A Green Spine for England

Water, Power, Transport, Communications

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The Big Idea

Not

But
In the 1930s, engineer John Pownall spotted what all the early canal and railway builders - James Brindley, George Rennie, George Stephenson - knew, that at about 300ft above sea level there is a "natural canal line". It wiggles across the country, avoiding most obstacles. In 1942, Pownall propounded the Grand Contour Canal. It was to be 100ft wide and 17ft deep.
Why?

• Water storage and supply
• Power transmission
• Transportation
• Communications
• District heating
• Uplift in land values
• Leisure and tourism
• Opportunities for regeneration
The Continuous Contour – Is It Real?

YES!

Source: Kielder Water

Destination: River Lee
Balancing Length and Cost

• Although we want the canal to follow the contour as much as possible, in some cases it would be cheaper to construct a more direct route.

• Key to analysis was forming an algorithm that takes account of varying cost based on change in formation level.
Least Cost Path Model

• The user creates just the start and end points for the route, on the same contour

• Model uses start height to assess relative cost of route with reference to altitude and existing infrastructure constraints

• Path is one cell wide and is the cheapest route relative to the cost units defined by the original cost raster

• This is converted to a line feature for further analysis
Raster Maths

- For each route calculated the reference height is set, i.e. the contour we want to follow (95m in the example below)

- Calculate a new raster, which is the height difference from the reference height

- Calculate the cost factor, from our parameters
Altitude as Cost

- For each route, a new cost surface is calculated based on the reference height.
- Using just this surface would give us the cheapest route corridor if there were no other constraints.
Constraints as Costs

• Create a cost surface for constraints

• Buffer each constraint to make a polygon

• Convert polygons to raster, where the value in each pixel is the penalty cost for construction

<table>
<thead>
<tr>
<th>CONSTRAINT</th>
<th>BUFFER</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway</td>
<td>50m</td>
<td>10</td>
</tr>
<tr>
<td>Motorway</td>
<td>50m</td>
<td>10</td>
</tr>
<tr>
<td>Urban Area</td>
<td>50m</td>
<td>20</td>
</tr>
<tr>
<td>SSSI</td>
<td>20m</td>
<td>10</td>
</tr>
<tr>
<td>A Road</td>
<td>20m</td>
<td>5</td>
</tr>
<tr>
<td>Lake</td>
<td>50m</td>
<td>5</td>
</tr>
<tr>
<td>River</td>
<td>20m</td>
<td>5</td>
</tr>
<tr>
<td>B Road</td>
<td>20m</td>
<td>3</td>
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<tr>
<td>Minor Road</td>
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<td>2</td>
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<tr>
<td>Open Space</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Combined Cost Surface

• Both of our cost surfaces represent costs on the same scale

• The rasters can be added together to create a combined cost surface
The algorithm first finds a route from the source to the destination, and then re-calculates it in the reverse direction to minimise the cost.
First Attempt – Least Cost Path Route
Construction Type

- The route is split into segments approximately 50m long using the height raster.
- The height at the midpoint of each segment is compared to the contour to determine the type of construction required, using the height/cost parameters.
• First task was to see if there was a range of contours that could each be used to create a route (75m/85m/95m/105m/115m)

• The range of cost factors for these runs was too small, resulting in a lot of tunnels, and some unrealistic options

• But it proved that there were options
• Next set of runs used a more realistic scenario

• At 900 Mld, minimum of 12m difference in level across 625km required

• Canal divided into “pounds” at fixed levels, connected with 5m deep locks, creating a hydraulic gradient
Route Options – Changing Level

• Better differentiation between relative construction costs

• Changed balance of construction away from tunnels and towards level sections along contours

• Alternative routes/levels for southern section investigated
The pound based approach creates a more feasible overall route, avoiding major conurbations and meeting most of the objectives.

<table>
<thead>
<tr>
<th>Aqueduct</th>
<th>Cutting</th>
<th>Embankment</th>
<th>Level</th>
<th>Tunnel</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>143km</td>
<td>86km</td>
<td>66km</td>
<td>275km</td>
<td>56km</td>
<td>526km</td>
</tr>
<tr>
<td>22.9%</td>
<td>13.7%</td>
<td>10.6%</td>
<td>43.9%</td>
<td>8.9%</td>
<td></td>
</tr>
</tbody>
</table>

With the revised cost factors there is still too much in tunnels or especially on aqueducts, but the overall balance of construction type is better than previous model runs.
• Process the manual segment through the construction type model

• All options are expensive, so a route through a town has been considered economic

• Manually edit the alignment to avoid urban area
Conclusions

- There is a potential route for the Canal
- Geo-processing models can be re-run with different parameters, construction type, and cost
- More detailed costs and specific routes need investigation
- The business case is not yet made
  - Is there a credible economic case?
  - How does it compare to other major infrastructure schemes?
- Using ArcGIS for route testing provides an efficient, multi-criteria optimisation with instant visualisation
Thank you for listening