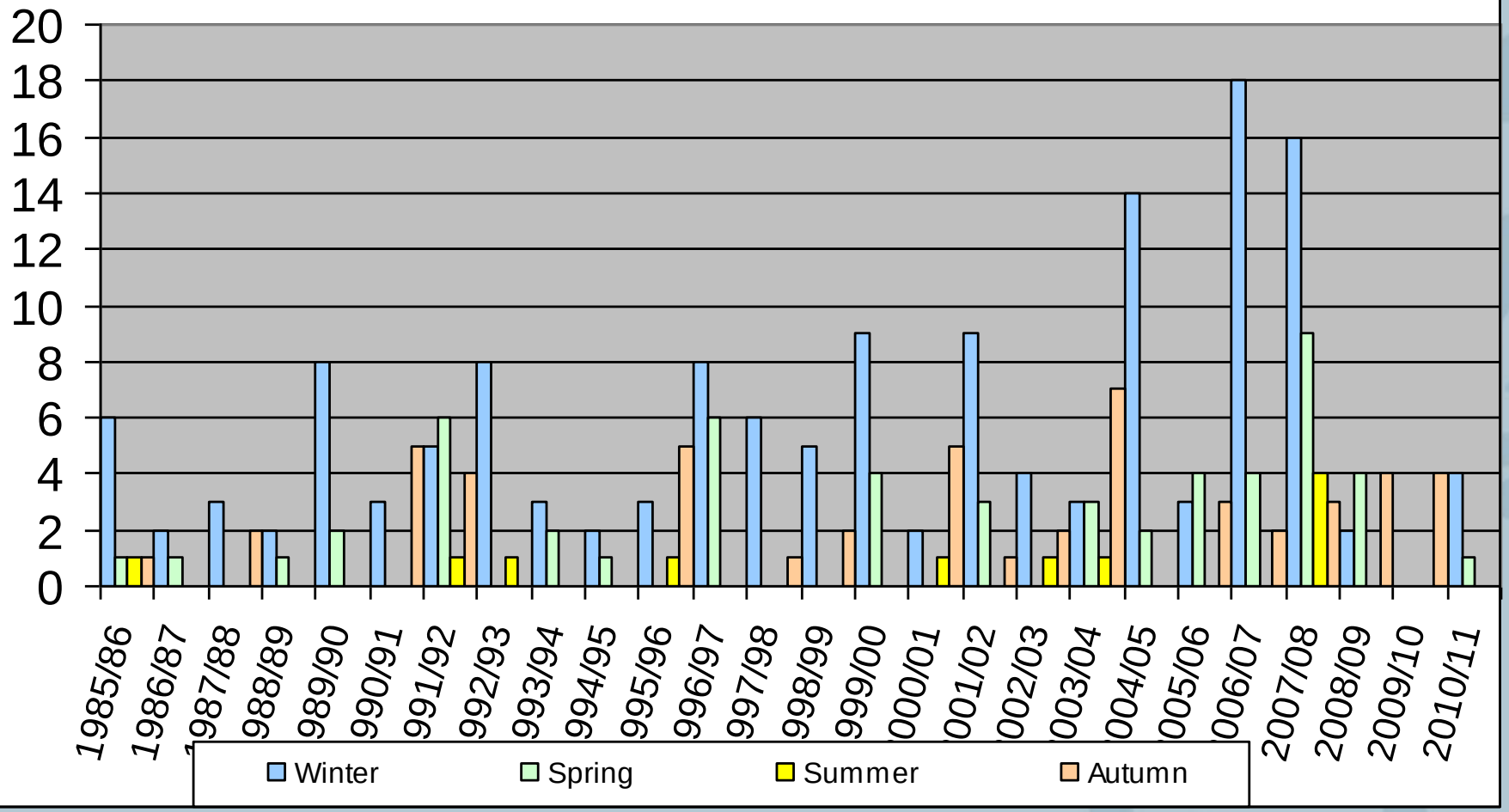
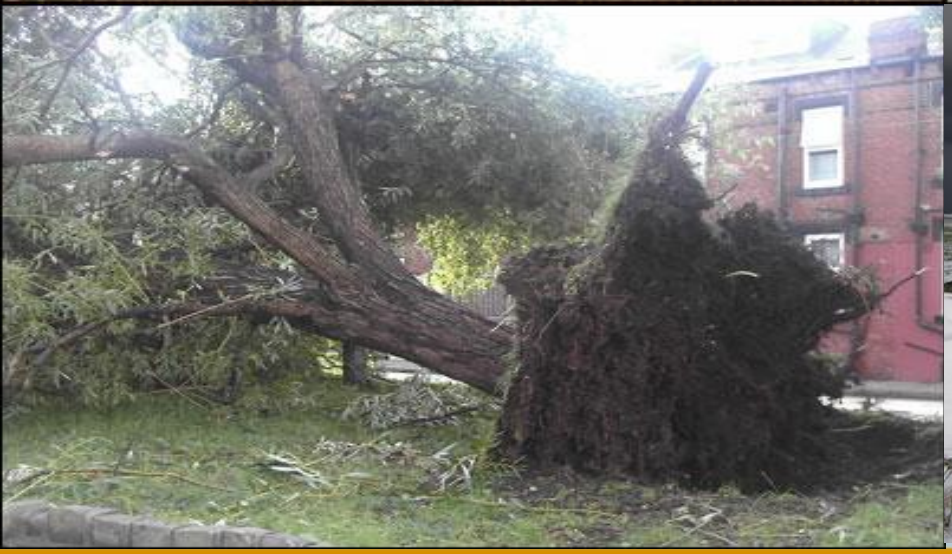
2007/08
2008/09
2009/10
2010/11
2011/12
2012/13

Number of Gales by Season



RECENT CLIMATE RISKS IN LEEDS



A Local Climate Impacts Profile (LCLIP)

- A LCLIP will help identify existing vulnerability to climate risk.
- Trawl of electronic archive headlines from regional/local newspapers (YP/YEP) + personal Weather Log!
- Spreadsheet completed for 7 years (2002-08), includes:-
  - Date/source/headline/weather hazard & location
  - Relevant facts/figures & possible photo evidence
  - Significance of event (Disruption/related issues)
- 45 out of a total of 180 weather events were identified as significant, using the Rooney method for assessing disruption

LCLIP Impact Summary Table

Season:	2002	2003	2004	2005	2006	2007	2008
Winter (Dec-Feb)	30-31 Dec; 28 Jan; 11 Feb; 22 Feb	4 Feb	2 Jan; 28 Jan	1 Jan; 7-9 Jan; 20 Jan; 24 Feb		18 Jan	4 Jan; 21 Jan; 23 Jan; 25 Jan; 31 Jan; 27 Feb; 2-4 Dec; 7 Dec
Spring (Mar-May)		13 Apr	20 Mar	3 May	4 Mar		22 Mar
Summer (Jun-Aug)	30 Jul-2 Aug	22 Jun; 12-13 Jul; 3-9 Aug	August		2 Jul; 17-31 Jul; 17 Aug; 23 Aug	June	10 Jun; 4 Sep
Autumn (Sep-Nov)	28 Oct				14 Sep; 26 Oct		


Strong winds


Flooding


Heavy rain


Lightning strike


Wintry conditions


Heat

1st order event (highly disruptive)

2nd order event (disruptive)

3rd order event (inconvenience)

4th order event (nuisance)

LCLIP Severity Orders

Severity of event	Strong winds	Flooding	Heavy rain	Lightning strike	Wintry conditions	Heat
1st order (highly disruptive)	3	3	0	0	1	0
2nd order (disruptive)	4	2	0	0	2	0
3rd order (inconvenience)	3	5	3	2	5	2
4th order (nuisance)	2	0	3	0	3	2
Total:	**12**	**10**	**6**	**2**	**10**	**4**

- The most disruptive & frequent events were strong winds & flooding. (descriptions in LCLIP)
- Missed the last 5 winters & further wet summers!

Climate Proofing Template for Transport

- **Warmer, Wetter Winters:**
  - **Cleansing drains/watercourses, SUDS, porous asphalt, modified winter maintenance & verge management, chloride attach on structures, slope stabilisation, reduce pest infestation**
- **Hotter Drier Summers:**
  - **Resilience of highway infrastructure to high temps, thermal comfort issues for PT, infrastructure & landscaping resistant to subsidence & low soil moisture in drought**
- **Flooding:**
  - **Use of EA/LA flood maps & vulnerability mapping, emergency planning, UTC diversions & intranet warnings, SUDS & resilience of road surfaces & bridges to increased water scouring/erosion**

Climate Proofing Template for Transport

- **Gales:**
  - **Improved VMS/ISA warnings on exposed routes, use of natural shelter belts, wind flow modelling of structures, wind stress resilience for infrastructure & highway landscaping**
- **Other Major Sectors**
  - **Utilities**
  - **Built environment (Domestic/Non domestic)**
  - **Health & social Care**
  - **The Natural environment**

UKCP(09) Yorkshire & Humber Region (2080, Medium Emissions)

- **Increase in Winter Mean Temps**

(90% probability +1.6C, 50% = +3C, 10% = +4.6C)

- **Increase in Summer Mean Temps**

(90% probability +1.7C, 50% = +3.3C, 10% = +5.4C)

- **Increase in Winter Precipitation**

(90% probability +2%, 50% = +15%, 10% = +33%)

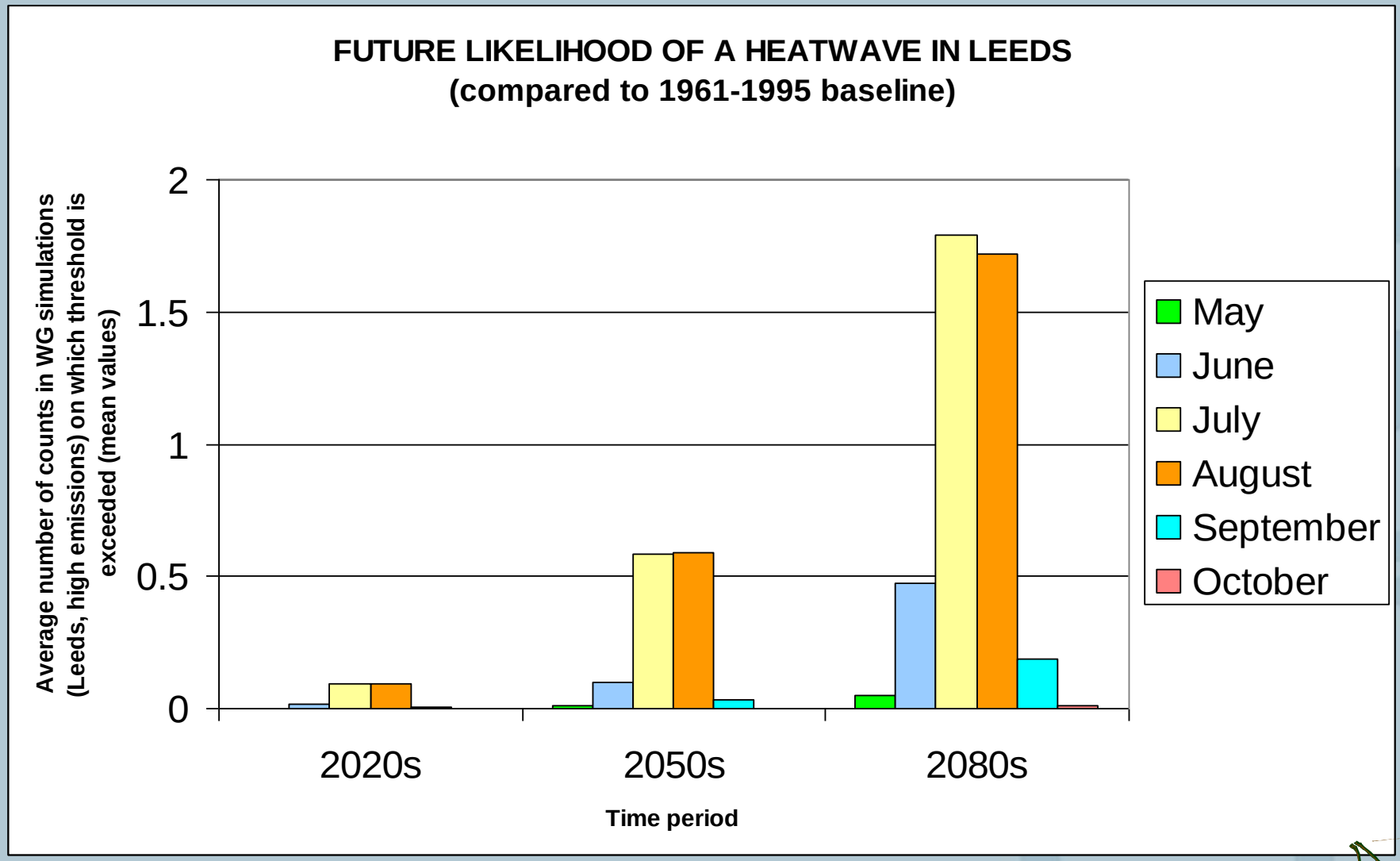
- **Decrease in Summer Precipitation**

(90% probability 0%, 50% = -23%, 10% = -44%)

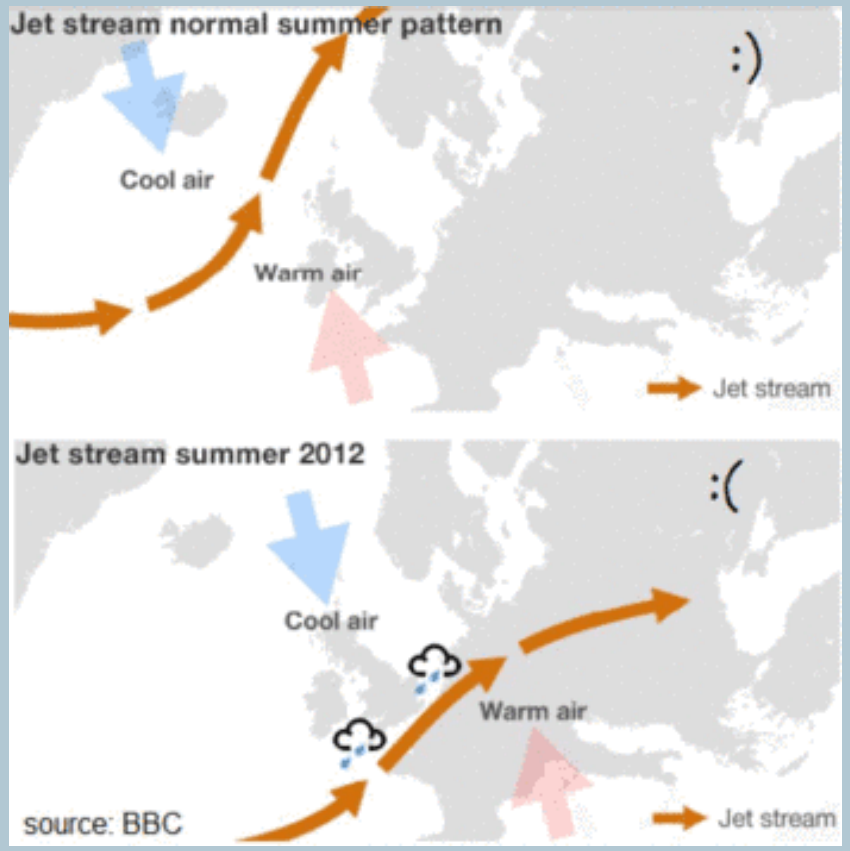
- **Increased risk of Severe Weather Events**

Use of UKCP(09) Examples/Thresholds

- **Weather Generator**
  - Provides a statistical representation of future climate/30yr slots
- **Threshold Detector**
  - Can identify future probability of exceeding weather thresholds. (Cannot assess wind, or effect of Jet Stream!)
- **Potential Transport Weather Thresholds**
  - Exceed the Heatwave criteria for NE England (2 consecutive days >30 Celsius & intervening night >15 Celsuis)
  - Bridge scour/river flooding (Prolonged heavy rain >50mm)


FUTURE LIKELIHOOD OF A HEATWAVE IN LEEDS
(compared to 1961-1995 baseline)
Average number of counts in WG simulations (Leeds, high emissions) on which threshold is exceeded (mean values)
2
1.5
1
0.5
0
2020s
2050s
2080s
Time period
May
June
July
August
September
October

Implications of the Jet Stream?

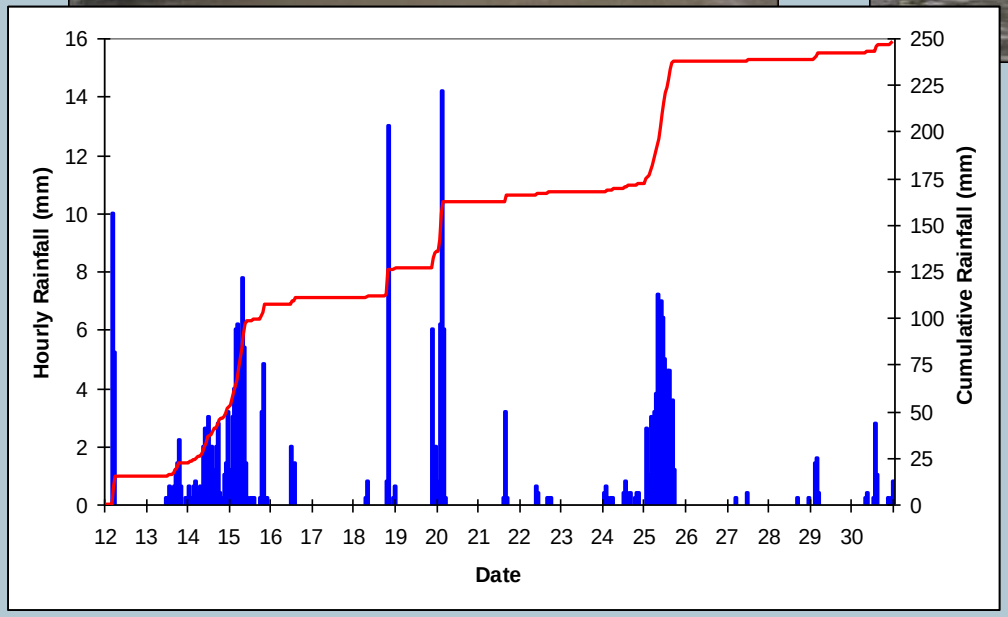


- Responsible for recent poor summers & cold winters
- Theory from Sheffield University Scientists:-
  - Weakening temp gradient between Poles & Equator
  - Reduced Jet Stream power
  - Easily distorted & can lead to 'Blocking Systems
  - Eg July 2012-record rainfall
  - Eg March 2013-record cold & snow

Other Severe Local Weather Events

- **Rainfall:**
  - June 2007, worst flooding for over 100yrs in Hull, Sheffield
  - April 2011-March 2012, worst drought since 1921 in parts of N & E Yorks. (Reservoirs full in W Yorks)
- **Temperature:**
  - November 2010, record high & low (-14 to +18C)
  - December 2010, coldest for >100yrs (-19C Topcliffe)
  - February 2012, big contrasts in Yorks (-13 to +18C)
  - March 2012 Heatwave, 10cms snow April 4th
- **Links with Global Weirding (BBC Horizon)**
  - Huge global extremes eg. W Texas, worst floods on record 2010, followed by record drought 2011/12

FLOODING IN LEEDS (15th & 25th JUNE 2007)

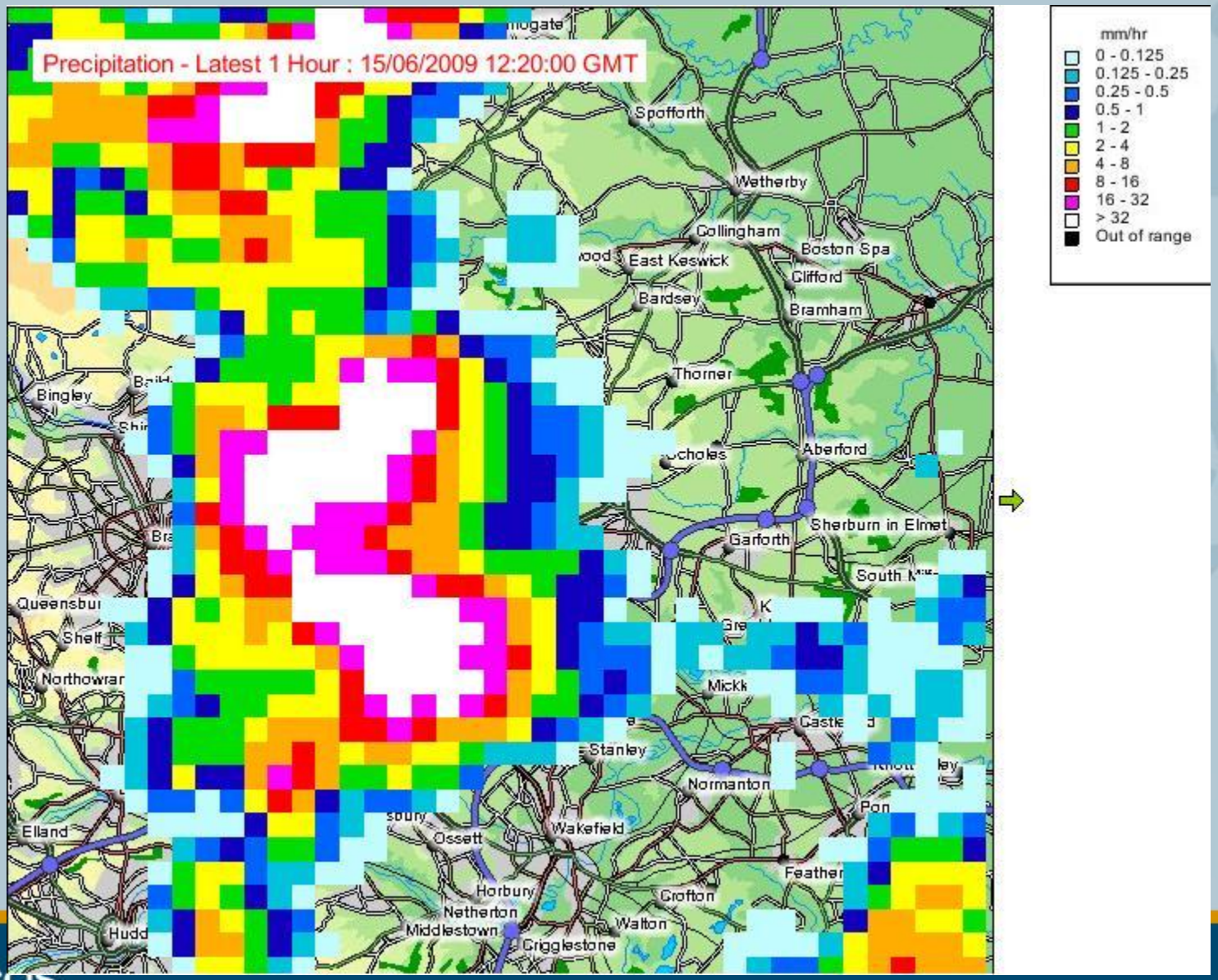


Integrated Actions to Reduce Flood Risk

- Partnership working between Flood Risk Management, Environment Agency & Yorkshire Water
- Integrated measures are being developed to reduce vulnerability to flooding.
  - Modelling of catchment areas & data collection
  - Use of rain gauge network/collection of rainfall intensity & totals
  - Use of met Office real-time rainfall radar data (Enviromet)

    (Estimates rainfall intensity/5-min/Km2)
  - Making space for water, etc.
- Aid knowledge for Surface Water flood maps

Output From Enviromet Rainfall Intensities



Examples of Climate Proofing
Cleansing of Watercourse/Culvert Flood Hotspots

- Flood Risk Management responsible for keeping all watercourses clear (Budget ~£0.5m)
- Have identified top '50 flood hotspots'
- Use of Contractor for regular cleansing of watercourses. (Fortnightly)
- Vulnerable locations include culvert grids, or watercourses prone to fly-tipping.
- 50 Asda shopping trolleys found in Wyke beck, following floods, May 3rd,2005. (Now highway cones!)
- Asda wheel locking system now in operation, Leeds Enforcement/fining of supermarkets for trolleys

Bespoke Flood Protection Measures

Cleansing of Watercourses

Improved Gully Cleansing, also undertaken

IMPROVE EFFICIENCY OF GULLY CLEANSING

- Blocked gullies exacerbate problems of flash flooding & disrupt transport & damage property.
- Recently purchased 2 additional gully cleansing vehicles.
- Range of efficiency measures to reduce highway flooding:-
  - Includes total of 170,000 gullies!
  - GIS for gully location & priority for cleansing/upgrades
- First flush after dry spell & leaf fall, cause problems!
- New drainage design takes CC into account:-
  - **+ 20% extra flood storage**
  - **+ 30% additional rainfall**

Sustainable Drainage for East Leeds Link Road

- Alignment of ELLR in Lower Aire Valley (prone to fluvial/valley flooding)
- Elevated carriageway (1 metre) with granular subdrain, reed beds & controlled discharge.
- Balancing tanks/pipes (1.2 diameter by 100 metre), ensure run-off rates to Wyke Beck are not increased.
- Large granular drains/discharge pipes, capable of storing 1 cubic metre of water/ metre carriageway.
- Dry balancing pond & reed beds, with controlled discharge.

(Benefits to biodiversity & water quality)

ELLR Sustainable Drainage

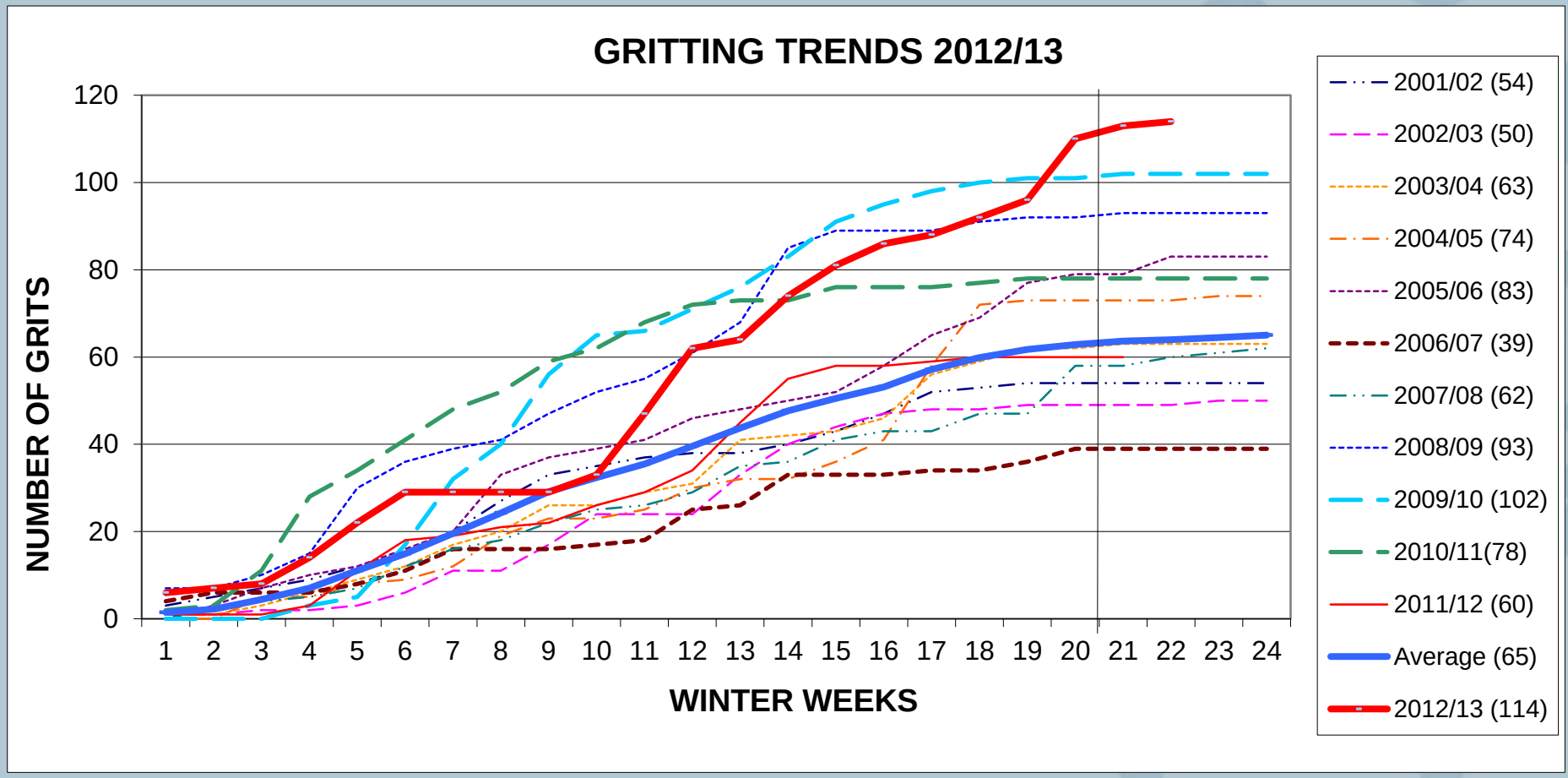
Other measures include, balancing tanks/pipes & reed beds

SUDS can improve water quality & Biodiversity

WINTER MAINTENANCE PROCEDURES

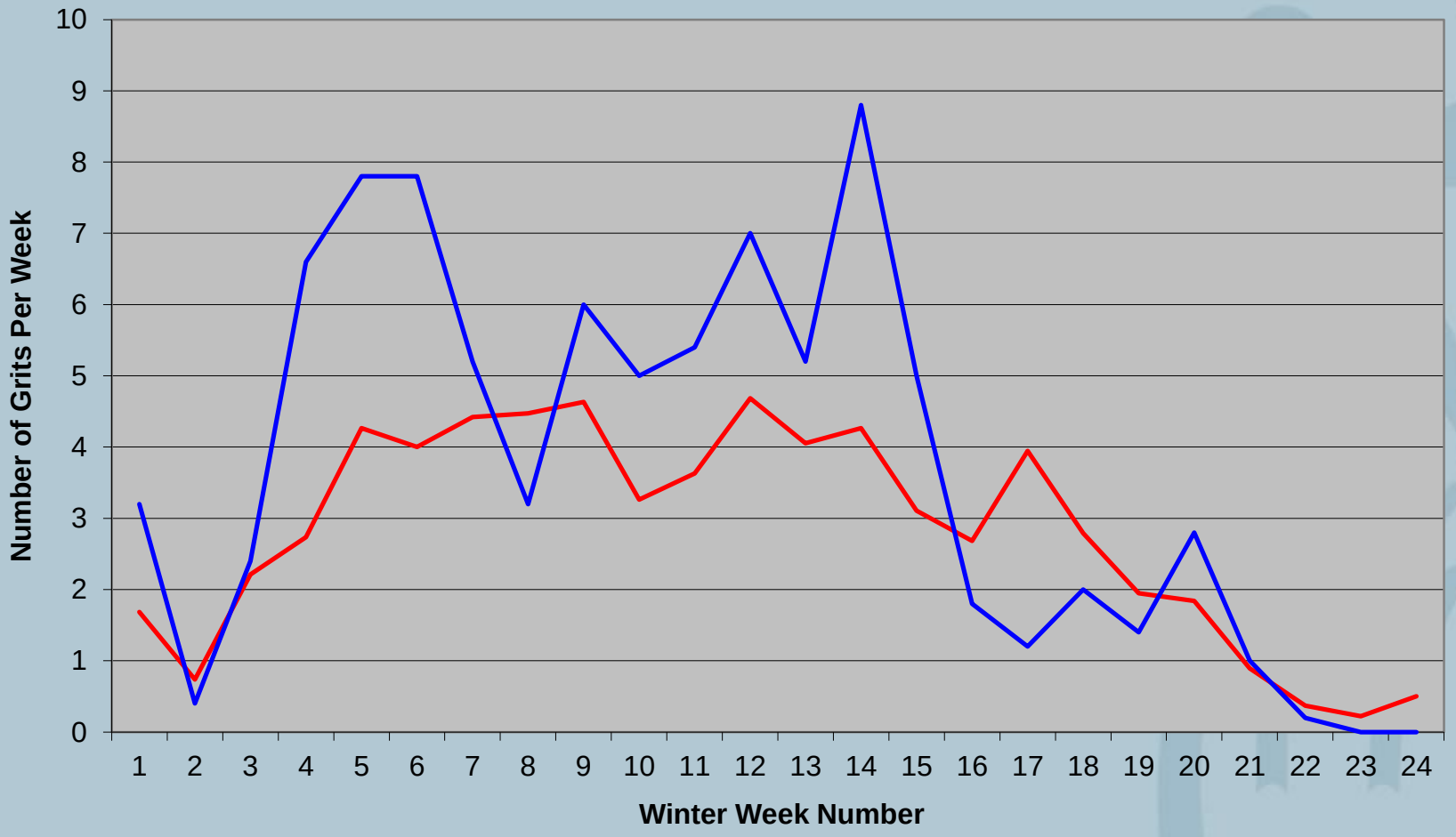
- Aided by highway Met stations, Met Office forecasts, thermal mapping & salt sensors
- Increased partial grits, e.g. routes >300ft/>500 ft /cold/wet spots
- Use of computerised/low spread gritters
- Snowploughs upgraded, rarely used until 2008/09 to 2012/13
- Gritting complications:-
  - Increased marginal conditions
  - Increased flushing of salt (rainfall/runoff)
  - Recent run of cold snowy winters
  - Significant increase in No. of grits & total costs
  - Increased salt stock holding
  - Benefits of sheeting up salt stocks/salt barns
  - Successful use of quad bikes gritters for footways

HIGHWAYS GRITTING TREND (1994-2009)



- Gritting costs £1-2 million/year

Comparison of Average Number of Grits Per Week



Alternative De-Icing Agents/Processes

- How to reduce salt application on highways:-
  - Improved spreading system & reduce application rate
- Alternative de-icing agents
  - Urea, used at Leeds Bradford International Airport
    (Expensive, effects on water quality)
  - Salt with molasses, reduces flushing off, 'rat friendly'
  - Omex (Potassium Acetate), good for the environment & structures, 2.5x more expensive
  - Trial being considered for vulnerable areas eg Leeds IRR
    (Now being used by Highway Agency on certain bridges)

Climate Proofing Concrete Structures
Chloride Attack

- Increased salt application has exacerbated chloride attach on concrete structures
- 1mm of corroded steel, expands 100x & cracks concrete
- Approx £30m being spent repairing/strengthening structures on Leeds Inner Ring 2009 to present day
- Climate proofing measures being considered include:-
  - Improved drainage, waterproofing & bonding of highway surfaces
  - Reduce use of bearings & expansion joints
  - Alternative construction materials, eg. Stainless steel, epoxy coating

Chloride Damage to Bridges

Water Scouring of bridges Abutments

Increased River Flows & Bridge Scour

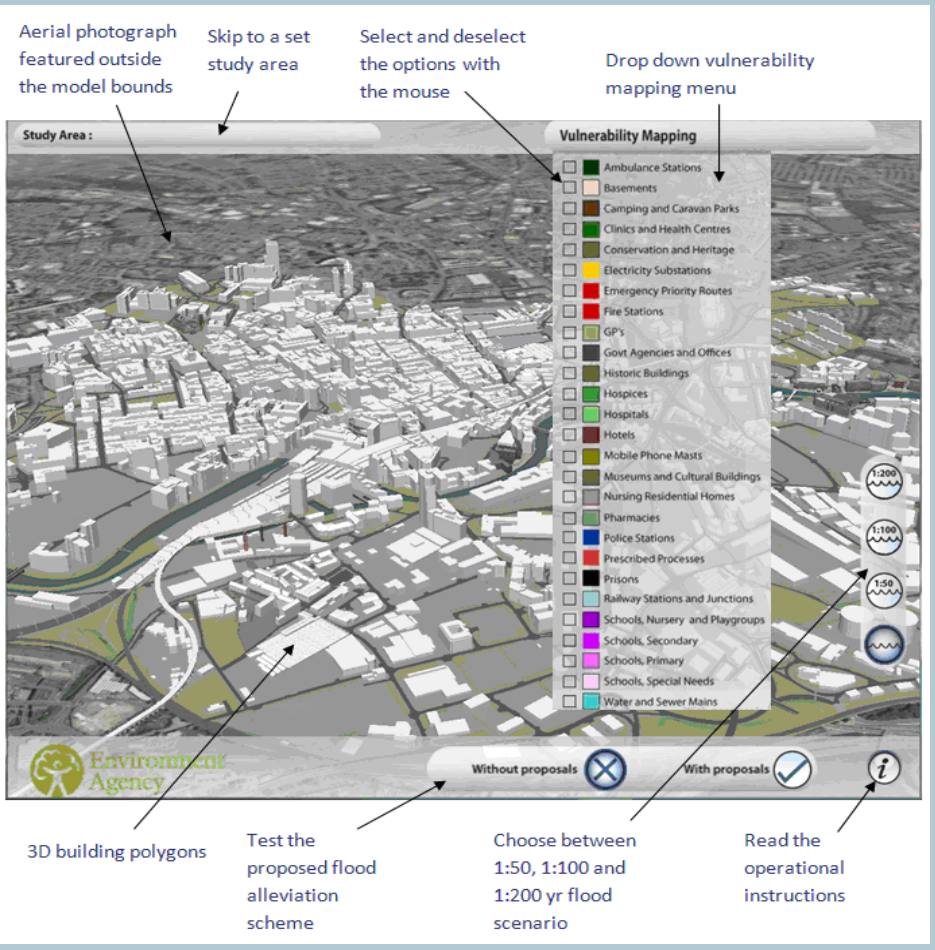
- Increased wet periods/rain intensities, lead to increased river flows
- Greater risk of bridge foundation scour & debris blocking arches
- All highway bridges are inspected at least every 2 years by Underwater Specialists
- Detailed Principal Inspection by Consultant every 6 yrs
- Annual scour inspections take place by divers, for river Aire, Wharfe & Calder bridges
- Since June 2007 floods, additional scour inspections now take place once a flood event has subsided.

Water Scour Damage to Bridges

Improve Resilience of Highway Materials to Increased Surface Temperatures

- Isolated problems with carriageway 'fatting up' or 'rutting'.
- Stiffer materials needed to stop rutting at bus stops.
- Pro's & Con's associated with surface dressing procedures:-
  - Correct viscosity of binder/size of chippings
  - Affects on "skid resistance" & "tyre noise".
  - Surface dressing now used to seal surface, to help prevent potholes
- Need to develop road surfacing policy that considers all aspects of severe weather
  - **(drainage, runoff, porosity, water scouring, free-thaw process).**

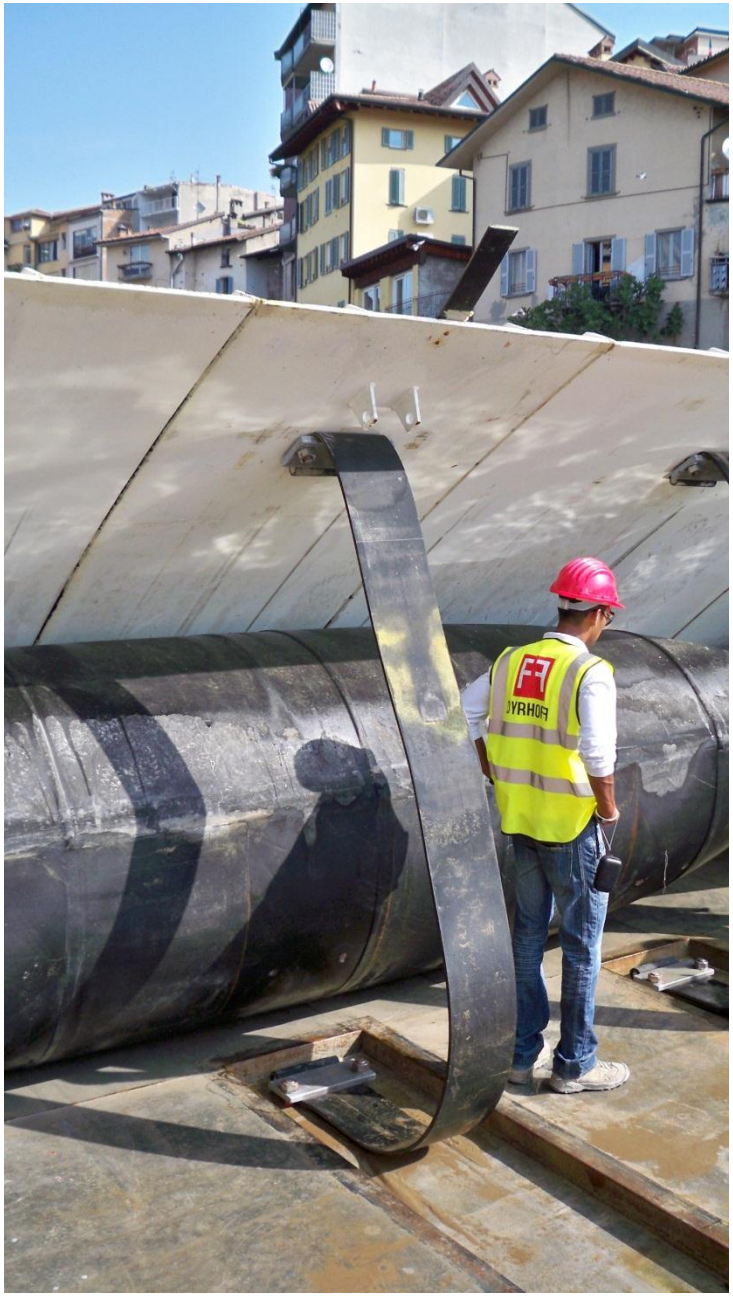
Use of Flood Visualisation Model



The Leeds Flood Alleviation Scheme (FAS)

- Initially a 1 in 75 year Standard of Protection in the city centre
- Phase 1 cost approx £45m
- Phase 2, extend 1 in 75 year protection to outer sections of Leeds
- Later to be increased to 1 in 200 year protection
- Typically a 1 in 75 year protection would prevent Direct or Indirect flood impacts for ~ 3,400 dwellings/premises
- An economic saving up to 10x cost of scheme!

Leeds Flood Alleviation Scheme



Construction of Moveable Weirs in Italy

BEFORE

New fish pass

New moveable weir

Existing heritage weir to remain

AFTER