Estimating blockage potential at culvert trash screens

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The problem

• Culverts represent pinch-points in the river system which often have trash screens installed to prevent internal blockage.

• However these can be a flood hazard in themselves if not cleared and maintained at an appropriate inspection interval.

• Material delivered into the river system includes natural (organic) debris and also anthropogenic trash.
Current guidance

Trash and Security Screen Guide
(TSSG) (EA, 2009)
<available EA website>

Culvert Design and Operation
Guide
(CDOG) (CIRIA, 2010)
<commercial publication>

WP 4.1 Research Aims

Build on the current scientific knowledge base regarding trash screen blockage:

• Determine key variables driving delivery and blockage.
• Examine possible temporal trends.
• Develop potential predictive equations to estimate the:
  Probability of debris load delivery to screens
  Potential screen area likely to block (blind)
• Assess their validity and applicability.
• Make recommendations for decision support and update best-practice guidance.
Estimating blockage extent

Current best-practice methodology for estimating potential screen blockage (CDOG and TSSG).

Analysis approach

- Used detailed inspection records (25,000 observations) from 140 screens located in Belfast (supplied by NIRA) to determined the probability of delivery of significant debris loads ($P_d$) and average screen area likely to block ($S_a$).

- Related these two parameters to hypothesised driving variables using multiple regression analysis to generate predictive equations: $\frac{P_d}{S_a} = f$.
**Driving variables**

\[ SA_b = \text{function of} (NL, SL, Q, R, AG, SO, SU, U, ID, S, A) \]

- NL = upstream contributing river length.
- SL = upstream slope.
- Q = flow with 'x' year return period.
- % landuse cover:
  - R = rural
  - A = agricultural
  - SU = suburban
  - SO = suburban open
  - U = urban
- ID = income domain (social deprivation).
- S = screen bar spacing.
- A = screen angle.

**Significant variables**

\[ SA_b = \text{function of} (L, SL, Q, R, AG, SO, SU, U, ID, S, A) \]

<table>
<thead>
<tr>
<th>Rank</th>
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<tr>
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<td>R</td>
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<td>5</td>
<td>SO</td>
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While the equations have weak statistical significance they have highlighted the key parameters that influences screen blockage.
Asset management staff should be aware that blockage extent can vary with time of year. Consequently it may be prudent to assess worst case conditions when estimating associated risk.
Greater loads of organic matter during autumn – compounds affect of precipitation.

Scheme for decision support:

- Source control
- Reduce debris load
- Increase screen size
- Alter screen properties A / S
- Calculate clear screen area:
  \[ S_{Ac} = S_{At} - S_{Ab} \]
- Compute increase in afflux
- Determine change in inundation extent
- Select screen
- Equation from statistical analysis
- Risk not acceptable
  - Modify screen
- Risk not acceptable
  - Reduce debris load
- Risk acceptable
  - No action
- Risk acceptable
  - Modify screen
  - No action
Source control

• Legislation

Restriction of access

Stakeholder engagement

• stewardship schemes (education, litter clearing: need incentives).
• financial incentives for farmers to dispose of agricultural waste efficiently.

Day-lighting

Summary

• A large empirical dataset has been used to assess factors driving screen blockage.

• The probability of debris delivery and screen area likely to block were related to key driving variables using regression analysis.

• These equations have very low statistical significance but do highlight the key influencing variables.

• Screen properties had the greatest influence when considering blockage.
Summary

• The most important driver common to both measures was social deprivation which has implications for source control.

• Debris delivery and blockage was found to vary according to time of year. This may be controlled by precipitation and organic material availability.

• A scheme has been presented that forms the basis for a screen management decision support tool.

• The equations and schemes developed indicate potential approaches: they are not fit-for-purpose, and cannot be promoted as best-practice at present.

Outputs

**Guidance**

• FRMRC WP4.1 Final Science Report.
• Technical note to accompany CDOG.
• Report on integration of science outputs with FRM.
• Report on trash screen research needs.

**Books**

Papers


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