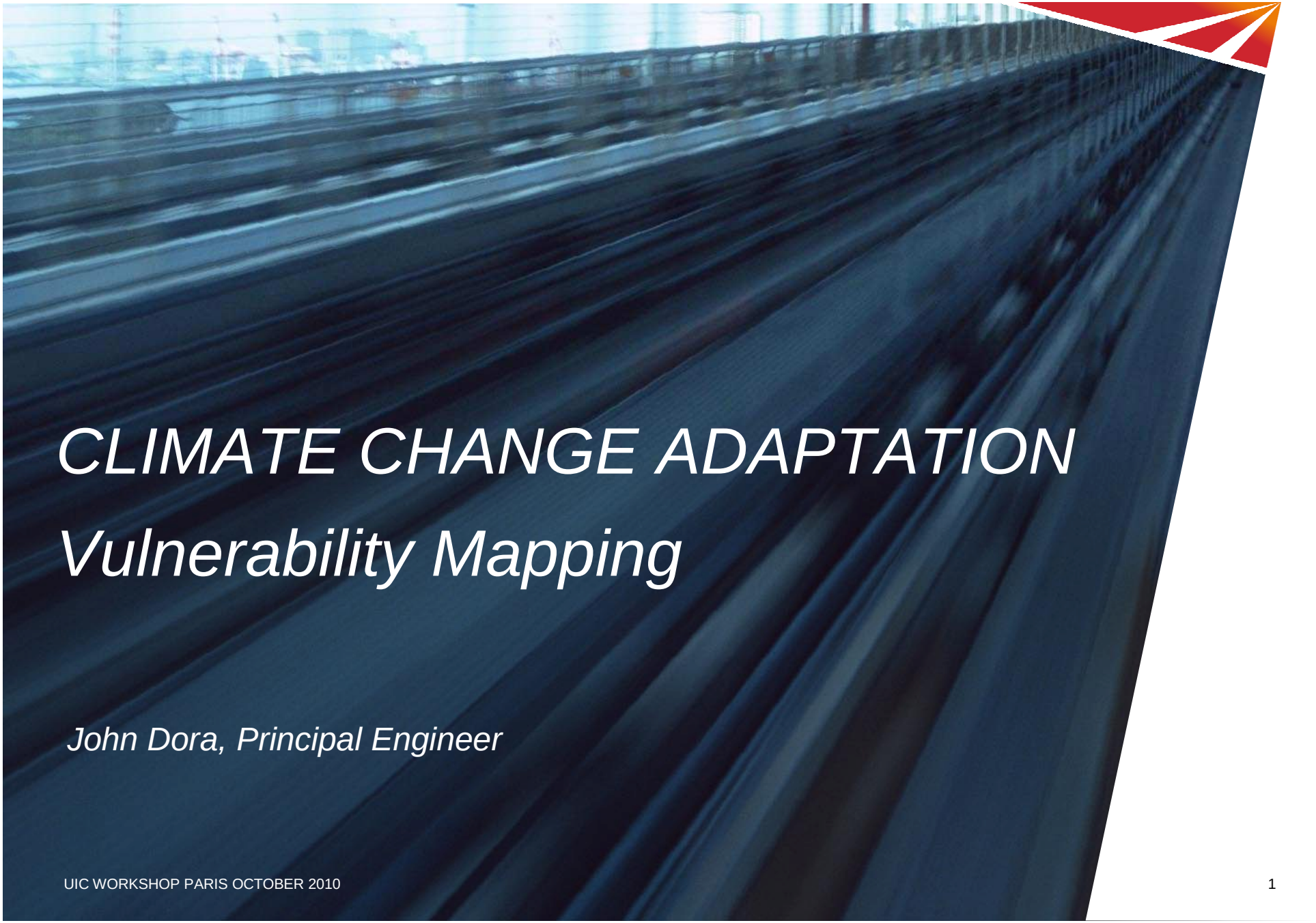


CLIMATE CHANGE ADAPTATION

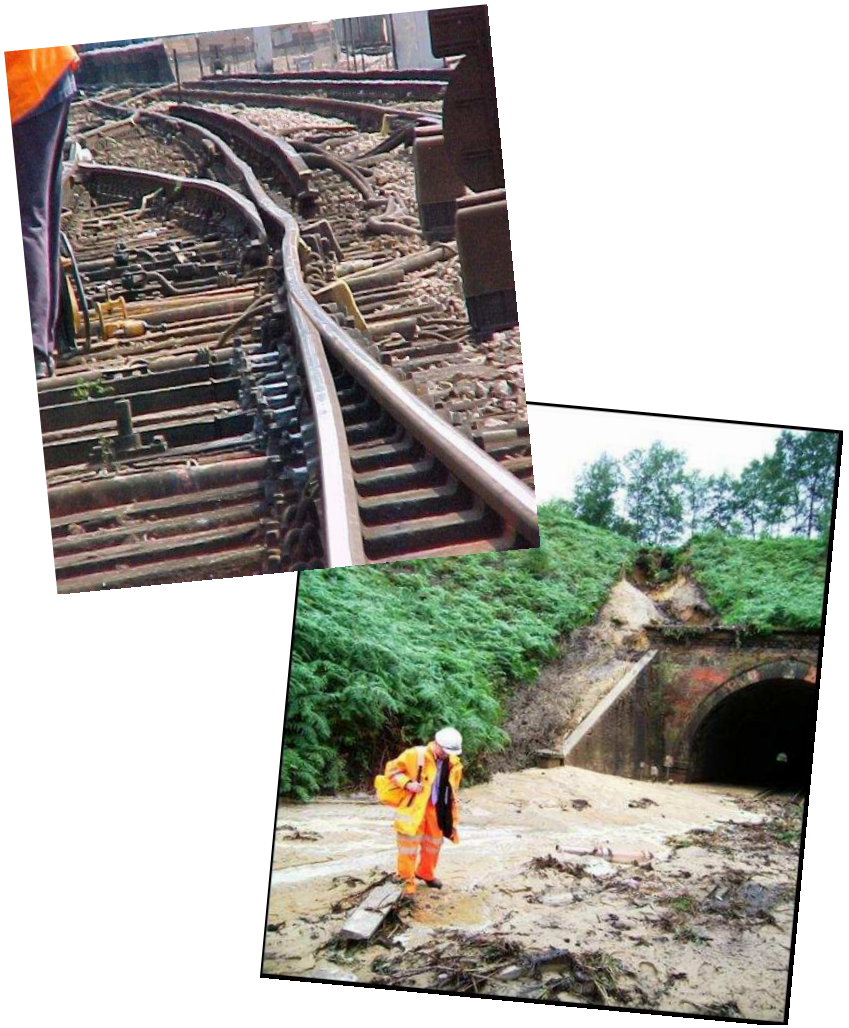
Vulnerability Mapping

John Dora, Principal Engineer

Vulnerability Mapping

Two approaches described:

1. Track buckle risk management and impact on performance
   - Based on climate modelling, historic delay data and standards
2. Earthwork and water risk
   - Based on digital mapping tools



Track Buckle Risks to Performance

- Track buckle risk management and impact on performance
- Network Rail Standards give thresholds:
  - Actions are taken at Critical Rail Temperatures (CRTs)
  - These include the deployment of heat watchmen who monitor rail temperature, to the imposition of speed restrictions to reduce the risk of derailment
- Tables specify the criteria – next slide
  - Track Engineers advised three representative criteria

Track Buckle Risks to Performance

Track condition	CRT (W)	CRT (30/60) = CRT (W) +	CRT (20) = CRT (W) +	Period for which CRT shall apply
Undisturbed, fully ballasted and consolidated	SFT[1] + 32	5	10	Permanently
Re-railed only (no other disturbance or deficiency)	SFT + 32	5	10	Permanently
No ballast shoulder: level with sleeper top (no other disturbance or deficiency)	SFT + 27	5	8	Until shoulder is restored
Tamped/lined with slues/lifts up to 25mm	SFT + 22	4	7	3 days
Tamped/lined with slues/lifts > 25mm	SFT + 20*	3	6	5 days
Mechanised stoneblown	SFT + 20	3	6	5 days
Tamped or stoneblown S&C	SFT + 20	3	6	7 days
Measured shovel packed/hand-held stoneblown	SFT +17	3	5	3 days
3 Consecutive sleepers voided at 15mm or more	SFT + 17	3	5	Until packed and stable
Ballast generally full between sleepers and on shoulders, but not consolidated (8 beds or more)	SFT + 15*	3	5	tonnage dependent
Ballast generally full between sleepers and on shoulders, but not consolidated (less than 8 beds)	SFT + 15	3	5	5 days
3 or more consecutive slurried beds, where ballast is not compacted against the sleeper ends	SFT + 10	3	5	Until packed and stable
Severe shortage of ballast between sleepers and/or part sleeper ends exposed, extending 8 beds or more	SFT + 10	N/A (apply 20 ESR at SFT +13)	3	Until fully ballasted, then 5 days

Track Buckle Risks to Performance

The main actions are designated as follows:

- CRT(W): a Watchman will be in place to monitor the length of track concerned
- CRT(30/60): a 30/60mph speed restriction shall be applied
- CRT(20): a 20mph speed restriction shall be applied
- The rail temperatures at which these actions are taken depend on the nature and condition of the track

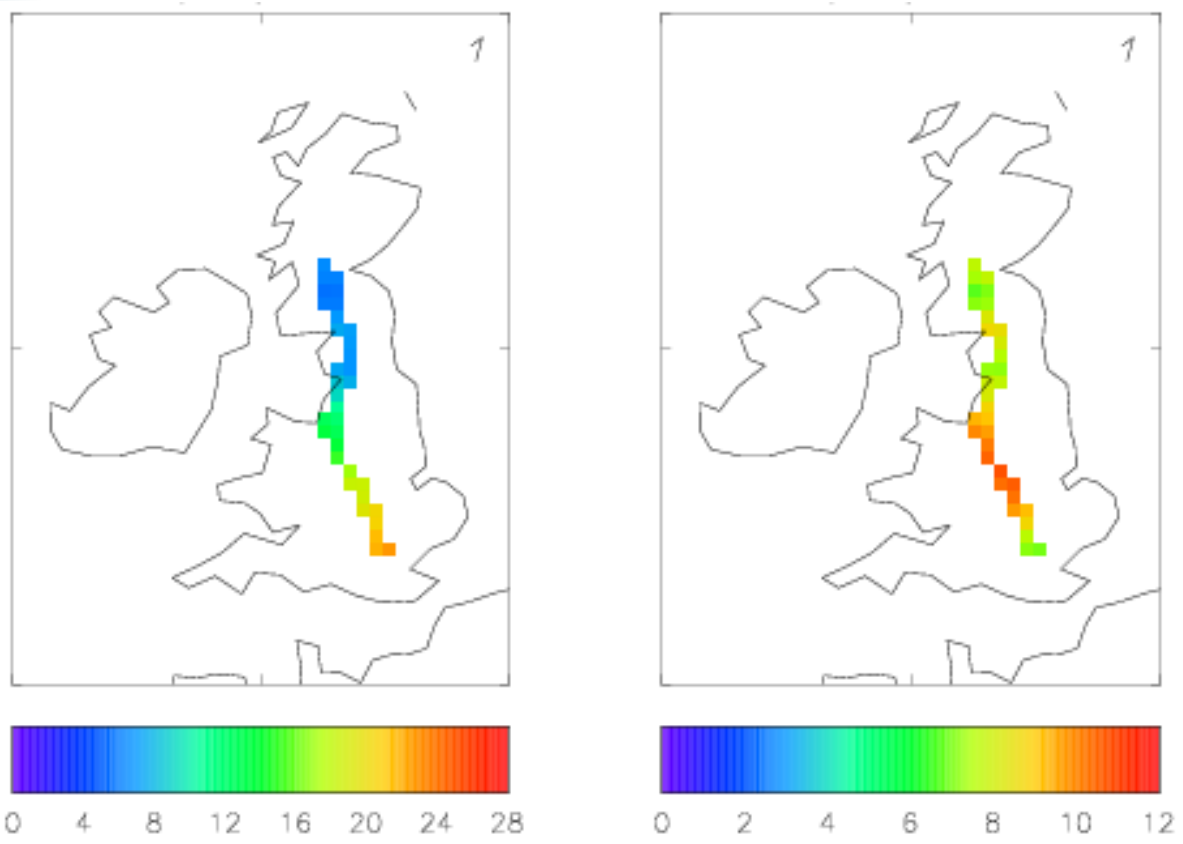
Track Buckle Risks Methodology

- Convert Rail temperature to Air temperature
  - Hunt, 1994 gives the relationship between air (T_{air}) and rail (T_{rail}) temperature (ºC) as follows:

$$T_{air} = 2/3\ T_{rail}$$

- Correct bias using observed data
- Establish frequency of days exceeding T_{air} for 2020s, 2030s, 2040s via Climate Models
- Use historic delay data on West Coast Main Line to identify where the greatest increases will be
- Calculate change for future decades

Track Buckle Results - Example

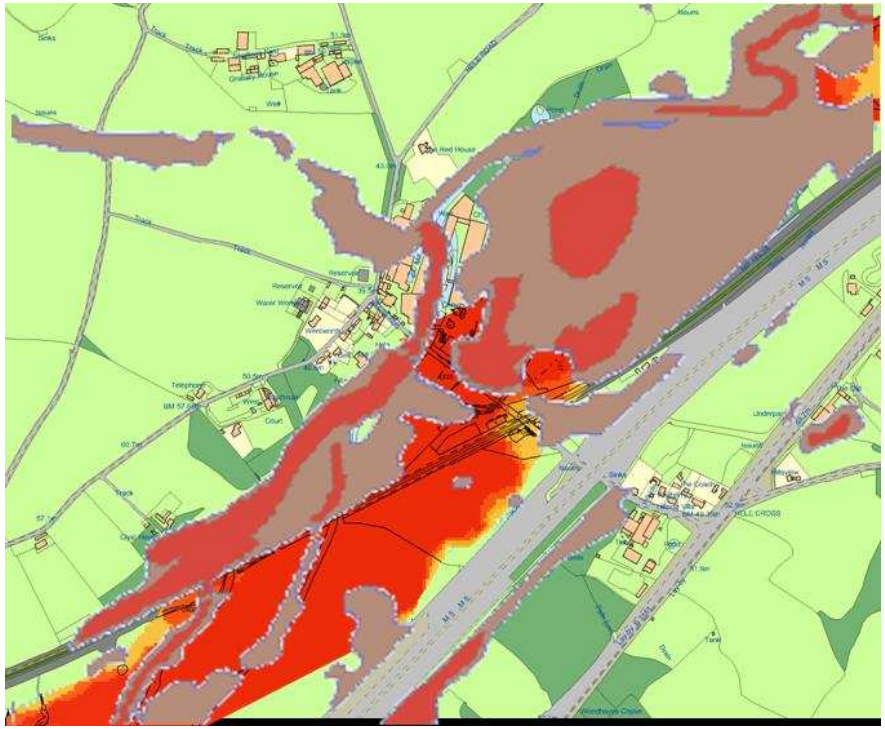


This report uses source data which is freely available from UKCP09 (c) Crown Copyright 2009. The UK Climate Projections (UKCP09) have been made available under licence from the Department for Environment, Food and Rural Affairs (Defra) and the Department of Climate Change (DECC) using data developed by the Met Office, UK Climate Impacts Programme, British Atmospheric Data Centre, Newcastle University, University of East Anglia, Environment Agency, Tyndall Centre and Proudman Oceanographic Laboratory.

Ensemble mean number of days heat watchmen are required, for 3 consecutive slurried beds in the present day (left) and change into the future (right). The uncertainty in these results is currently being assessed.

Water Risk on Earthworks

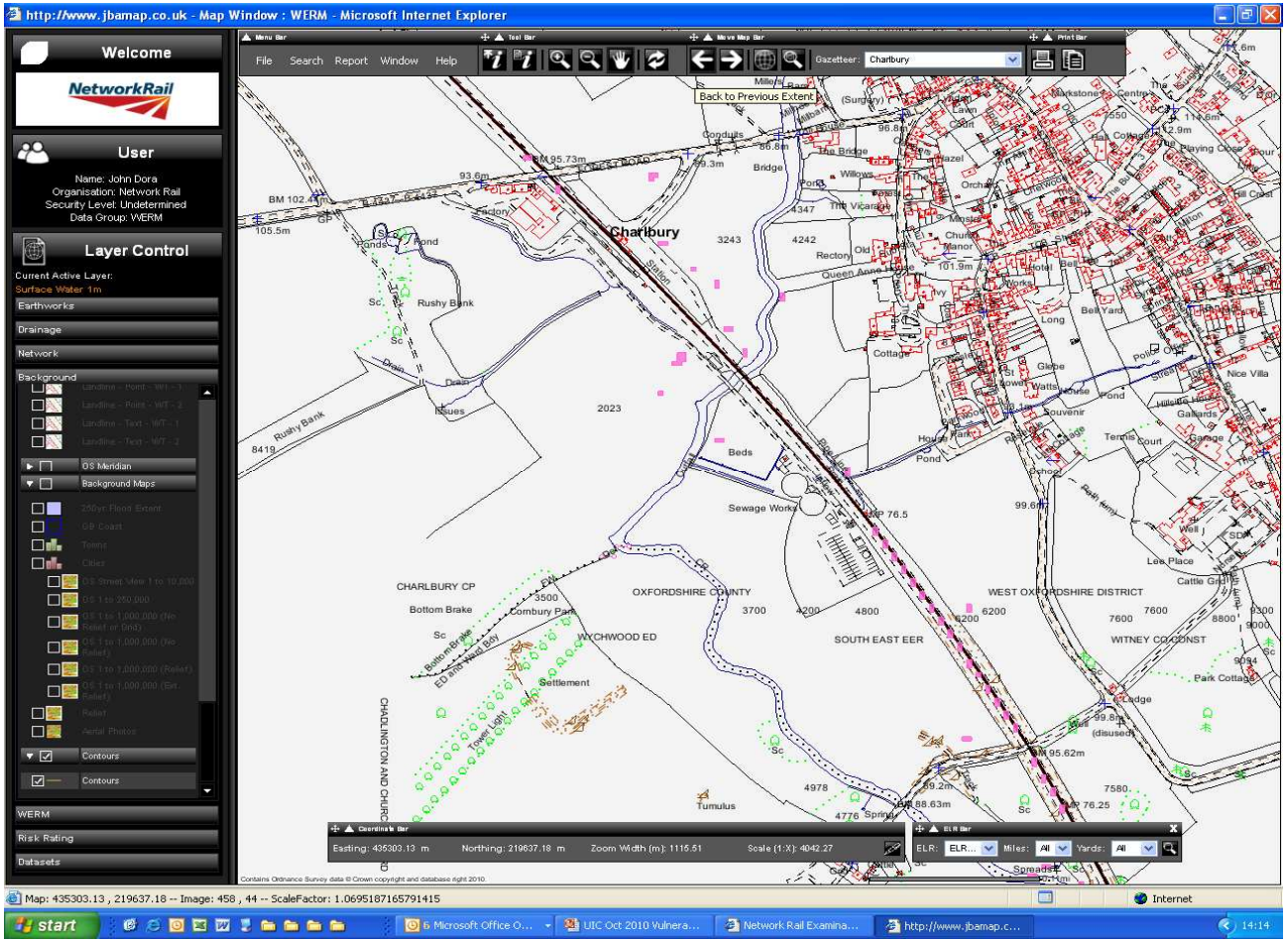
- Makes use of digital elevation and terrain modelling
- 100m swath across whole network – detailed elevation data
- Coarse data outside this swath



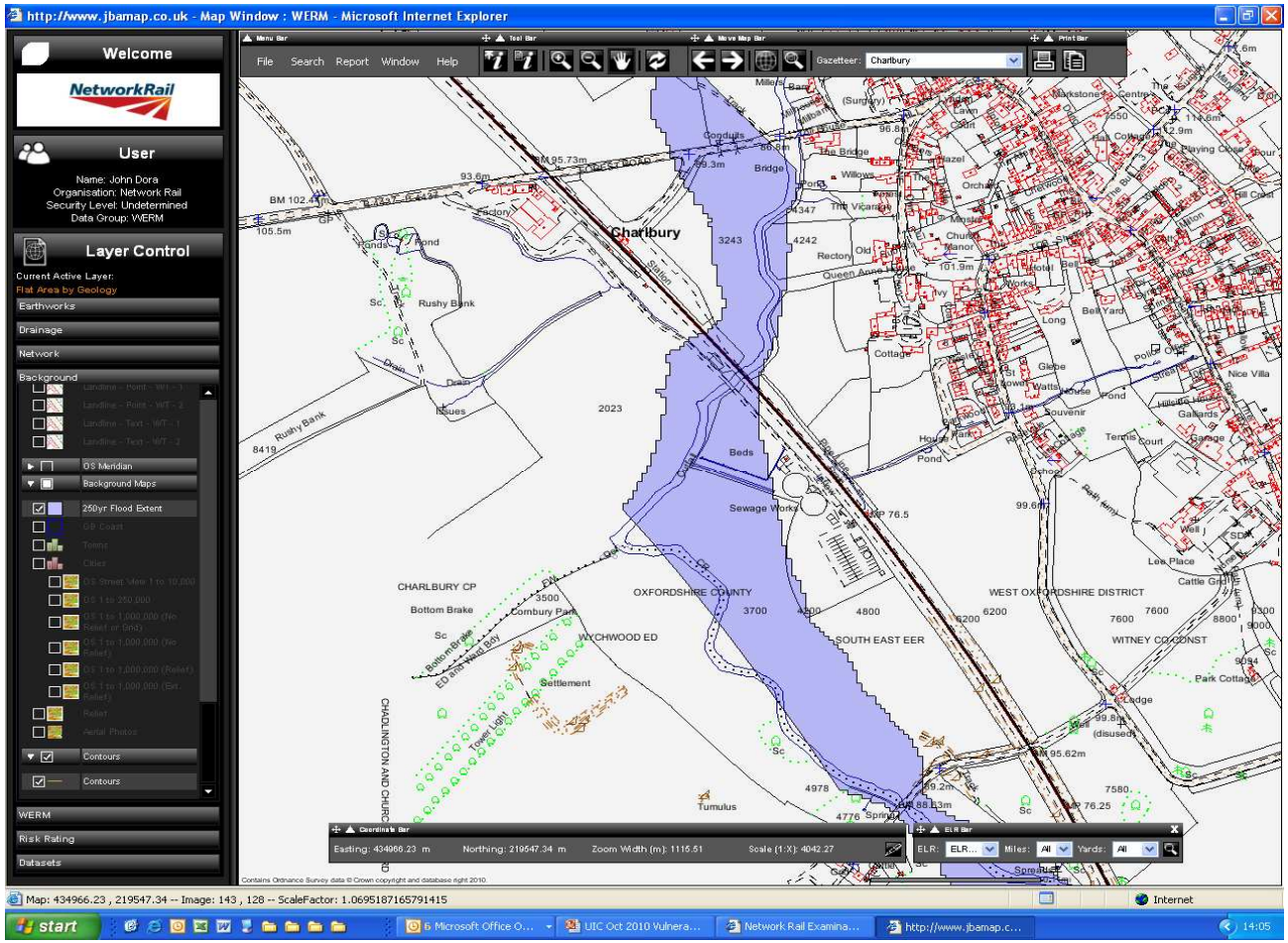
Water Risk on Earthworks

- Surface water flood risk and fluvial flood risk from Environment Agency-developed tools
- Geology from British Geological Survey
- Slope towards/ away from railway at 2m cross sections
- Risks categorised numerically:
  - water concentration + geology + height

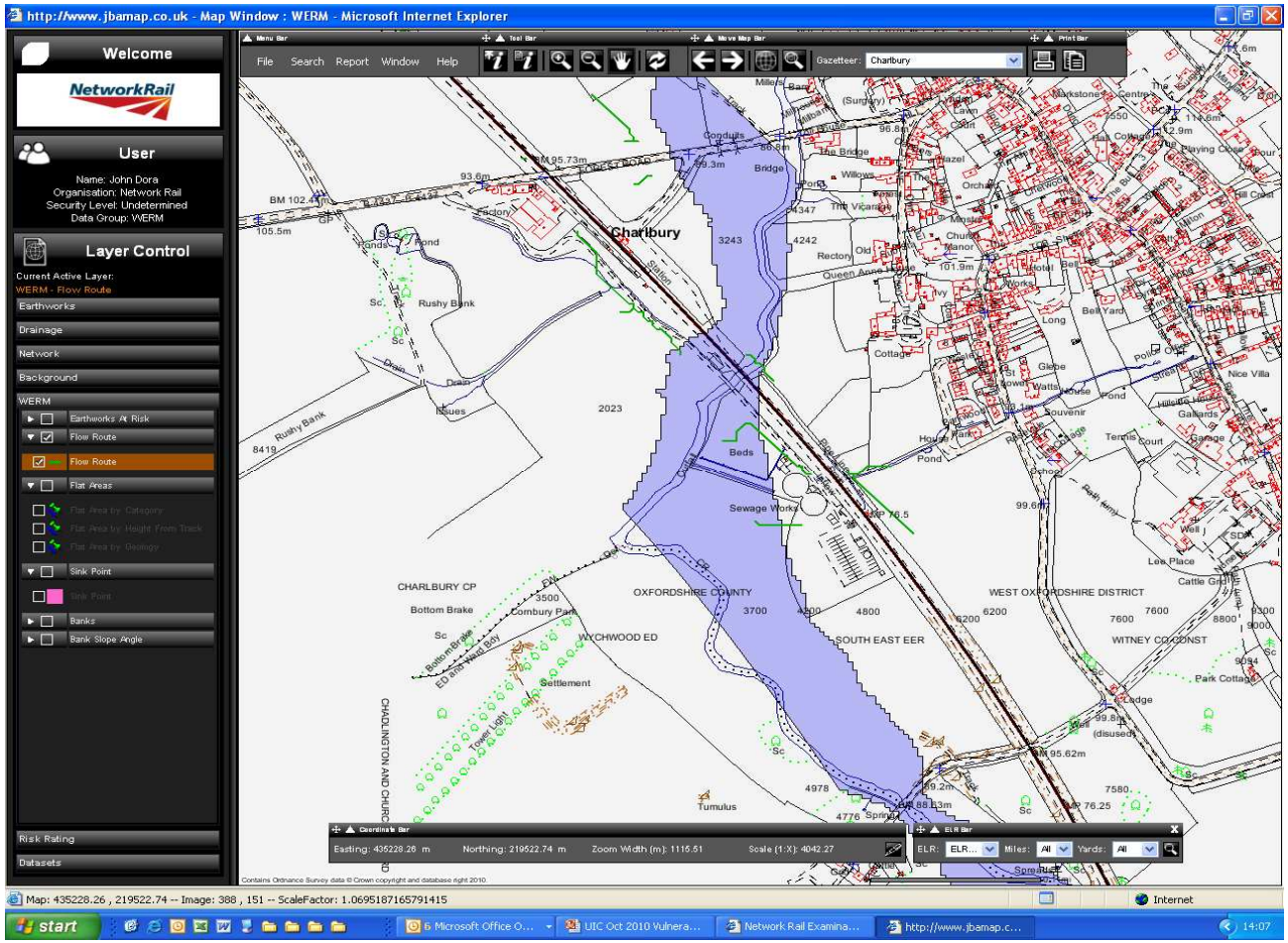
Initial map


http://www.jbamap.co.uk - Map Window : WERM - Microsoft Internet Explorer
Welcome
NetworkRail
User
Name: John Dora
Organisation: Network Rail
Security Level: Undetermined
Data Group: WERM
Layer Control
Current Active Layer:
Surface Water 1m
Earthworks
Drainage
Network
Background
Background Maps
Contours
WERM
Risk Rating
Datasets
File Search Report Window Help
Gazetteer: Charlbury
Back to Previous Extent
Charlbury
Rushy Bank
Bottom Brake
CHARLBURY CP
OXFORDSHIRE COUNTY
WYCHWOOD ED
SOUTH EAST EER
WEST OXFORDSHIRE DISTRICT
WITNEY CO CONST
Sewage Works
Settlement
Tumulus
Easting: 435303.13 m
Northing: 219637.18 m
Zoom Width (m): 1116.51
Scale (1:X): 4042.27
Map: 435303.13 , 219637.18 -- Image: 458 , 44 -- ScaleFactor: 1.0695187165791415
Internet
start
14:14

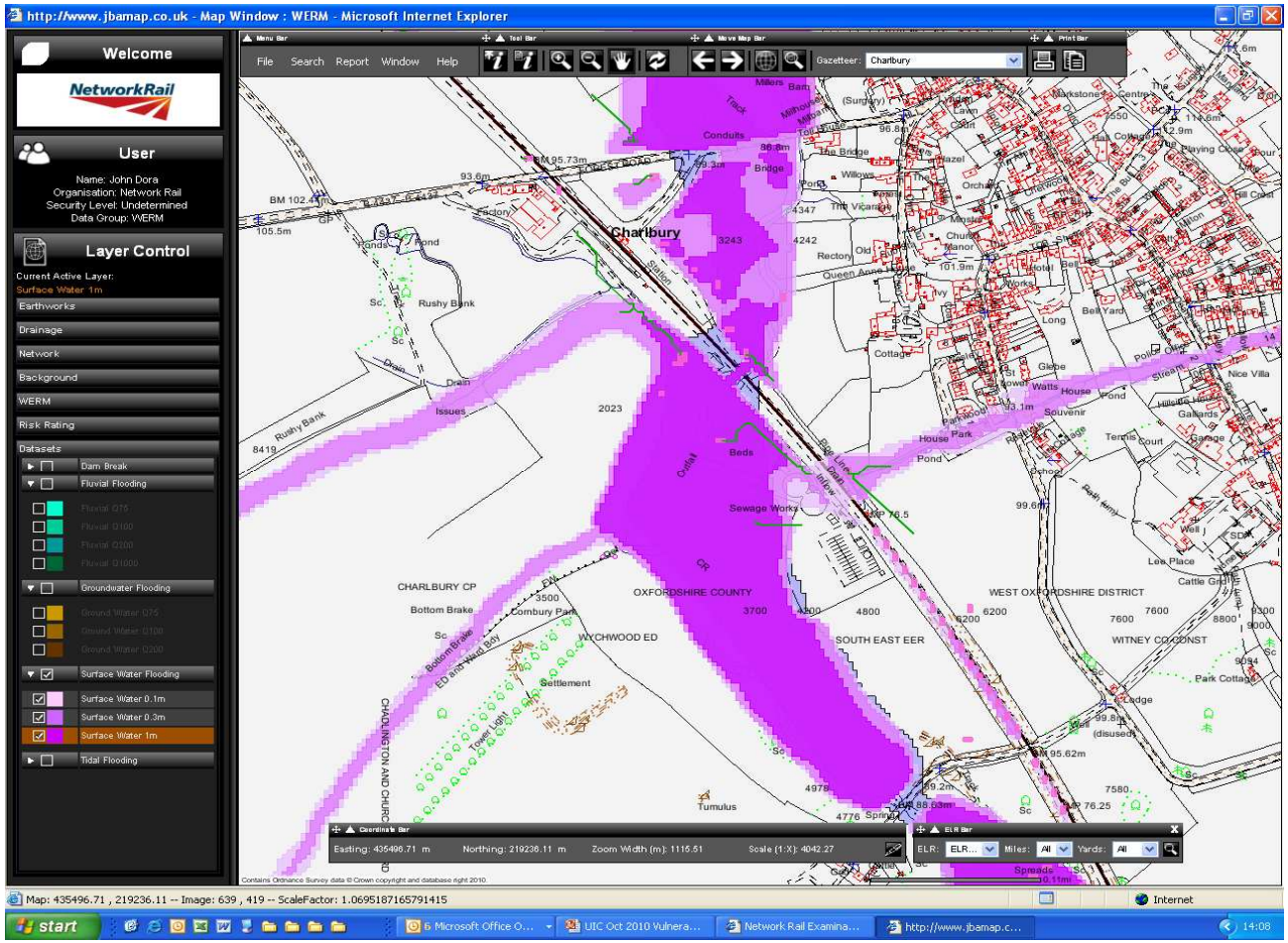
Add 250 year floodplain



Add surface water flow routes

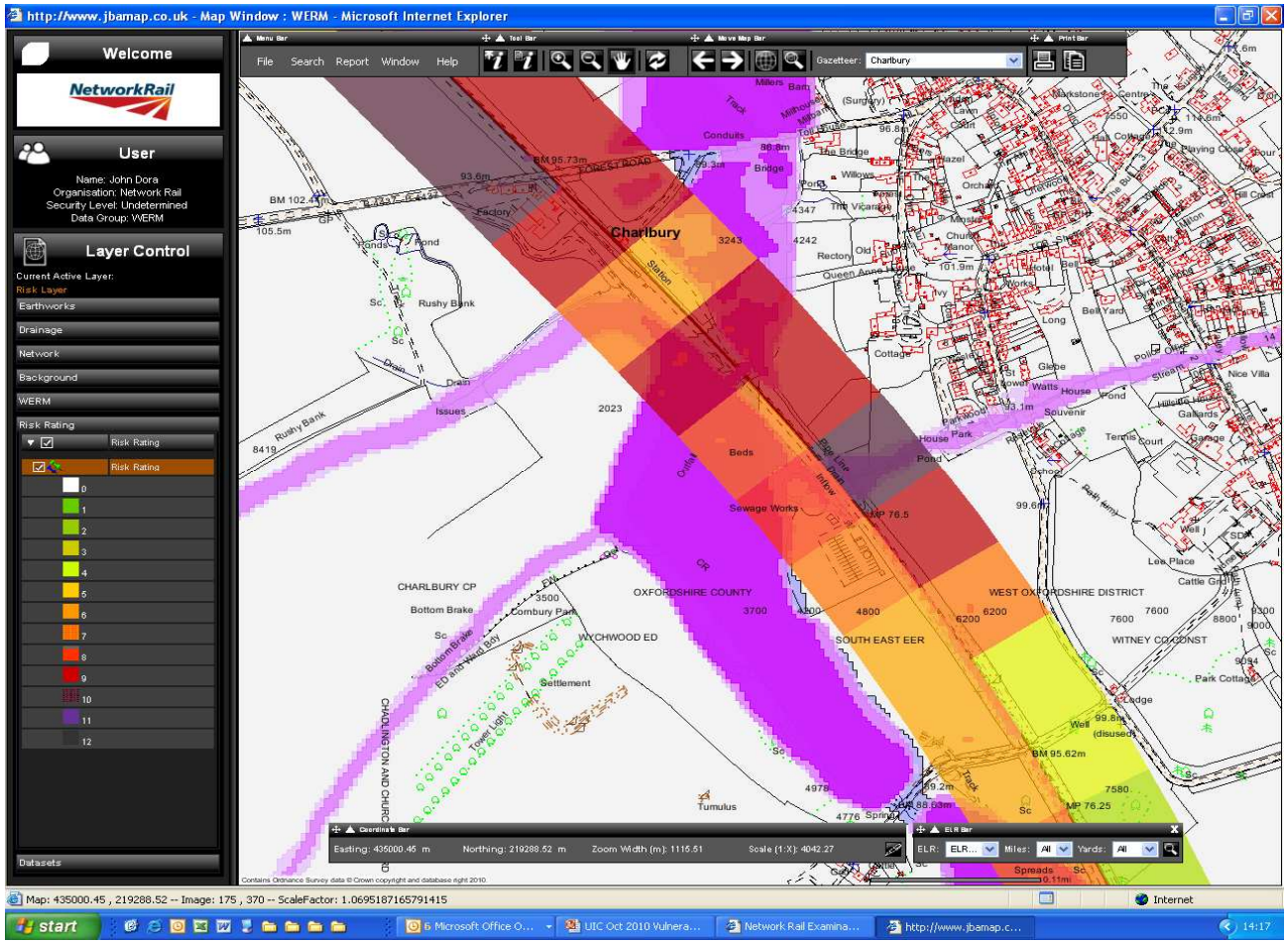


Add sinks and surface water depths

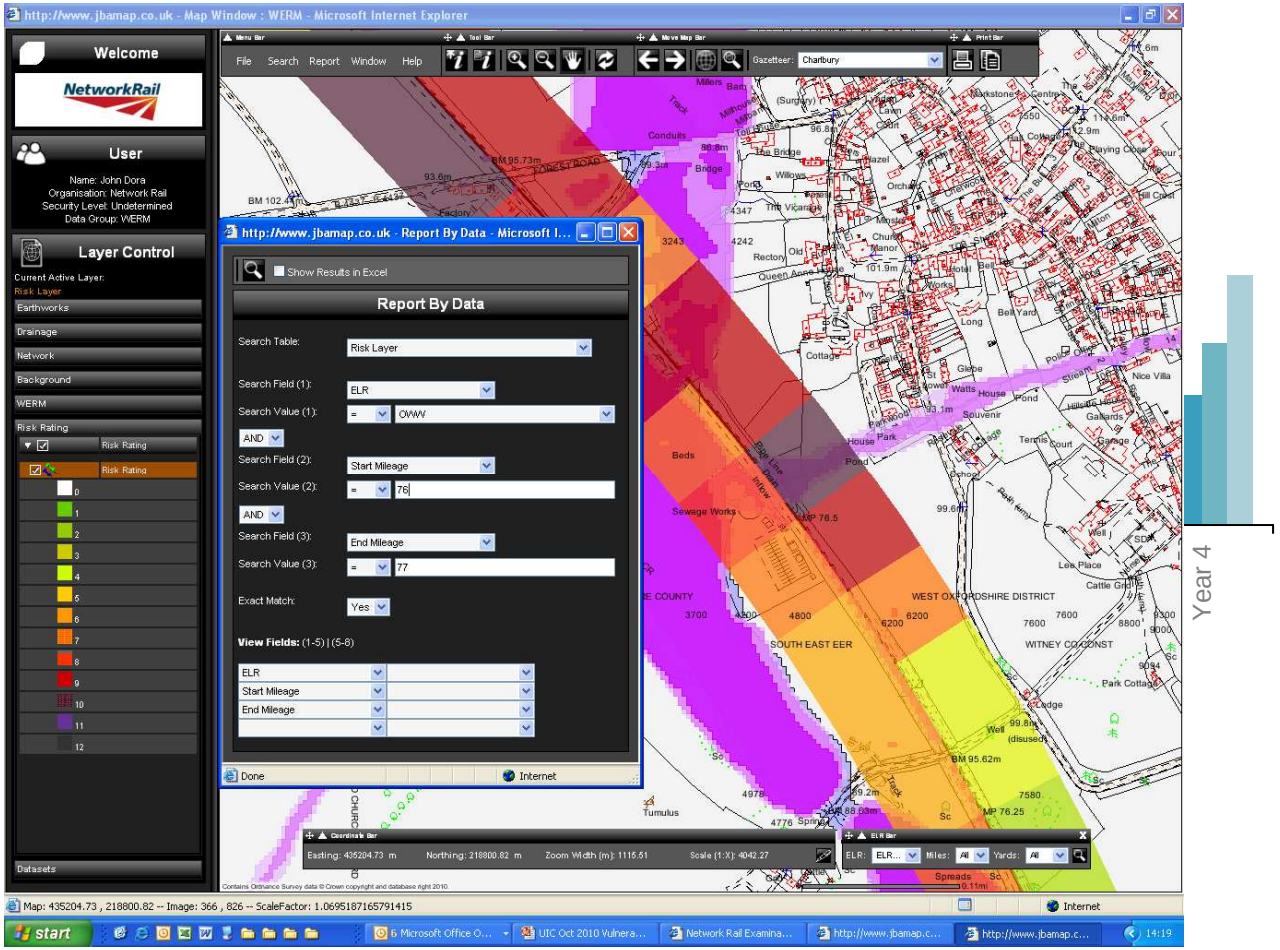


Numerical risk categories applied

Process data into viewable risk bands

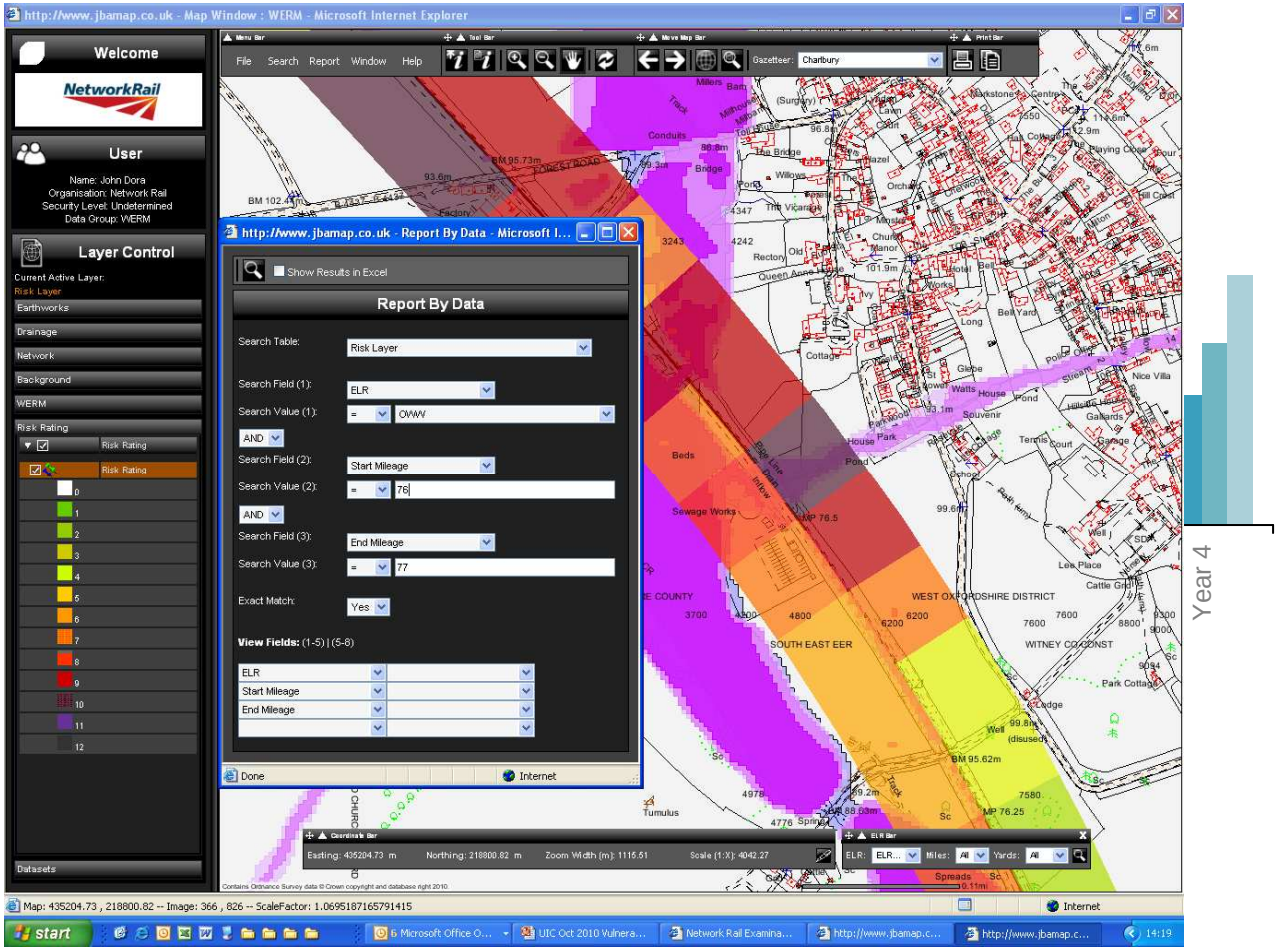


Data can be analysed

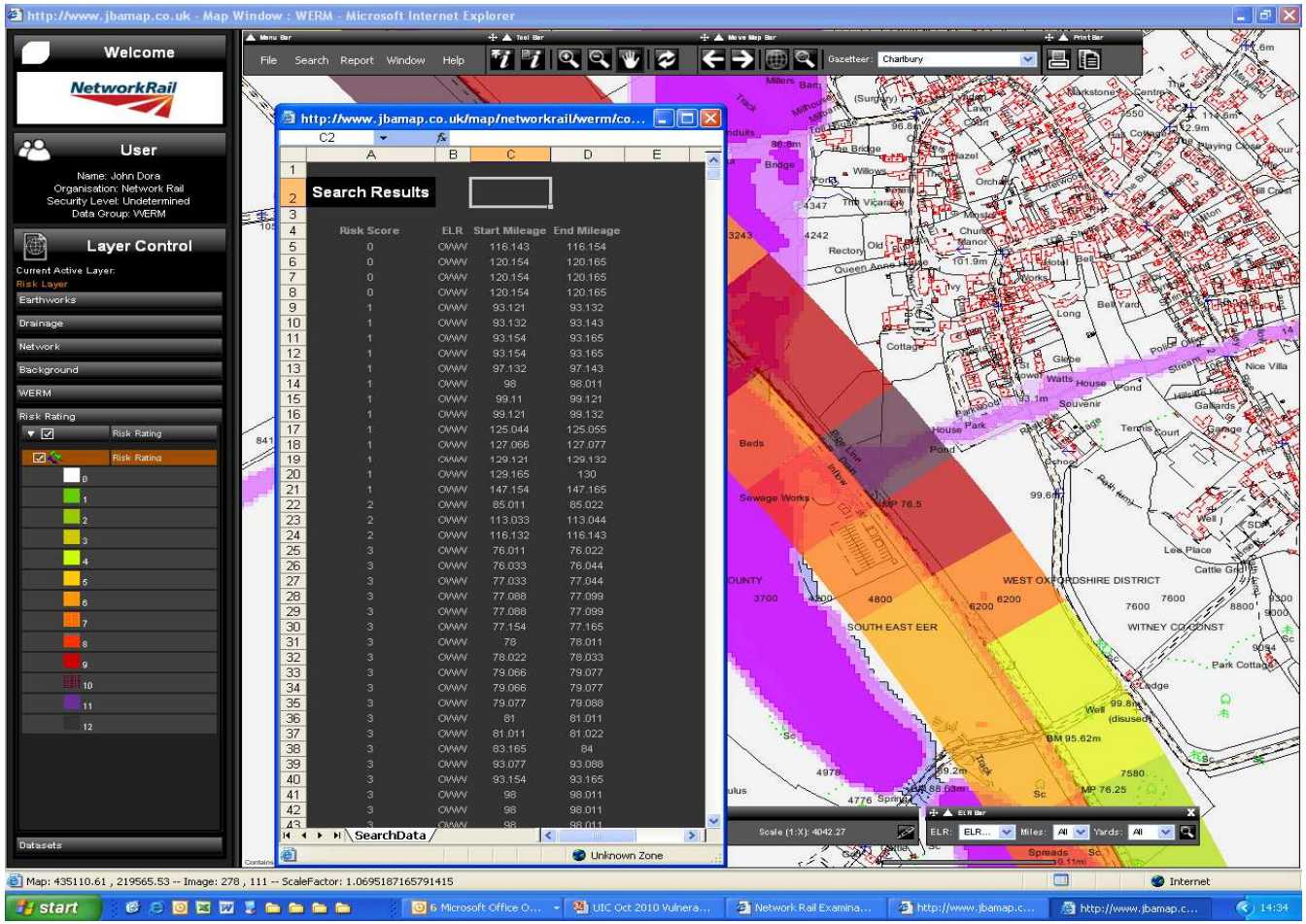


Export into spreadsheets

Not just pretty pictures!



...Spreadsheet..



Conclusions

- There are different ways to approach modelling
- Many tools have been developed to manage current risks
- Use these tools, data and science to build knowledge…
- Think System Resilience
  - Think Engineering Solutions
    - Think Priorities
      - Think Early Benefits in improved Reliability