APPLICATION OF AN INTEGRATED 3-D HYDROLOGICAL HYDRAULIC MODEL, COUPLED WITH A HIGH RESOLUTION DIGITAL ELEVATION MODEL, ON A WETLAND AREA IN THE SOUTH-WEST OF IRELAND

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The Lower Feale catchment

Cork
The Lower Feale
Flooding
Flooding
Sluiced culvert

- Embankment
- Berm
- Culvert
- Callow
- Backdrain
- River
- Flap Valve
Polder system - year 1500 in the Netherlands
<table>
<thead>
<tr>
<th>POLDER</th>
<th>CATCHMENT AREA (km²)</th>
<th>POLDER</th>
<th>CATCHMENT AREA (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2R</td>
<td>4.86</td>
<td>C2A</td>
<td>2.23</td>
</tr>
<tr>
<td>C4HA</td>
<td>1.0</td>
<td>C5A</td>
<td>3.64</td>
</tr>
<tr>
<td>C2K</td>
<td>7.52</td>
<td>C20</td>
<td>1.67</td>
</tr>
<tr>
<td>C2U</td>
<td>4.29</td>
<td>C5B</td>
<td>2.41</td>
</tr>
<tr>
<td>C3C</td>
<td>5.40</td>
<td>C32A</td>
<td>1</td>
</tr>
<tr>
<td>C2M</td>
<td>4.34</td>
<td>C18</td>
<td>1.63</td>
</tr>
<tr>
<td>C3A</td>
<td>5.08</td>
<td>C23</td>
<td>0.92</td>
</tr>
<tr>
<td>C4H</td>
<td>1.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Areas of the 15 Polders in the Feale Model [Table 4 in John Martin’s, PhD thesis]*
The Feale system in 200 km²

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Length (km)</th>
<th>Storage (km³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAIN TIDAL CHANNELS &amp; TIDAL TRIBUTARIES</td>
<td>6</td>
<td>49</td>
<td>-</td>
</tr>
<tr>
<td>NON TIDAL (SLUICED) TRIBUTARIES</td>
<td>6</td>
<td>16</td>
<td>0.55</td>
</tr>
<tr>
<td>BACK-DRAINS &amp; LAND DRAINS</td>
<td>45</td>
<td>66</td>
<td>0.53</td>
</tr>
<tr>
<td>EMBANKMENTS</td>
<td>-</td>
<td>107</td>
<td>-</td>
</tr>
<tr>
<td>SLUICED CULVERTS</td>
<td>55</td>
<td>1.3</td>
<td>-</td>
</tr>
<tr>
<td>SLUICED BARRAGES</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>WEIRS</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Arterial drainage scheme – 1950
worked then
not working now!
Flap valve
Sluiced barrage - Crompaun/Brick
Gate - 5’x4’ teak
Models

Feale GIS integrated model

Feale RR rainfall-runoff model

Feale NET hydrodynamic network model

Astronomical tide and surge [C3] model

Feale DEM digital elevation model

Water level data

Acoustic + visible data
## Software

<table>
<thead>
<tr>
<th>MODEL</th>
<th>SOFTWARE PACKAGE</th>
<th>FUNCTION</th>
<th>DATA REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feale_NET</td>
<td>Mike11 (2000b)</td>
<td>To compute Hydrodynamics and Water Levels</td>
<td>Discharge Data, Water Level Data, Cross-section Data, Sluiced Culvert &amp; Hydraulic Structure Data, Feale_RR Results</td>
</tr>
<tr>
<td>Feale_RR</td>
<td>Mike11 NAM (2000b)</td>
<td>To compute magnitude of Rainfall Run-off Flux</td>
<td>Rainfall Data, Soil data</td>
</tr>
<tr>
<td>Feale_DEM</td>
<td>ERMapper5.5, ArcView 3.2a</td>
<td>Digital Representation of Topography of the Floodplain</td>
<td>Digital Image Data, Results of Processing of Digital Image Photogrammetry</td>
</tr>
<tr>
<td>Feale_GIS</td>
<td>Mike11, ArcView 3.2a, Mike11-GIS (2000b)</td>
<td>To integrate Hydrodynamic Water Level Data with Topography to generate Floodmaps</td>
<td>Digital Elevation Model (Feale_DEM), Results of Feale_NET, Data about Floodplain Control Features</td>
</tr>
<tr>
<td>Feale_EVAL</td>
<td>Microsoft Excel 97</td>
<td>Analysis of Feale_NET Model Results to compute benefits of Flood alleviation measures (in terms of reduction in water level and flood inundated area)</td>
<td>Results of Feale_NET, Area Elevation Curves</td>
</tr>
</tbody>
</table>
RGB, nIR, panchromatic visible data 20cm pixel

Merged over-flights missing data

ERmapper algorithm identifies wet and dry areas
DEM 20cm vertical resolution - 1m horizontal grid

Each pixel \((x,y,z)\) geo-referenced to national grid +/- 20cm
Contour map
Integrated flood model
Residual error

**Ferry Bridge**

<table>
<thead>
<tr>
<th>Date</th>
<th>Difference in Water Level (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.3.98</td>
<td>-2.25</td>
</tr>
<tr>
<td>17.3.98</td>
<td>-1.75</td>
</tr>
<tr>
<td>19.3.98</td>
<td>-1.25</td>
</tr>
<tr>
<td>21.3.98</td>
<td>-0.75</td>
</tr>
<tr>
<td>23.3.98</td>
<td>-0.25</td>
</tr>
<tr>
<td>25.3.98</td>
<td>0.25</td>
</tr>
<tr>
<td>27.3.98</td>
<td>0.75</td>
</tr>
<tr>
<td>29.3.98</td>
<td>1.25</td>
</tr>
</tbody>
</table>
Flood maps
Social calibration

This road acts as a flood control feature
Social calibration

The Fault Theme Line simulates the effect of the Flood Control feature
Gradient vector field

Pause for flood animations
Historical analysis

- Remove the hydraulic infrastructure
- restore the land to 12’ OD (ordnance datum)
- simulate - - -

* result: large inundation
Historical analysis

- Insert the 1950s scheme
- place the land at 12’ OD (ordnance datum)
- place the inverts of all culverts at 6’ OD
- simulate --

*result: no flooding
Historical analysis

• Why has the performance of the system deteriorated?

Hydraulic head through the culverts has declined in magnitude, frequency, and duration.
Historical analysis

- Why has the performance of the system deteriorated?

River sediment
no longer floods onto callows
confined to the embanked channels
Historical analysis

- Why has the performance of the system deteriorated?

Settlement of the landscape
  Lower water level in the fields
  Removes buoyant support
  Consolidation of soil
  Bio-oxidation of the peat
Historical analysis

• Confirmation of hypothesis?

Historic maps
  Alexander Nimmo 1815
  …

Reference to similar landscapes
  The Netherlands
  The Fens
Alternatives

• Re-engineer the hydraulic system
Alternatives

• Re-engineer the hydraulic system
  – individual sluiced culverts
  – all culverts in a polder
  – all polders together

Minor improvement
Not credible with stakeholders
Alternatives

- Storm gates in the mouth of the estuary
  - to keep out storm surge and spring tides

traps river floods
Alternatives

- New interceptor drains
  - to divert runoff away from the polders

purchase of way leave
densive
Alternatives

• Dredging
Is the estuary blocked?
Dredging

- Depth
- Shape
  - side-slopes less than 1:1.5
- Path
  - start at the mouth
  - different end points in the network
    - one
    - many
Two reference floods at Listowel

- 50 years of flows
  - December 1997 - January 1998 minor floods, return period 2 years
  - March 1998, return period 9 years
The Lower Feale Experiment

Department of Civil & Environmental Engineering
University College Cork (NUI)

Dredging

REDUCTION IN PEAK FLOOD LEVEL (m)

DREDGED VOLUME (m$^3$)

JANUARY'98

MARCH'98

A_JAN
B_JAN
C_JAN
D_JAN
E_JAN
A_MAR
B_MAR
C_MAR
D_MAR
E_MAR
REQD REDN_JAN
RQD REDN_MAR
Alternatives

• Pumping
  – very flexible
  – comparable costs and benefits
  – response of farmers unknown
    • best agricultural use
    • water table in the fields
    • water level in field- and back-drains
    • set-point of the pumps
  – pilot experiment underway!
Pumping station to dewater a test polder

Raised peat bog with active cutting of peat
**Pumps:**

- 3 submersible pumps
- 170 l/s discharge each
The Study Case:

C2M Polder and the Control Polder
Instruments installed on site
The EC Station
Eddy Covariance Station - Energy Fluxes

Kerry - Station #1 - Energy Balance Components - 2003

Energy Flux (W/m²)

DOY

The Lower Feale Experiment
OTT-Orphimeades
Water Level Gauge
Ground Water Levels recorded

- Pump Polder - GWL5/GWL5
- Rain Gage/Rain Gage - Upland Area
Ground Water Levels recorded

* Control Polder - GWL3/GWL3
* Rain Gage/Rain Gage - Control Polder
△ Control Polder - GWL4/GWL4
Water Levels recorded
Water Levels recorded

- Water Level North of Pumps - WL1/WL1
- Rain Gage/Rain Gage - Control Polder
- Ferry Bridge OPW Gage/Ferry Bridge

![Graph showing water levels recorded over a period from 11/04 to 16/04. The graph indicates fluctuations in water levels with specific markers for different locations.](image-url)
Boreholes logs

Borehole 1

Borehole 2

Borehole 3

Borehole 4

7m
10.5m
14m

4m

7m

3.5m

2.8m

Peat

Impervious clay

Silty clay with pebbles and boulders

Regional Watertable

Perched Watertable

Limestone
Resistivity Survey

Borehole 3
ArcGIS Database

The Lower Feale Experiment
Coupled model: 3D groundwater (SHE) + network model
preliminary results – Water level in the drains
Coupled model preliminary results – ground water level
Conclusions:

- Further calibration of the coupled model, not easy
- Mismatch between data and prediction raises the question: Why? and leads to insight into models, data and processes.
- Waiting for flood events to test the effectiveness of pumps (One major and several minor floods)
The Future

• Conservation and development plan
  – proposed Special Area of Conservation
  – restore wet-lands
  – eco-tourism
  – wind mills
  – best sustainable use of natural resources

• e-cooperative for farmers
  – local multi-national food company
Feale website

- http://www.rocketmedia.ie/feale/site