Development of Measured Data Based Nomograph for Flood Warning System of Small Streams

Tae Sung Cheong
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Backgrounds
1 Backgrounds

**Extreme rainfalls (>100mm/h) is increasing due to climate change**

- Frequency and occurrence area of extreme rainfalls are increased during 92 years (1927~2019)

![Trend of extreme rainfalls frequency](image1)

![Distribution of extreme rainfalls occurrence area](image2)
1 Backgrounds

Flood impacts is changing by extreme rainfalls

- Extreme rainfalls formed by localized heavy rainfall increasing flood damages in the small streams

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Rivers and Small Stream</td>
<td>6,841</td>
<td>938</td>
<td>577</td>
<td>2,266</td>
<td>1,458</td>
<td>413</td>
<td>1.05</td>
<td>3.28</td>
<td>621</td>
<td>299</td>
<td>271</td>
</tr>
<tr>
<td>Small Stream</td>
<td>2,896</td>
<td>431</td>
<td>262</td>
<td>878</td>
<td>661</td>
<td>237</td>
<td>0.42</td>
<td>2.48</td>
<td>165</td>
<td>146</td>
<td>113</td>
</tr>
<tr>
<td>Ratio (%)</td>
<td>42.3</td>
<td>45.9</td>
<td>45.4</td>
<td>38.7</td>
<td>45.3</td>
<td>57.4</td>
<td>40.0</td>
<td>75.6</td>
<td>26.6</td>
<td>48.8</td>
<td>42.0</td>
</tr>
</tbody>
</table>

- Rivers & Small Stream: 26,754 (65,549km)
- Small Stream: 22,823 (35,324km)
1 Backgrounds

Development of small stream disaster risk reduction technology

- Three key technologies solving the most pressing issues facing the climate changes

- Flood Warning System Related Technologies: nomograph, function etc.
- Design Codes Related Technologies: numerical, statistical models etc.
- Legislations Related Technologies: assessment, determination etc.

Nomograph  Function  Numerical Model  Assessment
Data Based FEWS
Data based flood early warning system

Enhancement of small stream flood early warning system (SSFEWS)

- Ministry of Interior and Safety developed the system during 5 years (12~16), NDMI evaluates it
There are no measurement data in small streams for the following reasons:

- **Inefficient Officials**
  - National, local: 3,835
  - Small Streams: 22,823

- **Dangerous Field works**
  - Deep & Fast Velocity
  - Low Measuring Points

- **Rapidly Changing Flow**
  - Rapid Depth Increasing
  - Difficult Peak Measure

- **Damages Ratio**
  - Small Streams: 40%
  - National, Local

- **Depth Gauges**
  - Total: 2,739
    - Small Streams: 6
    - National, Local: 2,733

- **Discharge Gauges**
  - Total: 513
    - Small Streams: 6
    - National, Local: 507
Data based flood early warning system

Development of technology for measuring data in small streams

- CCTV based Automatic Discharge Measurement Technology (CADMT) based on SIV
2 Data based flood early warning system

Establishment of technology for measuring data in small streams

- The CADMT was established in Jungsunpil stream
Data based flood early warning system

Measurement of hydraulics data by using the CADMT

- The CADMT represent high velocity small streams flow well in flood season
Data based flood early warning system

Data acquisition and sharing system

- The web based system was developed to develop technologies and share measured data.
Flood Early Warning Framework
Flood early warning framework

Technology to enhance the small stream flood early warning system

- Framework using both technologies of the rainfall-discharge nomograph and the rating curve

![Diagram showing the flood early warning framework with inputs, estimation, evaluation, and warning stages.]
3 Flood early warning framework

Selection of five small stream for test bed

- Development and evaluation of the framework by using measured data from small streams
Flood early warning framework

Selection of five small stream for test bed

- Development and evaluation of the framework

### Small Stream Basin Information

<table>
<thead>
<tr>
<th>Stream</th>
<th>Latitude</th>
<th>Longitude</th>
<th>$A_b$ (km$^2$)</th>
<th>$W_b$ (Km)</th>
<th>$S_b$</th>
<th>$C_b$</th>
<th>$L_c$ (Km)</th>
<th>$W_c$ (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jungsunpil</td>
<td>35.65.17 N</td>
<td>129.13.17 W</td>
<td>5.09</td>
<td>1.60</td>
<td>0.058</td>
<td>0.50</td>
<td>3.18</td>
<td>14.00</td>
</tr>
<tr>
<td>Sunjang</td>
<td>35.24.04 N</td>
<td>128.55.49 W</td>
<td>13.63</td>
<td>2.17</td>
<td>0.053</td>
<td>0.34</td>
<td>2.14</td>
<td>33.50</td>
</tr>
<tr>
<td>Unchon</td>
<td>37.33.15 N</td>
<td>127.70.96 W</td>
<td>6.98</td>
<td>2.01</td>
<td>0.012</td>
<td>0.58</td>
<td>2.88</td>
<td>21.50</td>
</tr>
<tr>
<td>Neungmac</td>
<td>37.24.31 N</td>
<td>127.16.81 W</td>
<td>2.41</td>
<td>0.78</td>
<td>0.004</td>
<td>0.25</td>
<td>3.09</td>
<td>9.450</td>
</tr>
<tr>
<td>Insu</td>
<td>37.40.20 N</td>
<td>127.00.20 W</td>
<td>3.66</td>
<td>1.17</td>
<td>0.025</td>
<td>0.38</td>
<td>3.12</td>
<td>17.06</td>
</tr>
</tbody>
</table>

### Rainfall Station Information for each small stream

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Distance (km)</th>
<th>10 yrs. Average Total Annual Rainfall (mm)</th>
<th>Elevation (E L.m)</th>
<th>Start from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doseo</td>
<td>35.62.03 N</td>
<td>129.14.35 W</td>
<td>183.1</td>
<td>1274.1</td>
<td>123.0</td>
<td>1991</td>
</tr>
<tr>
<td>Yangsan</td>
<td>35.30.74 N</td>
<td>129.02.01 W</td>
<td>9.86</td>
<td>1,588.20</td>
<td>6.29</td>
<td>2008</td>
</tr>
<tr>
<td>Yeojudaegyo</td>
<td>37.17.43 N</td>
<td>127.38.53 W</td>
<td>6.580</td>
<td>1180.1</td>
<td>51.5</td>
<td>1962</td>
</tr>
<tr>
<td>Yongin</td>
<td>37.27.01 N</td>
<td>127.22.18 W</td>
<td>5.830</td>
<td>1293.5</td>
<td>83.0</td>
<td>2005</td>
</tr>
<tr>
<td>Uijungbu</td>
<td>37.73.50 N</td>
<td>127.07.50 W</td>
<td>10.4</td>
<td>1544.50</td>
<td>72.0</td>
<td>2001</td>
</tr>
</tbody>
</table>
3 Flood early warning framework

Development of prediction technology for flood early warning

- Technologies were developed by using measured data from 2017~2020
3 Flood early warning framework

Evaluation of prediction technology for flood early warning

- Technologies were evaluated by using measured data from 2021
3 Flood early warning framework

Evaluation of prediction technology for flood early warning

- Technologies were evaluated by using measured data from 2021

<table>
<thead>
<tr>
<th>Small Stream</th>
<th>Peak Discharge (m³/s)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jungsunpil</td>
<td>Measured: 4.46</td>
<td>Predicted: 4.74</td>
</tr>
<tr>
<td>Unchon</td>
<td>Measured: 2.69</td>
<td>Predicted: 2.65</td>
</tr>
<tr>
<td>Sunjang</td>
<td>Measured: 207.74</td>
<td>Predicted: 206.56</td>
</tr>
<tr>
<td>Insu</td>
<td>Measured: 13.21</td>
<td>Predicted: 13.38</td>
</tr>
<tr>
<td>Neungmac</td>
<td>Measured: 1.43</td>
<td>Predicted: 1.44</td>
</tr>
</tbody>
</table>

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<th>Peak Discharge (m³/s)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jungsunpil</td>
<td>Measured: 0.53</td>
<td>Predicted: 0.56</td>
</tr>
<tr>
<td>Unchon</td>
<td>Measured: 0.82</td>
<td>Predicted: 0.83</td>
</tr>
<tr>
<td>Sunjang</td>
<td>Measured: 2.31</td>
<td>Predicted: 2.34</td>
</tr>
<tr>
<td>Insu</td>
<td>Measured: 1.20</td>
<td>Predicted: 1.18</td>
</tr>
<tr>
<td>Neungmac</td>
<td>Measured: 0.54</td>
<td>Predicted: 0.55</td>
</tr>
</tbody>
</table>
Future Works
Future works

Expansion of the CADMT

- NOIS and NDMI will expand the CADMT to about 22,000 small streams (10%)
Future works

Development of the DRR technologies based on measured data

- The DRR technologies development by classifying measured and unmeasured streams
Thanks for your attention

bangjaeman@korea.kr