Implementation and assessment of a critical input hyetograph generation methodology for use in a decision support tool for the design of flood attenuation systems

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Rationale for the research

Development of a decision support tool
Rationale for the research

- Run simulation of the sewer system
- Find conduit with the greatest spare capacity and the highest flooding consequence level
- Design and install FC in the downstream manhole of the conduit.
- Calculate the new cost of all installed FCs and new FC chambers

Critical input hyetograph theory

Time (minutes)

Rainfall Intensity (mm/hr)

$\text{Critical input hyetograph theory}$

$\text{Critical input hyetograph theory}$
For a given central time period of the CIH:

- For the given set of rainfall profiles, for the given time period, find the greatest depth of rainfall.
- Calculate the additional rainfall intensities so that the central time period of the CIH has the same rainfall depth.
- Repeat for a greater central time period of the CIH.

Points of interest:

- Duration of CIH is equal to the longest given rainfall profile.
- Shape of profile is defined by the above process.
- Purely a statistical process.
## Previous methodologies

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Superstorm” by Pluvius®</td>
<td>Generated from recorded rainfall</td>
<td>Requires storage of a vast amount of data, which is also financially expensive</td>
</tr>
<tr>
<td>Osborne’s method</td>
<td>No need for large amounts of storage</td>
<td>Method nor the validation is published.</td>
</tr>
<tr>
<td>“Composite storm” by Vaes’</td>
<td>No need for large amounts of storage</td>
<td>Derivation of accurate values for the IDF curves was found to be time intensive.</td>
</tr>
</tbody>
</table>


Osborne, M. (2012). Design storms - have we been getting it wrong all this time? WaPUG Spring Conference. Birmingham: WaPUG, CIWEM.

The improved methodology

Use FSR or FEH methodology to generate synthetic rainfall profiles.

- Time interval of 15 seconds
- Durations of 15 minutes to 24 hours in 15 minute increments (15 mins, 30 mins, 45 mins, … etc.)

Find greatest rainfall depth for time $c$:

$$I[x, c, k] = 2 \left( i[x, k] + i[x, k + 1] + \ldots + i \left[ x, k + \left( \frac{c}{2} \right) - 1 \right] \right) \left( \frac{\Delta t}{60} \right)$$

Generate CIH profile from its midpoint, $\left( \frac{L}{2} \right)$:

$$S[P] = \frac{I_{Max} - \left[ 2 \left( \sum_{P-\Delta t}^{L/2} S[P] \right) \left( \frac{\Delta t}{120} \right) \right]}{\left( \frac{\Delta t}{120} \right)} \quad P > \frac{L}{2}$$
The improved methodology

- Produces critical behaviour in sewer systems
- No need for computational storage
- Only one simulation required
- Process not computationally intensive
Case study model

Langley combined sewer system

- 46.9 hectare catchment
- >2,300 PE using 200 l/p/d
- 295 nodes & 14.5 km of pipe
- Simulated using InfoWorks CS V. 12
Case study inputs

CIH generated by the improved methodology

CIH generated using Pluvius®

Simulation A

Simulation B

M100-570 generated using the FSR methodology

Simulation C
Case study outputs
Case study outputs

- Proportion of conduit full vs Flow-rate (m³/s)
  - Simulation A v Simulation C
  - Simulation B v Simulation C
## Case study outputs

Two inputs used in the simulations compared

<table>
<thead>
<tr>
<th>Selected correlation coefficient</th>
<th>A &amp; C</th>
<th>B &amp; C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head of water in nodes</td>
<td>0.9194</td>
<td>0.8453</td>
</tr>
<tr>
<td>Flow-rate in nodes</td>
<td>0.9845</td>
<td>0.9693</td>
</tr>
<tr>
<td>Proportion of conduit full</td>
<td>0.9997</td>
<td>0.9994</td>
</tr>
<tr>
<td>Flood volume at nodes</td>
<td>0.9970</td>
<td>0.9940</td>
</tr>
</tbody>
</table>
Summary

• An improved hyetograph generation methodology was required for the use in a decision support tool

• An improved CIH generation methodology was developed that:
  • Has no storage requirements
  • Uses simple computational processes

• Through the validation case study, it was found that the improved CIH generated produced comparable simulation results to the CIH generated using Pluvius®.
Thank you

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In partnership with:

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