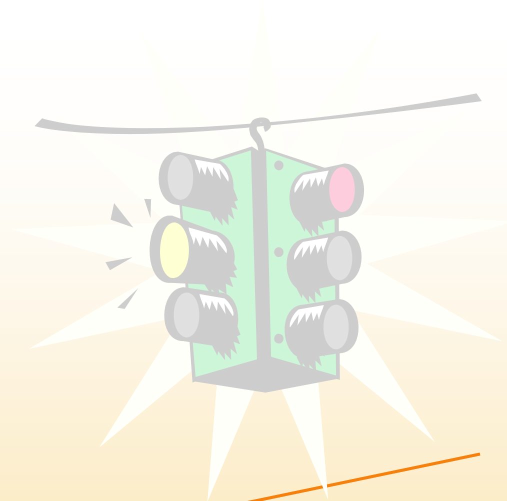
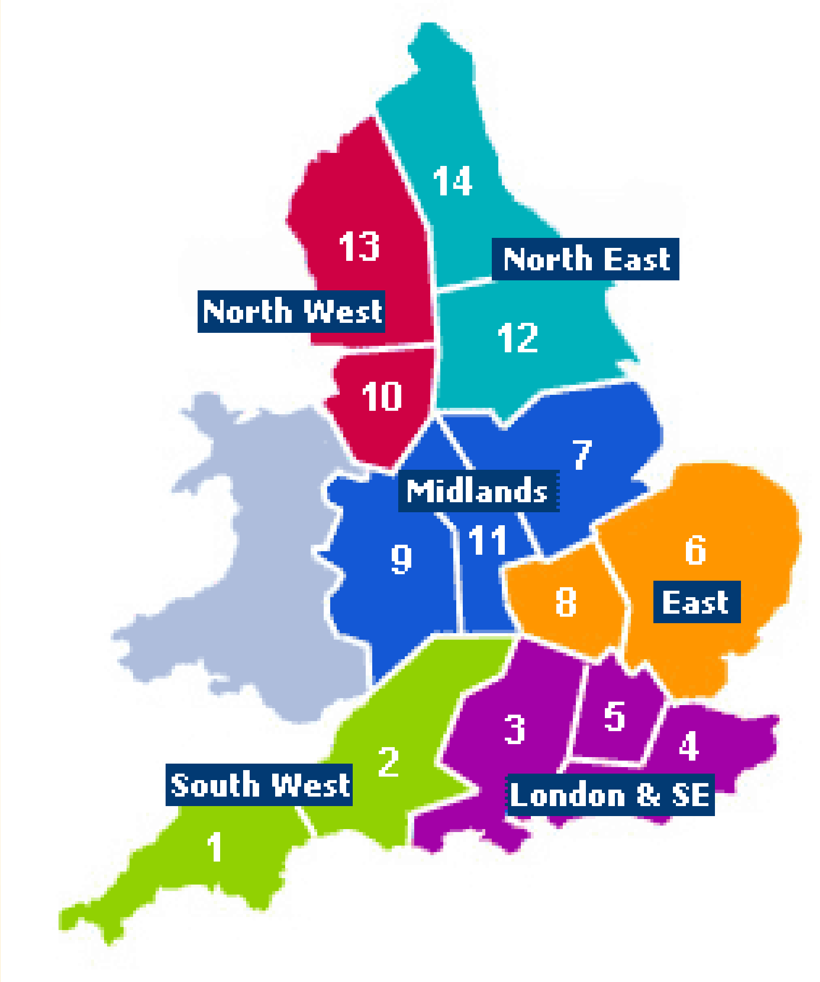
Feasibility of using Deflectograph data to review drainage network in the UK

- Morteza Zohrabi
- Mott MacDonald Ltd, UK
- Pavement Manager
- morteza.zohrabi@mottmac.com



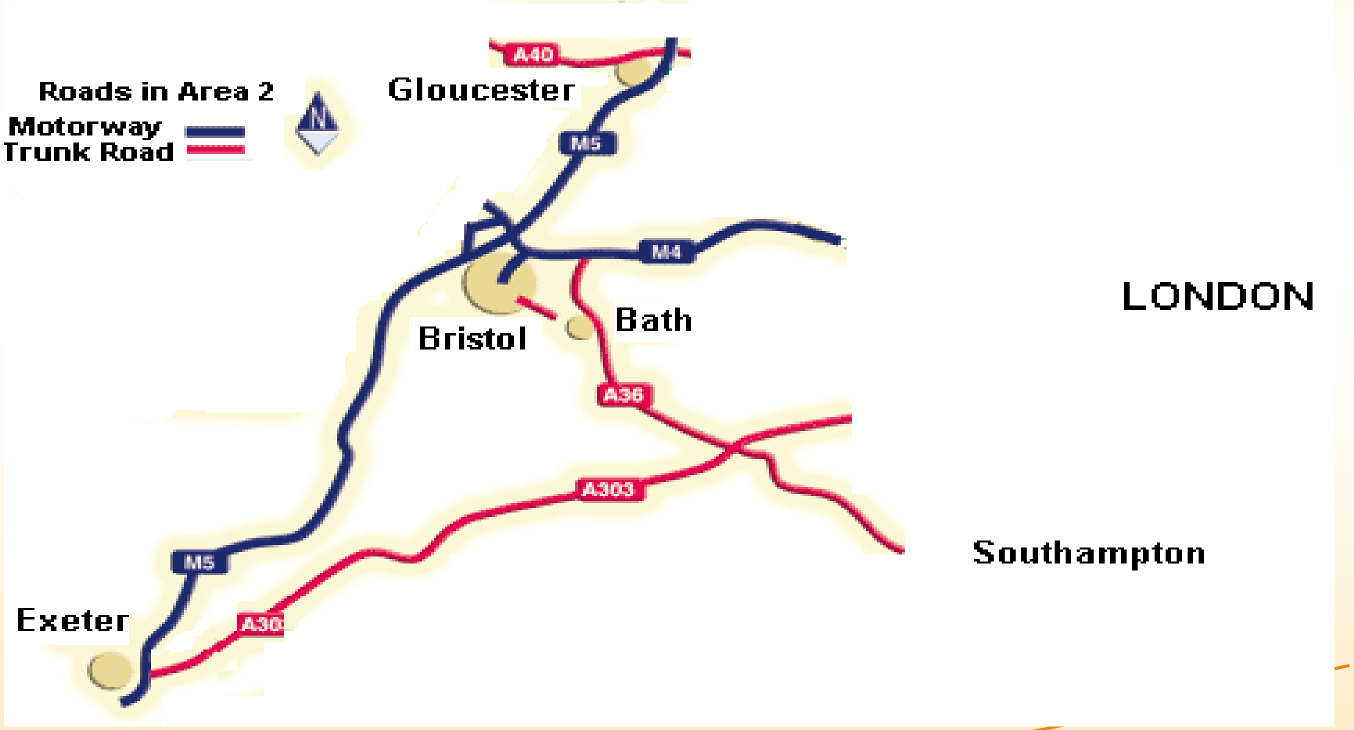
Highways Agency Network

- Network split into 14 Areas
- Operated by private companies and contractors
- 5 year commissions (+2 year extensions)



Area 2 network

- 6th largest Highways Agency Area with 2700 lane kilometre of carriageways



Why undertake this work?

- **Drainage is a key factor that jeopardises the integrity of the pavement asset**
- **Early stage drain failures not visible on surface**
- **Drainage works cannot be planned maintenance over programme period**
  - Often detected too late after the damage is done
  - Subsequent remedial works very costly
  - Long delays and traffic disruptions
- **Feasibility of developing a drainage network review process**

Hypothesis

- **Roadside sub-surface drains mostly located beneath or adjacent to nearside wheeltrack (NSWT)**
- **Defects in longitudinal sub-surface drains or adjacent filter drains impact the NSWT**
  - Less impact on the offside wheeltrack (OSWT)
- **Could Deflectograph data on both wheeltracks be used to study drainage behaviour?**
  - Variation in deflections
- **Could the problem be caused by other factors?**
  - Any associated geotechnical failures
  - Substandard pavement construction (i.e. widening of trunk roads)

Outcome

- **Advantages**
  - The process would use historical data
  - Identify which sites to undertake detailed inspections
  - Target CCTV surveys for best value
    - Current target: 10% each year. Allows full inventory to be assessed every 10 years. Maybe too late?
  - In the short term: May need more funding to address drainage problems but leads to long term advantages
  - Better planning of future drainage maintenance
- **A philosophical question**
  - Do we want to know where drainage is not working if the damage has not reached the pavement surface yet?

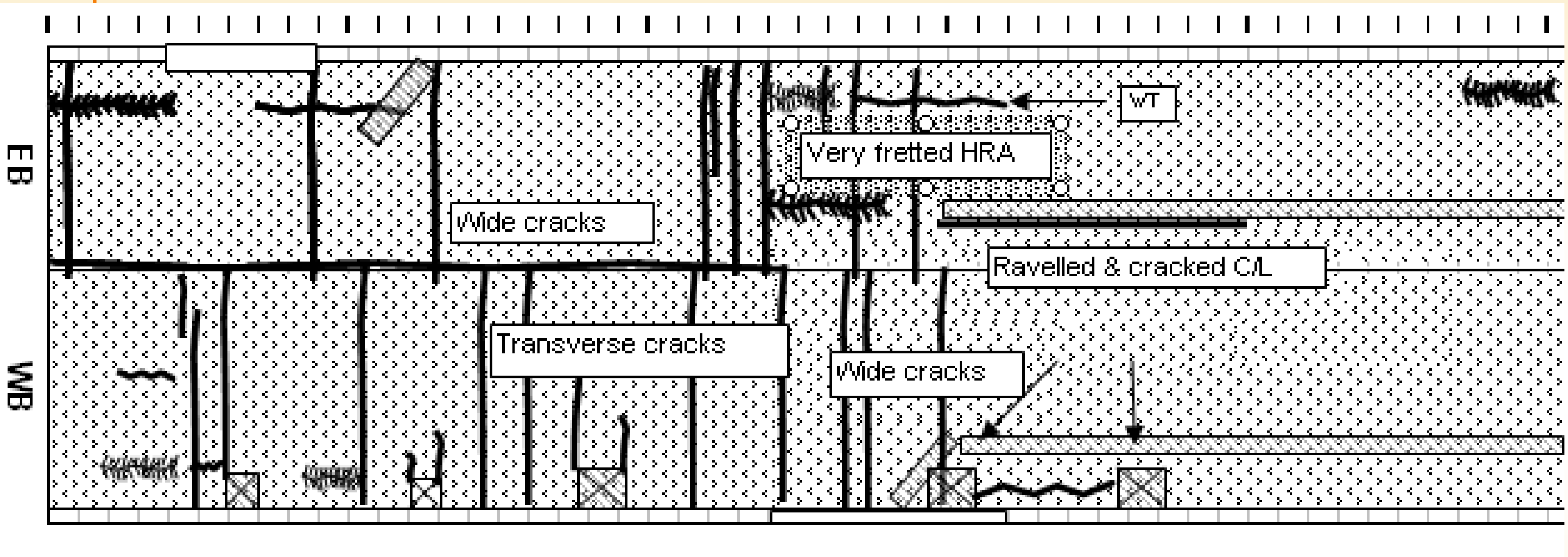
Putting the hypothesis to test

- **Three case studies considered in SW of England**
- **Fully flexible pavement schemes with confirmed drainage defects from detailed CCTV surveys**
- **GPR surveys also indicating moisture in the foundation**
- **Review available deflection profiles**
  - Identify distinct variations in deflection values
- **Detailed review of available pavement investigation data**
  - TRACS, coring, DCP, FWD, etc

Case study 1: A30 Honiton to Haynes Farm

- A 2-way trunk road.
- Some lengths containing no positive drainage that occasionally flood.
- Drainage mostly piped system (carrier drains).
- An over-flown stream floods the road in heavy rain.
- Constant flooding of pavement foundation at this location.

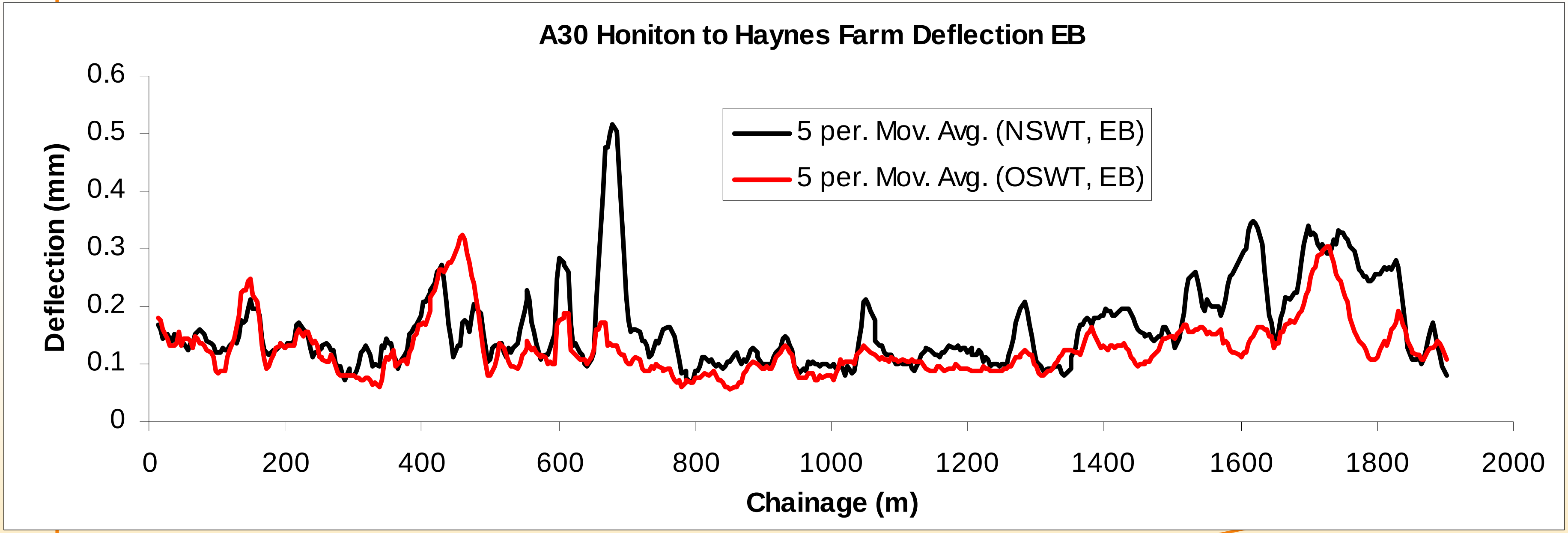
An illustration of some of the localised defects



- CCTV survey: some 29 short lengths (5 - 20m each) requiring replacement of the carrier drains
- Transverse and centreline cracking

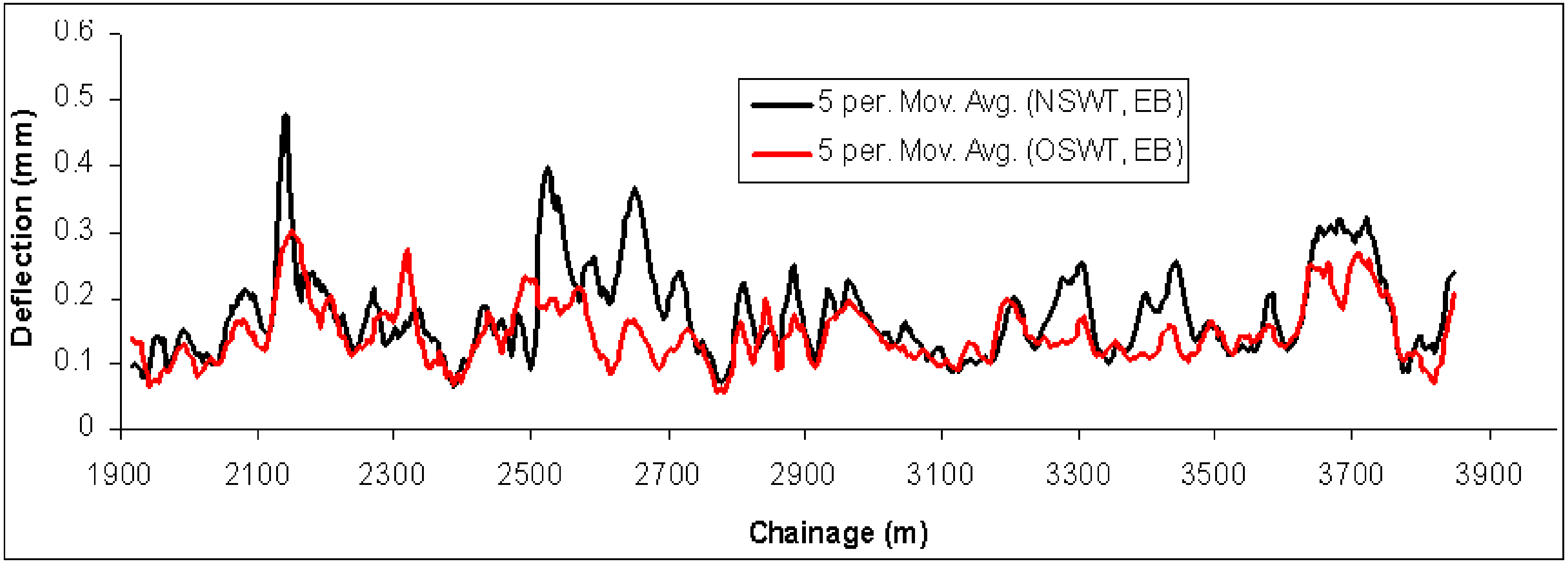
Case study 1 – EB direction

- **No drains at Chainage 600 to 780m and 1020 to 1220m**
- **A marked increase in the NSWT deflections at first location**



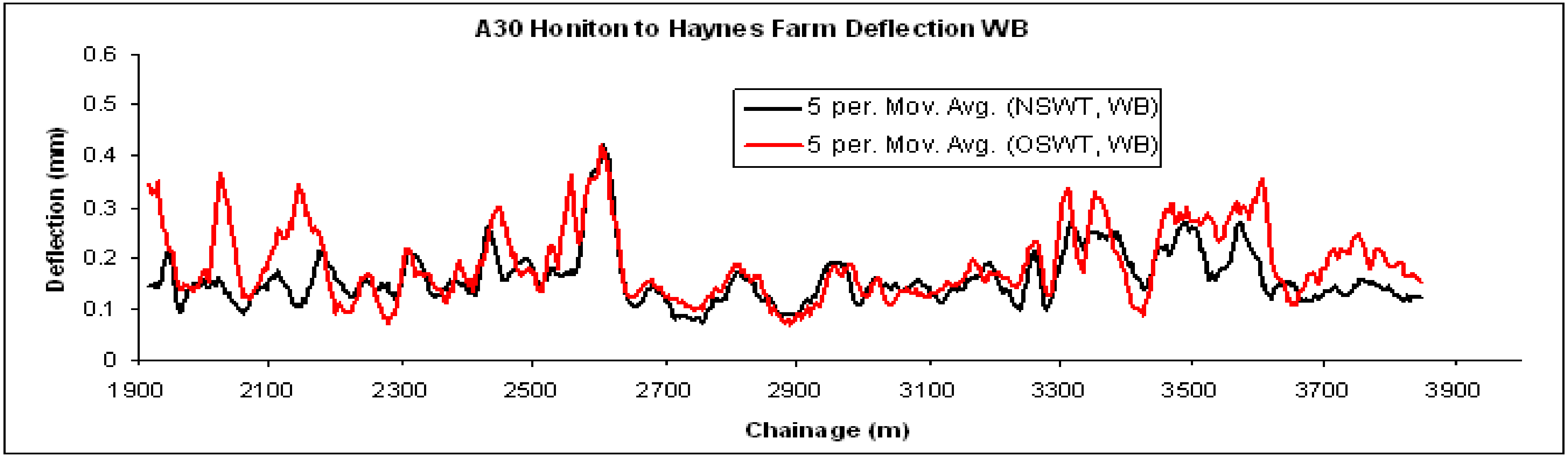
Case study 1 – EB direction

- **No drains from 2300 to 2700m and 3200 to 3500m:**
  - High deflection on the NSWT in both locations
- **Centreline joint cracking from 3300 to 3800m:**
  - Both deflections high but seepage water affected NSWT more than OSWT



Case study 1- WB direction

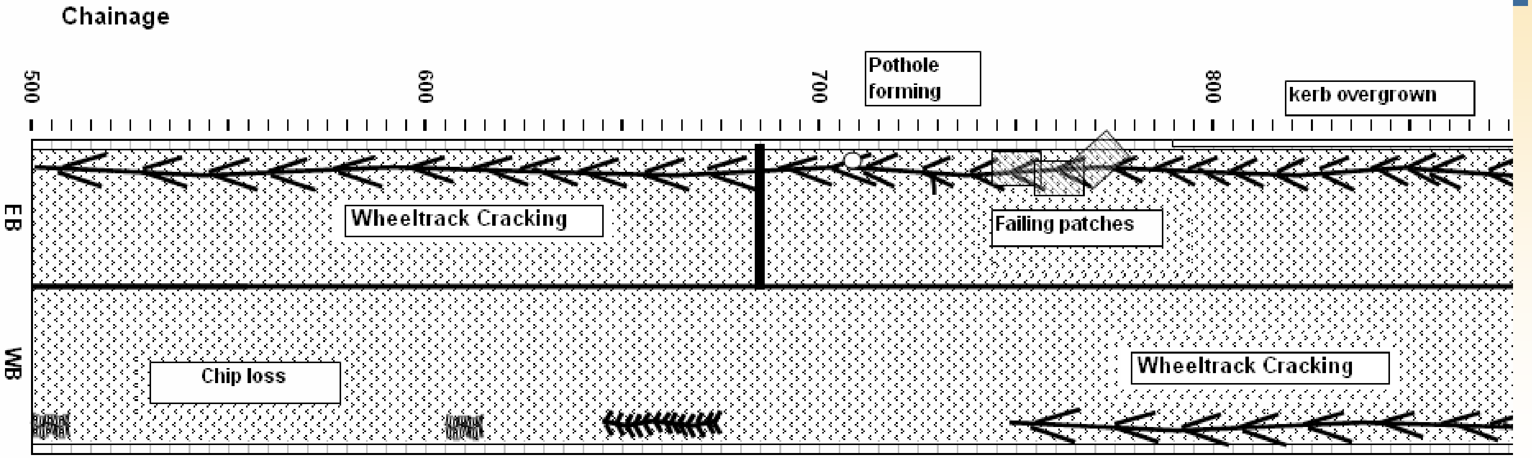
- **Chainage 3300 to 3800m**
  - Centreline joint cracking
  - Road camber makes seepage water run towards the WB carriageway
  - Both deflections high
  - OSWT foundation weakened more than the NSWT

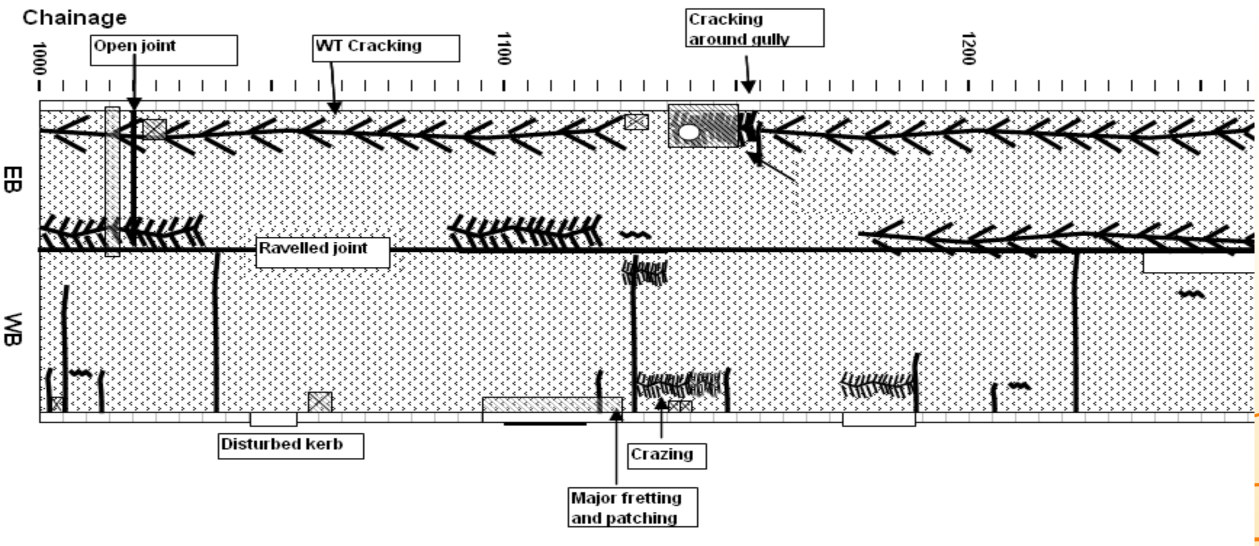


Case Study 2: A30 Rawridge Hill to Devonshire House

- Extensive longitudinal (alligator) cracking along the NSWT
- Poor drainage with water ponding on the road during prolonged periods of rain

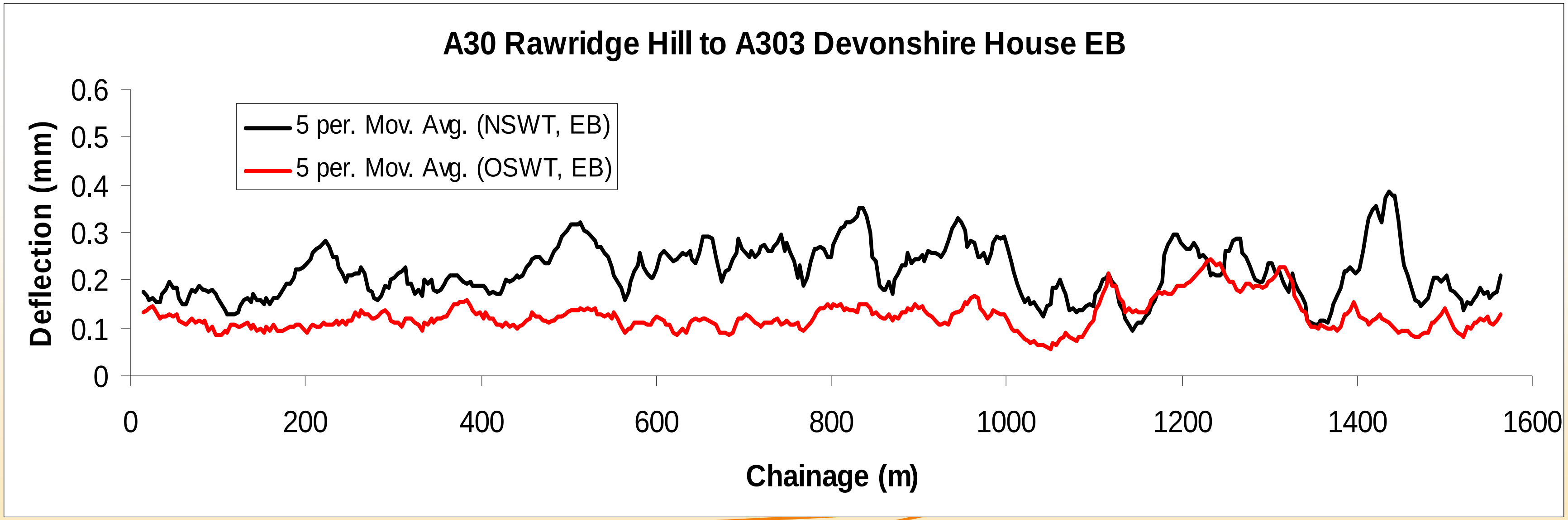
Schematics of selected locations





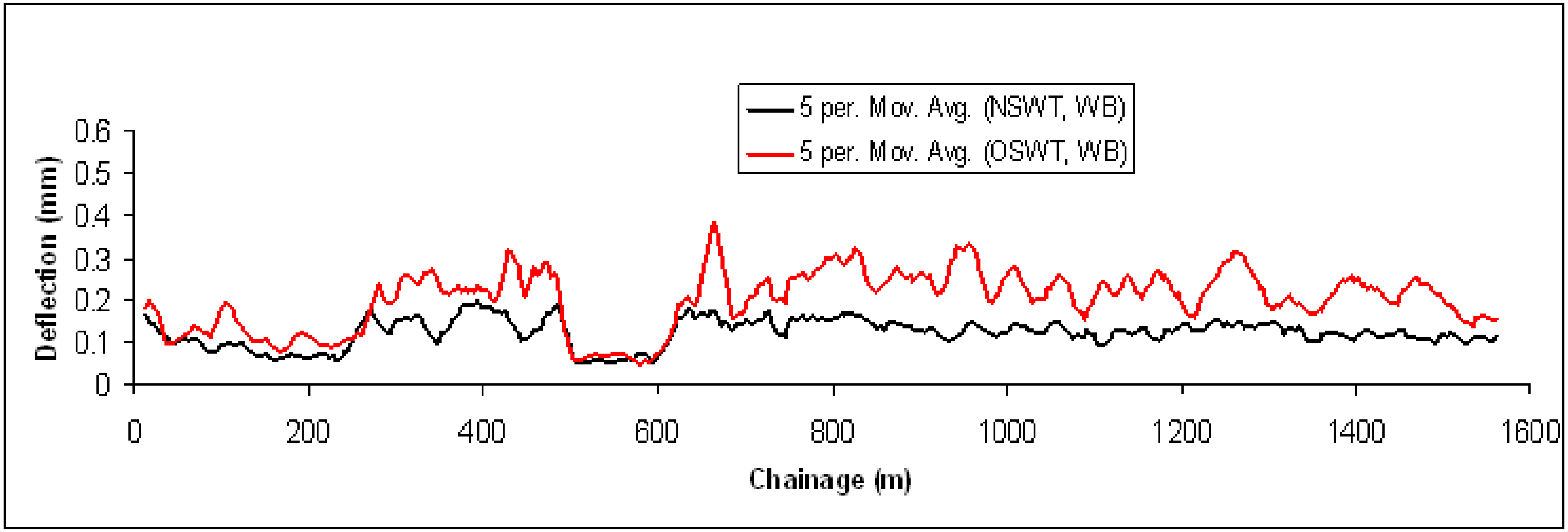
Case Study 2 - EB carriageway

- **OSWT consistently stronger than NSWT**
- **Only chainage 950 to 1500m has subsurface drainage along both the EB and WB carriageways**
  - 400m have failed and need replacement



Case Study 2 – WB carriageway

- Higher deflection on the OSWT than the NSWT
- Severe centreline joint cracking for chainage 1000 to 1200m
- Possible weakening of the foundation of the OSWT due to seepage water

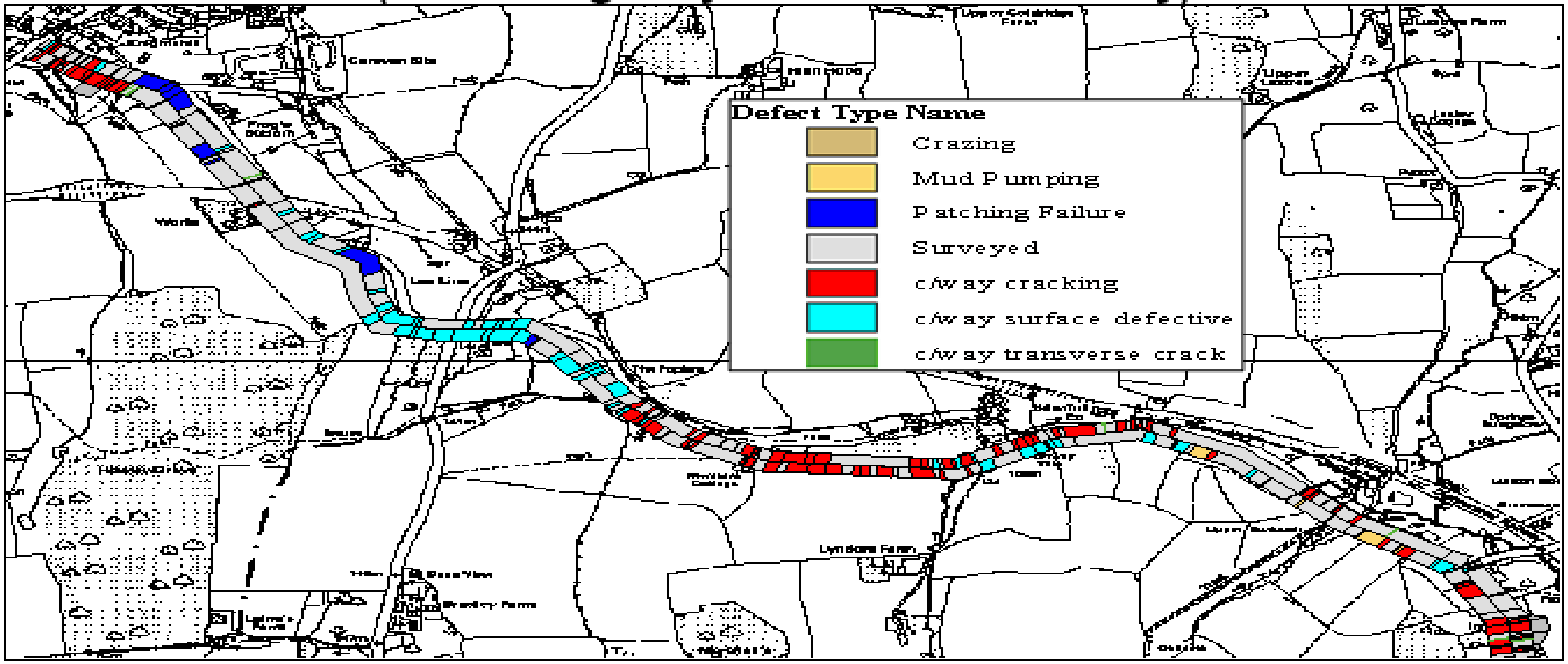


Case Study 3 : A40 Huntley to Lea

- **Main drivers on this 6km long scheme:**
  - Extensive surface disintegration
  - Localised NSWT cracking and collapsed gullies
  - NSWT flooding in heavy rain for most length, requiring emergency call outs

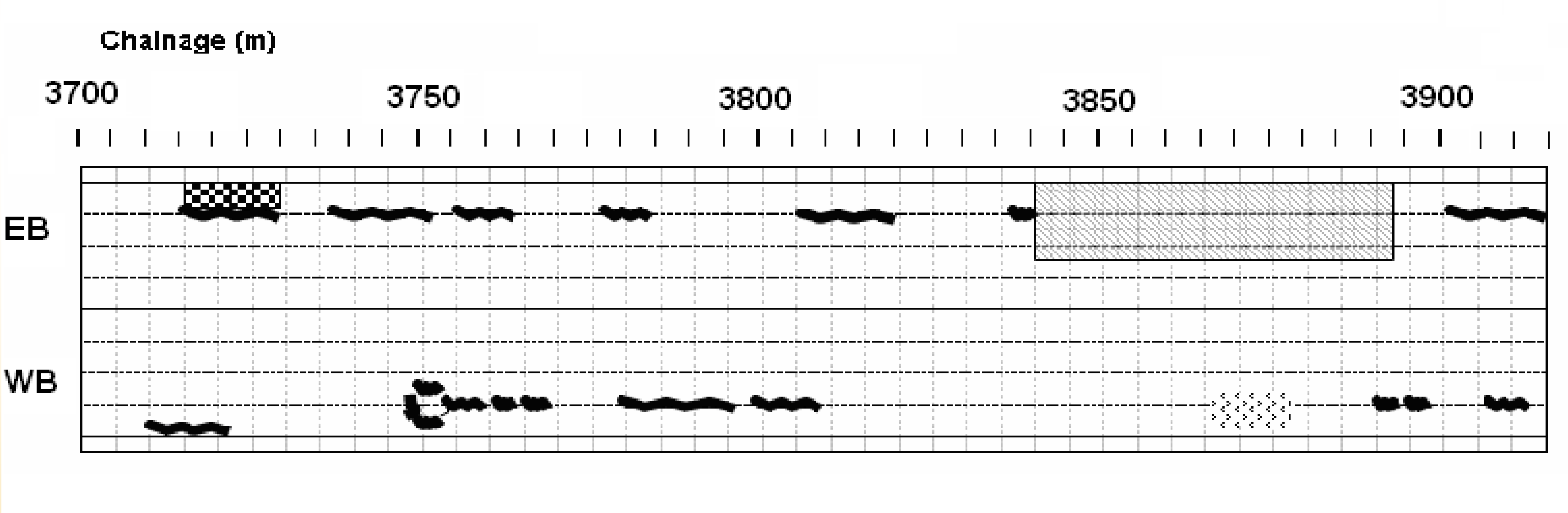
Case Study 3 – Distribution of defects

(On-carriageway walked visual survey)



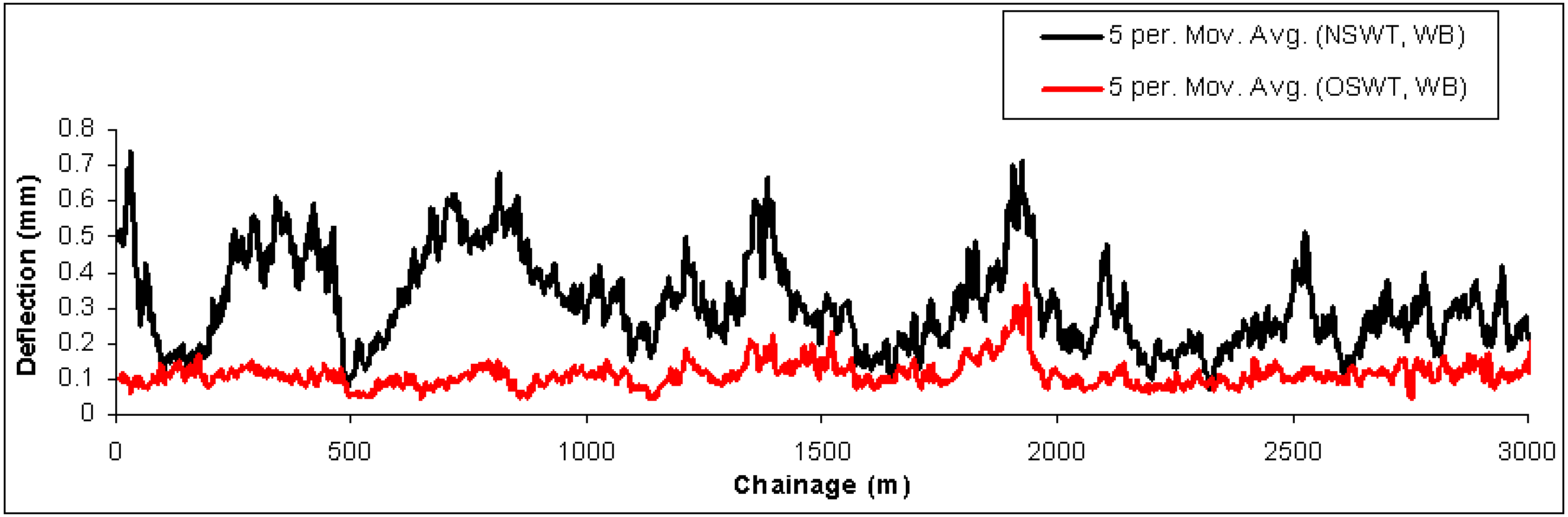
Case Study 3 – schematics of defects

Distribution of NSWT cracking along both carriageways



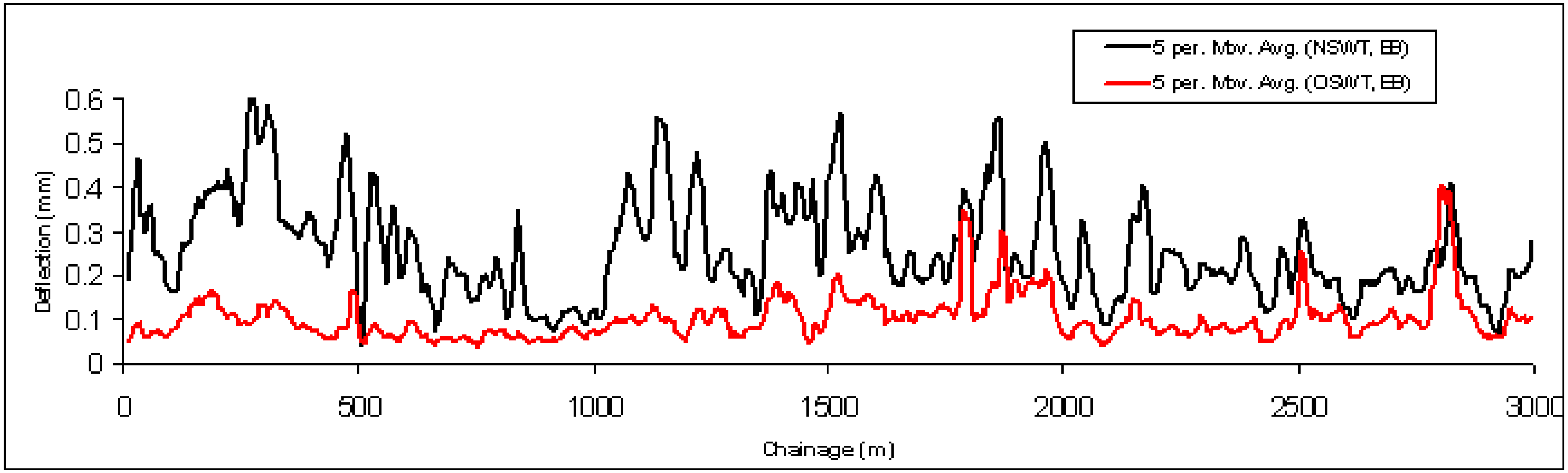
Case Study 3 – WB deflections

- **Constant lower deflections along OSWT**
  - Seepage water along NSWT / dry foundation along OSWT?
- **A known drainage scheme at Boxbush (chainage 1712 and 1900m)**
  - Major flooding of the road
  - Weakened foundation due to prolonged exposure to flooding



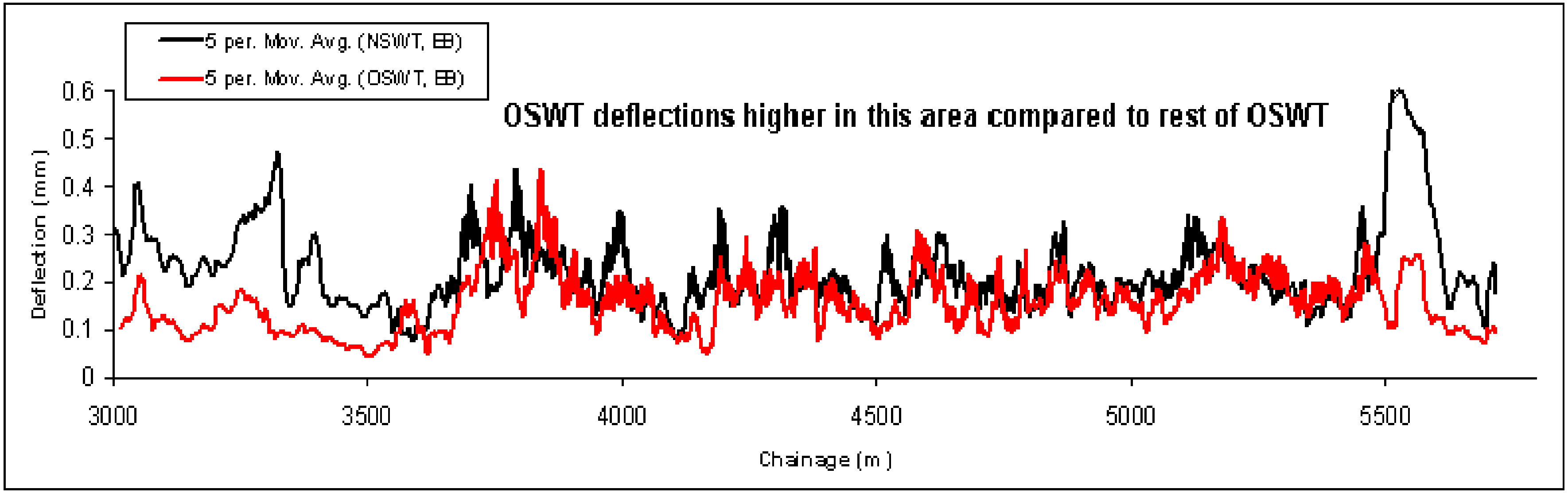
Case Study 3 - EB deflections

- Very volatile behaviour in the NSWT
- NSWT consistently weaker than OSWT



Case Study 3 - EB direction

- **Chainage 4000 to 5300m: A similarity in both deflection values**
  - No strengthening works in this area since first construction
  - Similar, but lower, residual life values in both wheeltracks due to old age of surfacing and general pavement deterioration



The way forward - Develop a network review process

1. Use existing historic Deflectograph results for given network
2. Choose a route
3. Download and transfer deflection data into a simple spreadsheet (say average every 20m length data)
4. Include geometry and other construction data in the spreadsheet
5. Identify general locations where the two adjacent deflection values are unusually different

Sample analysis: Identify potential investigation sites

Chainage (m)	Lane width (m)	NSWT Deflection (mm)	OSWT Deflection (mm)	Ratio of NSWT/ OSWT deflections
20	3.6	0.261	0.077	3.4
40	3.4	0.640	0.080	8.0
60	3.5	0.232	0.077	3.0
80	3.5	0.220	0.170	1.3
100	3.3	0.139	0.128	1.1
120	3.1	0.500	0.070	7.1
140	3.4	0.161	0.067	2.4
160	3.5	0.460	0.090	5.1
180	3.2	0.172	0.067	2.6
200	3.6	0.570	0.110	5.2
220	3.3	0.088	0.058	1.5
240	3.1	0.600	0.090	6.7
260	3.2	0.193	0.067	2.9
280	3.3	0.680	0.070	9.7
300	3.4	0.129	0.096	1.3
320	3.5	0.410	0.050	8.2
340	3.6	0.212	0.117	1.8
360	3.5	0.380	0.090	4.2
380	3.6	0.203	0.107	1.9
400	3.5	0.212	0.086	2.5
420	3.5	0.270	0.140	1.9
440	3.6	0.241	0.077	3.1
460	3.4	0.200	0.140	1.4
480	3.5	0.172	0.067	2.6
500	3.5	0.280	0.070	4.0
520	3.3	0.172	0.077	2.2
540	3.6	0.140	0.120	1.2
560	3.4	0.357	0.086	4.2
580	3.5	0.140	0.080	1.8
600	3.5	0.053	0.307	0.2

- **Highlight areas where deflection of the NSWT is greater than twice the OSWT one**
- **Run these areas against existing GPR data for moisture ingress issues**
- **Remove rogue data from further detailed investigation**

Sifting for possible rogue data

Physical features

- Deflectograph testing may be susceptible to any physical features such as gullies
- Averaging of deflections over 20m can remove localised volatility from the review

o ***Road geometry***

- Narrow road width can affect the output data
- Deflectograph is 2.4m wide
- NS wheels positioned close to the verge
- Remove data for lane width < 3m

o ***Geotechnical issues***

- Cross reference the highlighted sites against any other defect types (i.e. embankment failures, slips, etc).
- Possible to link this to GIS or the HADDMS (Highways Agency Drainage Data Management System) to graphically represent the potential problem areas.

Confirmation of potential investigation sites – a two stage process

1. **A drive through to rule out some of the bogus sites**
2. **Detailed investigation**:
   - target the annually committed CCTV surveys to confirmed sites from drive through
   - Transverse GPR to check moisture intensity variation across road width

- **Identify drainage related schemes for the forward programme**

Concluding remarks

- **A generally direct link between foundation weakness as a result of water seepage and deflection response obtained by Deflectograph testing**
- **Joint cracking issues**
  - OSWT weakening
  - Camber of the road
- **Assumptions on location of the longitudinal drains along the road foundation**
- **Possible to identify future drainage schemes**
- **The hit rate may not be high but it is an auditable process without requiring new surveys**
- **Tested only on fully flexible road schemes**

What next?

1. **Work is continuing. Still more historic data to consider**
2. **Consider averaging deflections over longer areas**
    - Allows top level understanding of drainage behaviour
    - Disadvantages of missing localised issues
3. **Possible to use 10m or 30m LPV data**
    - To identify and rule out local geotechnical issues (failures, slips, etc)
4. **Traffic Speed Deflectometer (TSD)**
    - Ready to be rolled out on the whole of HA network
    - Will only provide data along one wheeltrack profile
    - Can detect changes from one year to another
    - A one-off review of historic Deflectograph data on both wheeltracks is necessary to identify general variations variations between them