Ten years of learning lessons from English levee performance during severe flood events

Jonathan Simm
Approx 9000 km of raised flood defences (National Strategy, 2011)

- Reduce chance of flooding for many of the 2.4m households at risk of fluvial & coastal flooding →
  Winter floods 2013/14:
  - 11,000 properties flooded
  - 1.4m protected

- Managing the assets
  - Risk-based approach
  - High-Medium-Low consequence
  - Maximise return on investment
Defence performance reviewed for flood events since 2007:

- Collate information, formal and anecdotal
- Re-create the story of what happened
- Understand failure process and contributing factors
- Conclusions and recommendations, focused on asset management

There is no better way to understand the defences and learn lessons!
## Environment Agency visual Condition Grades

<table>
<thead>
<tr>
<th>Condition Grade</th>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Good</td>
<td>Cosmetic defects that will have no effect on performance</td>
</tr>
<tr>
<td>2</td>
<td>Good</td>
<td>Minor defects that will not reduce the overall performance of the asset</td>
</tr>
<tr>
<td>3</td>
<td>Fair</td>
<td>Defects that could reduce performance of the asset</td>
</tr>
<tr>
<td>4</td>
<td>Poor</td>
<td>Defects that would significantly reduce the performance of the asset. Further investigation needed</td>
</tr>
<tr>
<td>5</td>
<td>Very Poor</td>
<td>Severe defects resulting in complete performance failure</td>
</tr>
</tbody>
</table>
What happened?

- Major convective rainfall events
- 1000km levee tested, 500km overtopped, but only four breaches
- All four breached before they were overtopped:
  - Geotechnical failures, caused by local irregularities
  - Breaches did not contribute to damage to property or infrastructure flooding

Lessons:

- Breach is difficult to predict based on visual condition
- Focus more on local irregularities, transitions
Cumbria Floods 2009

What happened?

- Again only one full breach despite overtopping of almost all defences
- Formal and informal defences affected
- Bridge failure due to pressure of water and debris – disruption to travel, communications and utilities

Lessons:

- Performance not linked to condition grade
- Rural earthen levees do not breach easily, if no irregularities or transitions with structures
- Be careful with steep slopes and young grass
- Urban boundary walls acted as informal flood defences; many subsequently upgraded.
What happened

- Summer convective flash flood
- Two small breaches reviewed – close to summer 2007 breaches
- Both breached before they were overtopped:
  - geotechnical
  - steep slopes and local irregularities
- Breaches did not contribute to property or infrastructure flooding

Lessons:

- How to deal with ‘historic’, steep-sloped but low consequence levees
East coast storm surge, plus series of low pressure weather systems

Dawlish February 2014
Winter floods 2013/14

What happened

- Levee failures (of which 38 EA-owned)
- Majority due to coastal overtopping in ‘above design’ events
- ‘Historic’ non-formally designed levees, transitions

Lessons:

- Effect of transitions, irregularities, historic changes
- Dealing with low spots
- Woody vegetation shading effects (next slide)
Winter floods 2013/14: shading by woody vegetation
December 2015 – Storm Desmond record-breaking rainfalls
Winter floods 2015/16

What happened?

- 6 fluvial levee breaches:
  - 3 overtopped, 3 geotechnical
  - Steep slopes, local irregularities and low spots, ‘historic’ (non-designed) levees
  - Low consequence levees with reduced maintenance

- 2 coastal structural failures:
  - Low beach levels

- Limited contribution to property or infrastructure flooding

Lessons:

- How to deal with ‘historic’, steep-sided, but low consequence levees
  - Spillway strengthening at low spots?
Lessons (overview)

- English levees do not breach very often and seem to be ‘doing the job’
- Where they do breach, it’s generally due to local irregularities incl. transitions in historic levees where visual condition is not a good indicator of performance
- The risk-based approach to maintenance is working:
  - High / medium consequence levees (protecting property and infrastructure) generally haven’t breached
  - Lack of maintenance for low-consequence levees can cause breach – limited damage to receptors, but potential for high repair costs

Lessons are being learned
Issues to address

Historic levees

- Levees with steep sides and narrow crests
- Levees with transitions, weak and/or low spots
- Identification in advance is possible – the tools are there

Designing & managing for exceedance

- Strengthening of low spot spillway sections

Managing public expectations of performance of low consequence levees, when adopting a risk-based approach
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