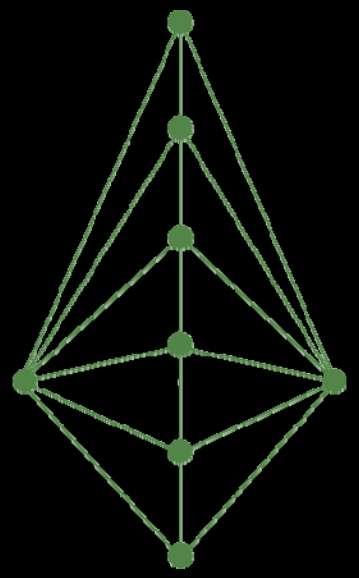
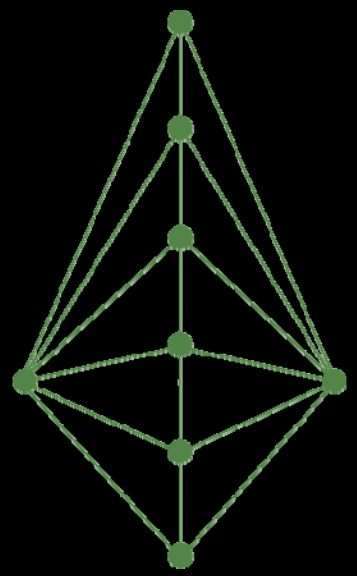
Managing Resource Networks with a Generic Open-source Software Platform



Julien Harou
University College London

UCL Bridging the Gaps Conference
16 February 2011



Collaborators

BTG funding
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Outline

- Sustainability and resource systems
- Systems modeling software
- HydroPlatform
- Example applications
- Project organisation
- Conclusions

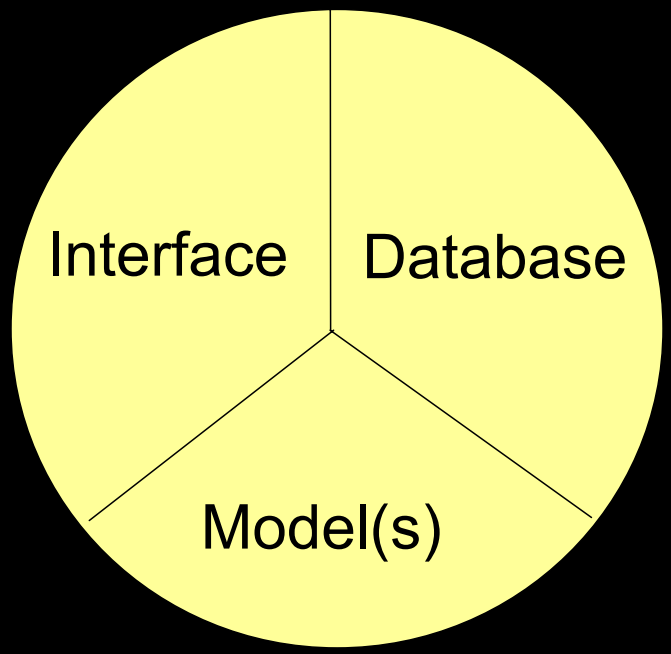
Sustainable City …
Sustainable Resource Network

Water resources, energy, food, transport, trade, logistics, social networks, …

Systems modeling in the 21st Century

- Large problems
- Multidisciplinary
- Many spatial and temporal scales
- Computationally complex
- Simulation, optimization, and mixed
- Data intensive
- Require sophisticated user interfaces

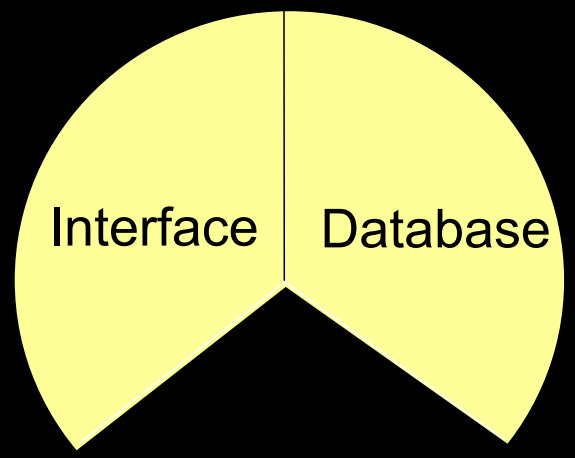
Traditional stand-alone software / DSS



Examples

- HEC products
- DHI products
- Riverware
- WEAP
- etc.

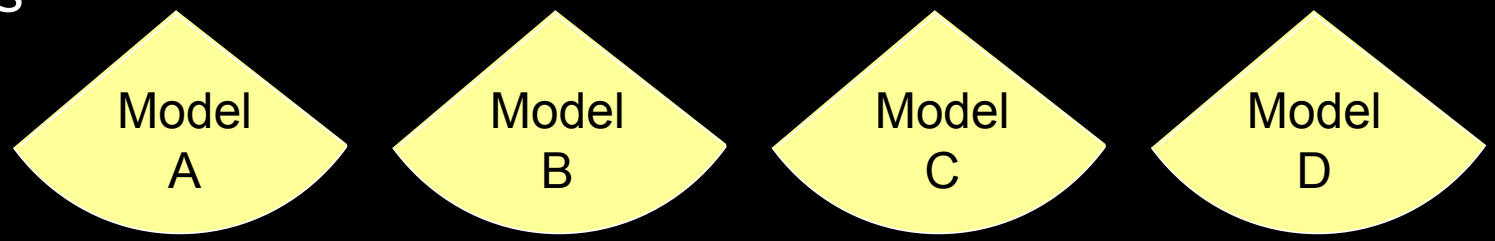
Model Platform



Manages & displays model inputs & outputs

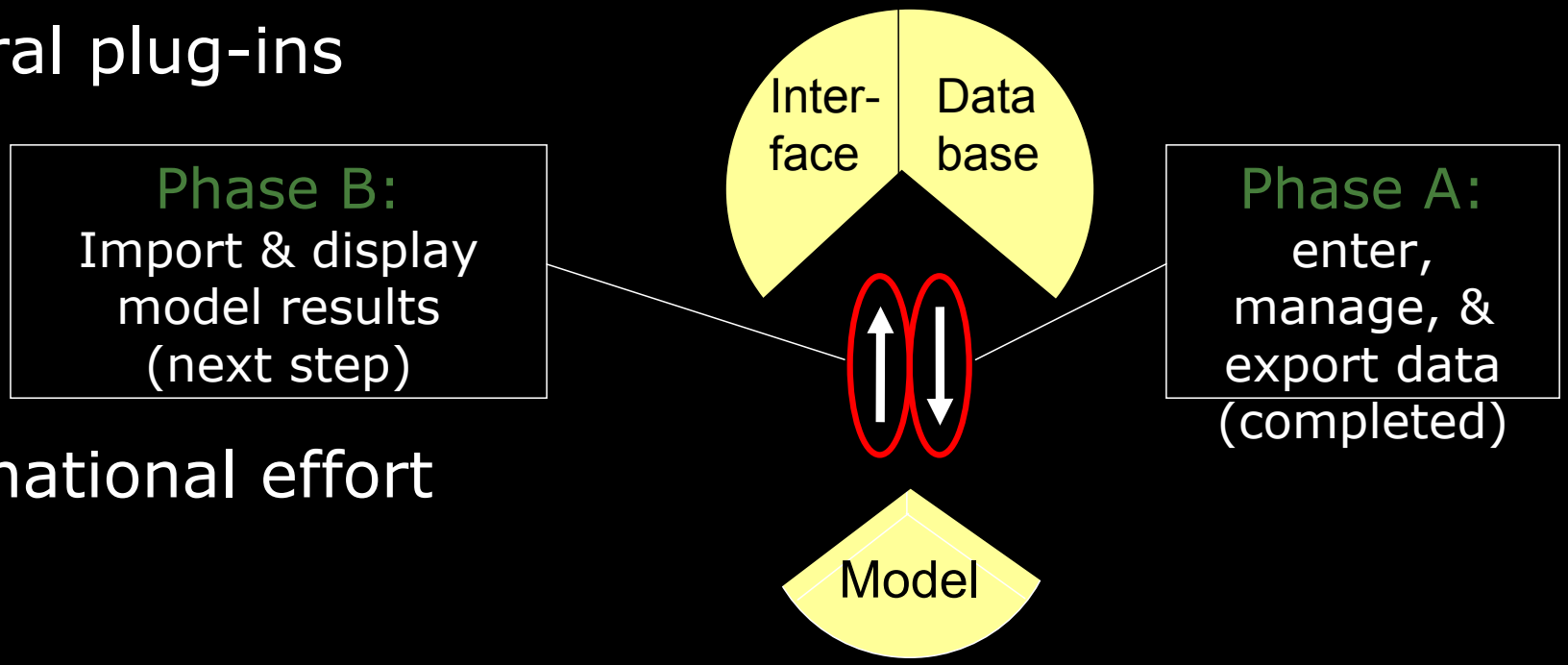
Export/import functions or add-ins

Open-source, freeware, or proprietary models



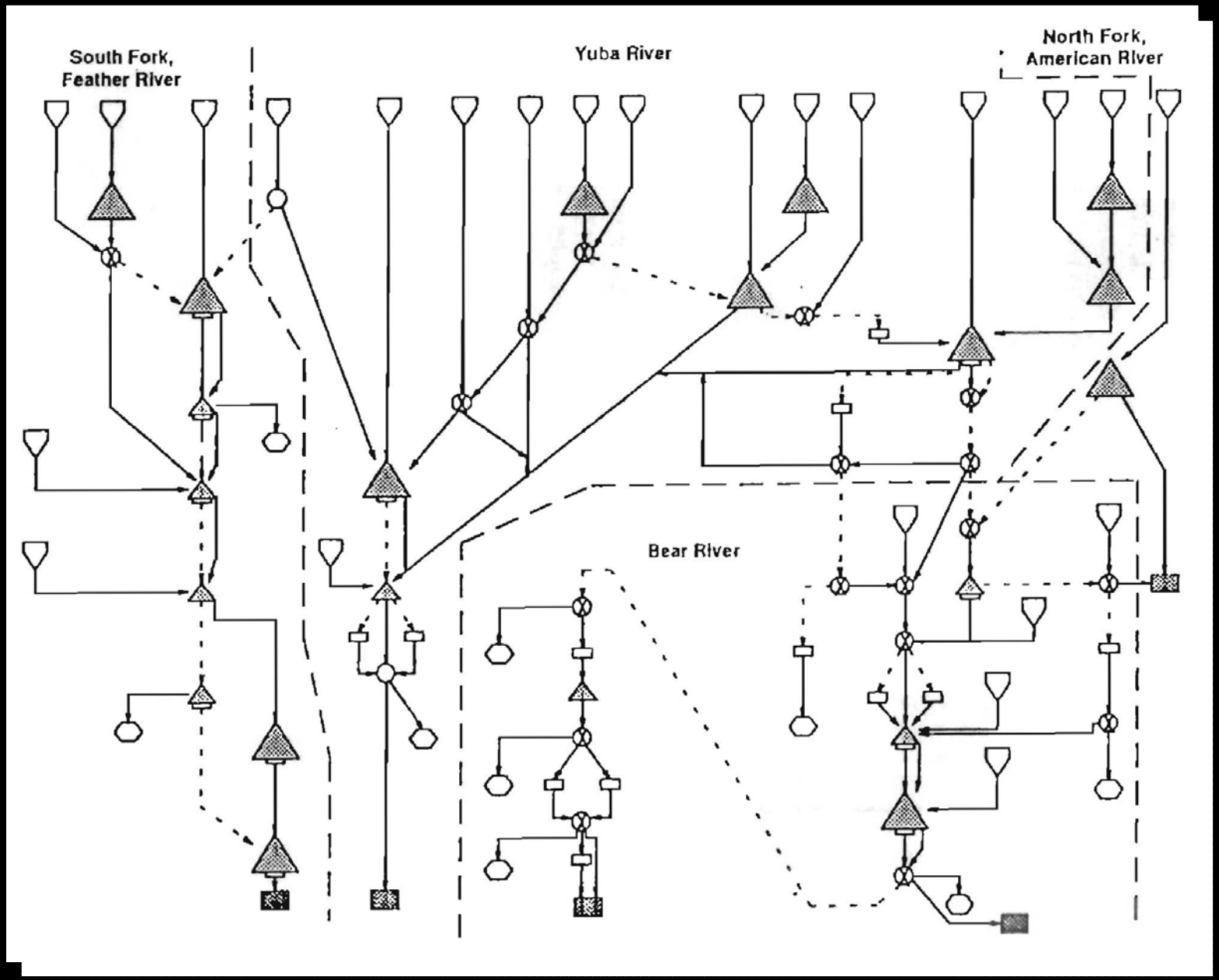
HydroPlatform
an example platform for network models

- Free, open source (GPL license & Python)
- GIS interface (Thubian)
- Customize node and link objects
- Several plug-ins



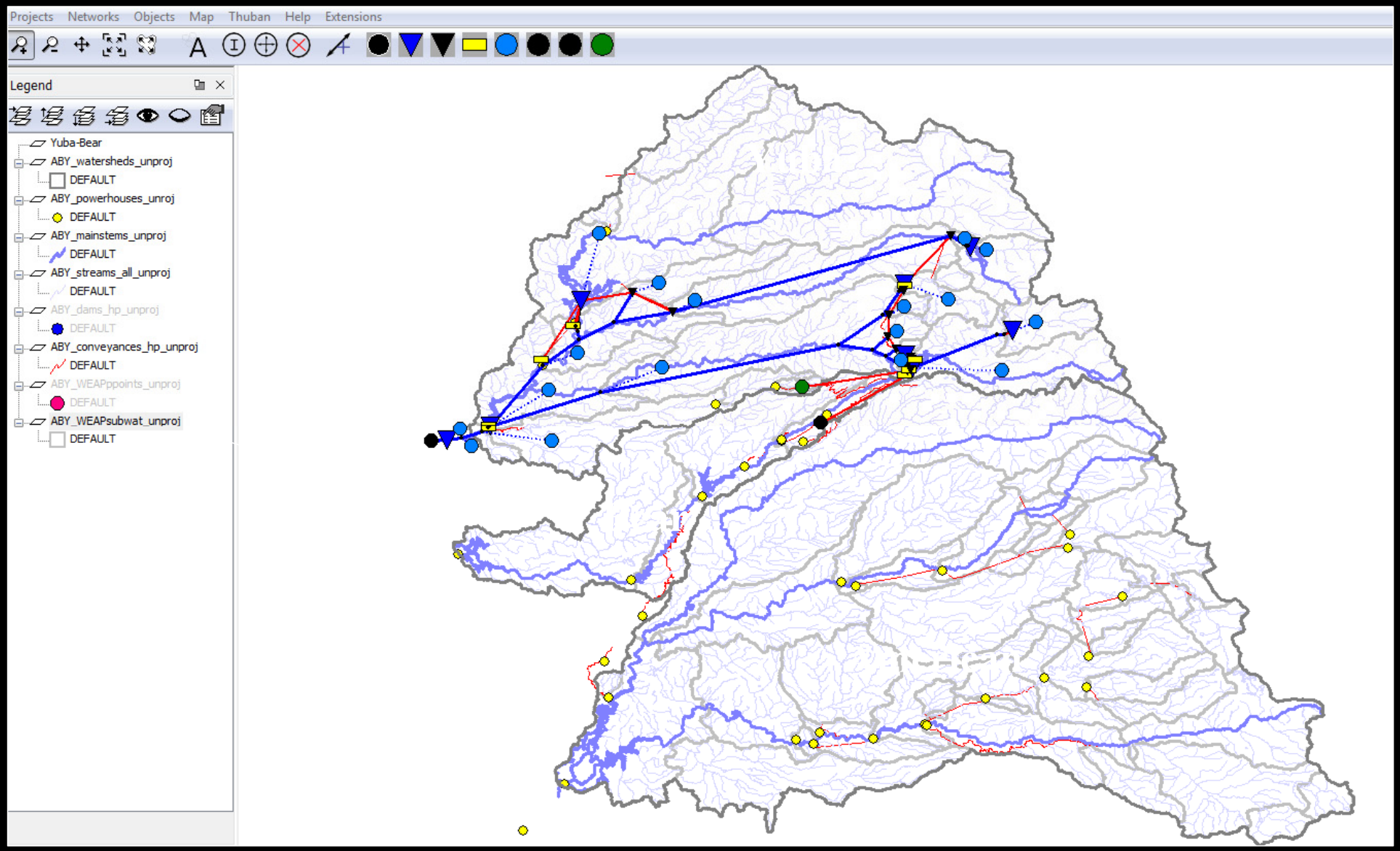
- International effort

The old way…

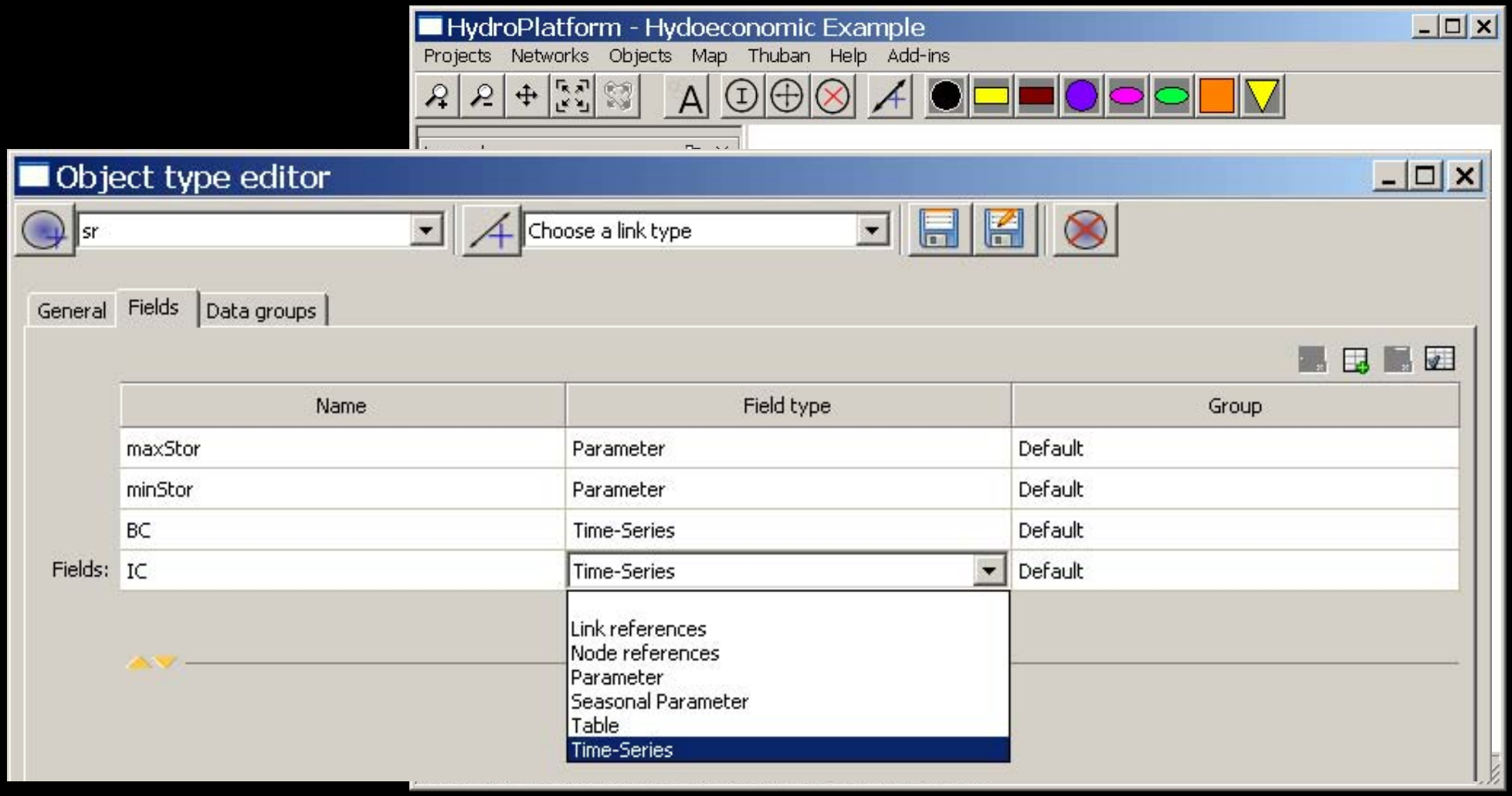


[Jacobs *et al.* 1995]

… in HydroPlatform



Define required data for each network object



Example Applications

London water supply and Thames water resource system

Water Supply Capacity Expansion and Trade in England

Zambezi Basin Hydropower

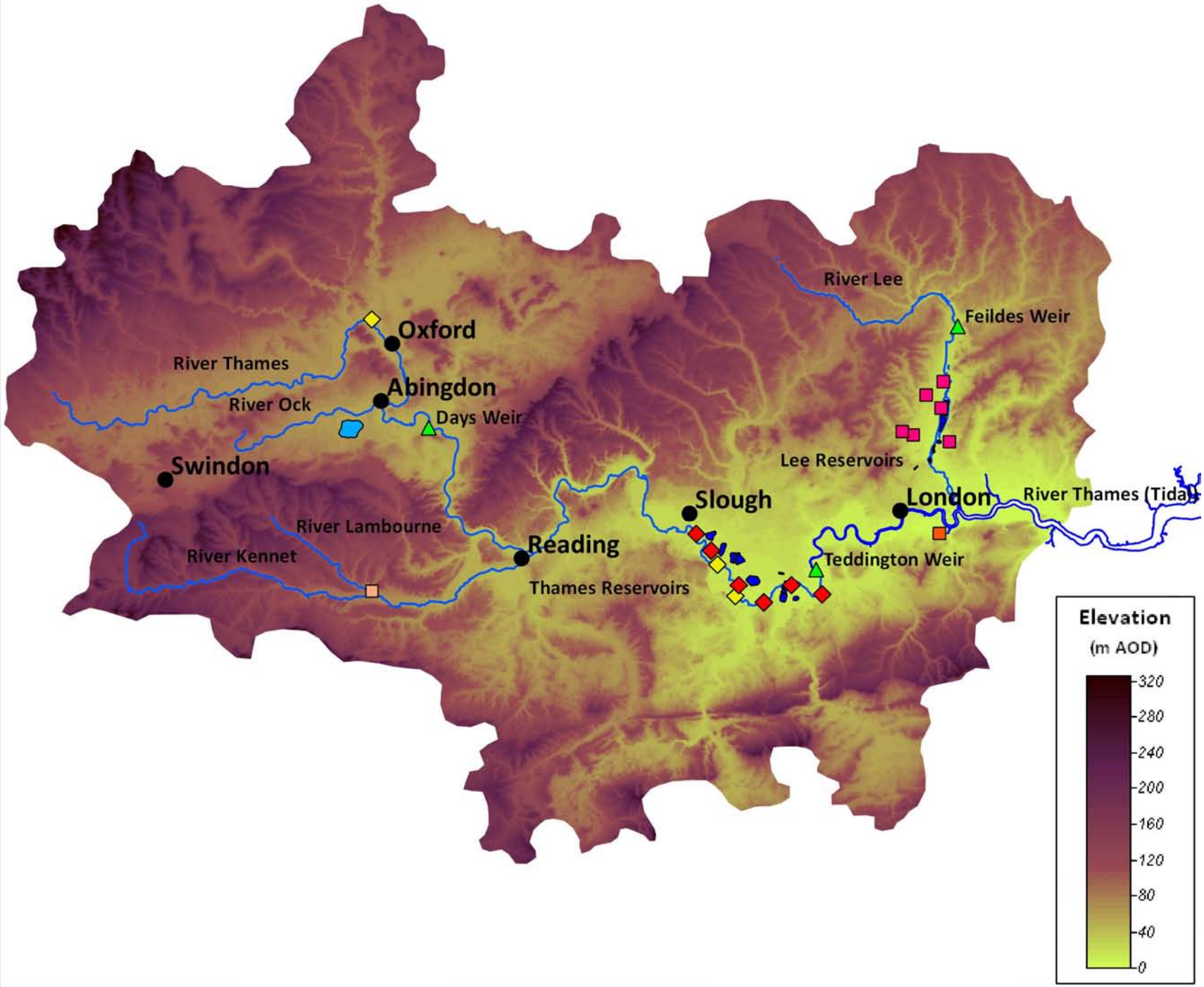
Traffic Optimsation

Network Analysis

English water management context

- Water supply & waste water utilities privatised since 1989
- Companies must submit environmental and financial water plan to regulators (EA, Ofwat) every 5 years
- Companies have incentive to invest in capital schemes (i.e. prefer a desalination plant to sharing supplies with neighbor)

London and Thames water resource system



West Berkshire Groundwater

Upper Thames Reservoir

Weirs

SLARS (General Location)

NLARS (Injection Sites)

Thames Water Abstractions

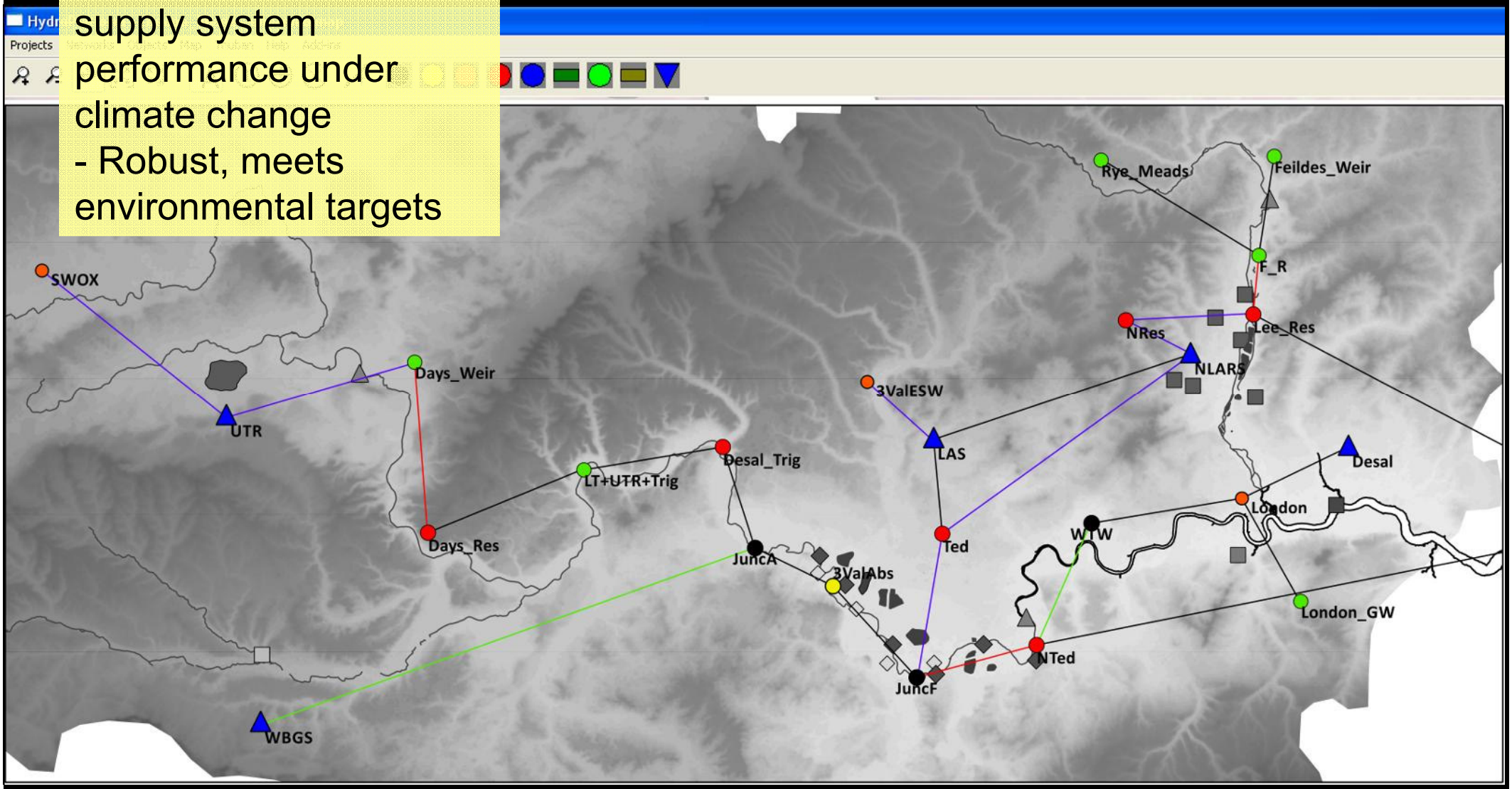
Three Valley's Abstractions

0 10 20 30 km

London and Thames water resource system

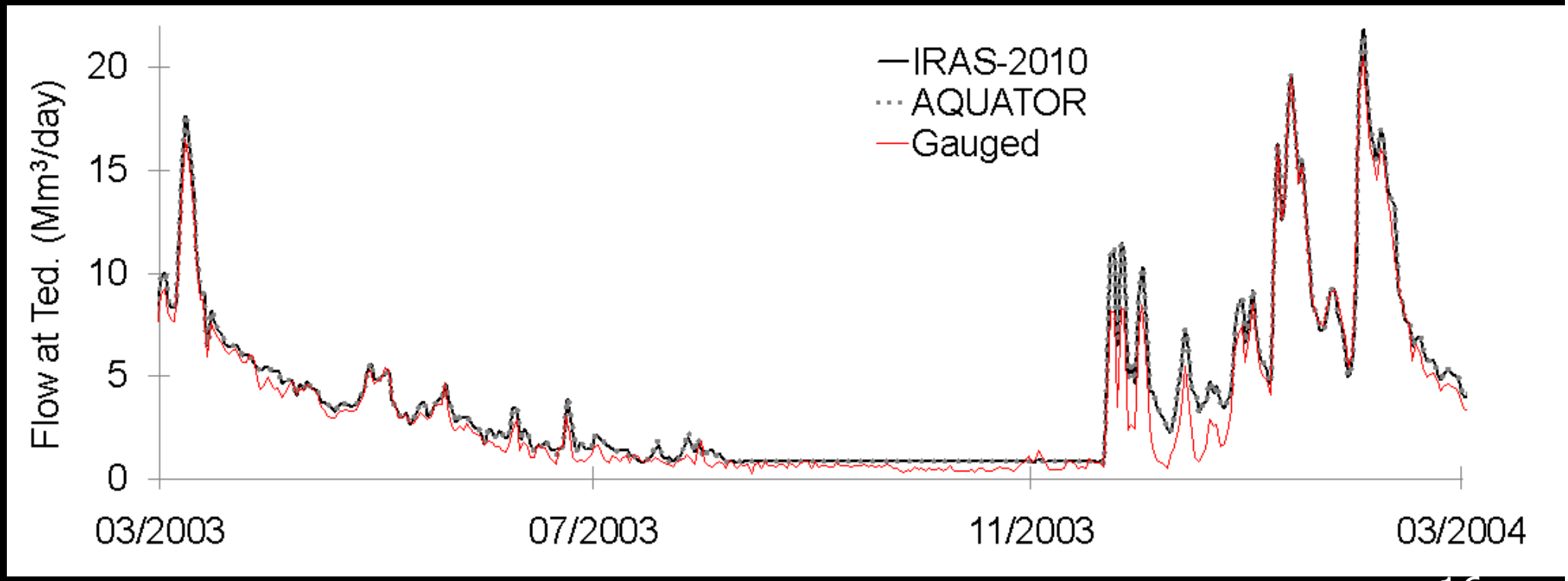
IRAS-2010 model uses a weekly time-step over 85-year time horizon with a runtime of 1 sec

Goal:
- Predict London water supply system performance under climate change
- Robust, meets environmental targets



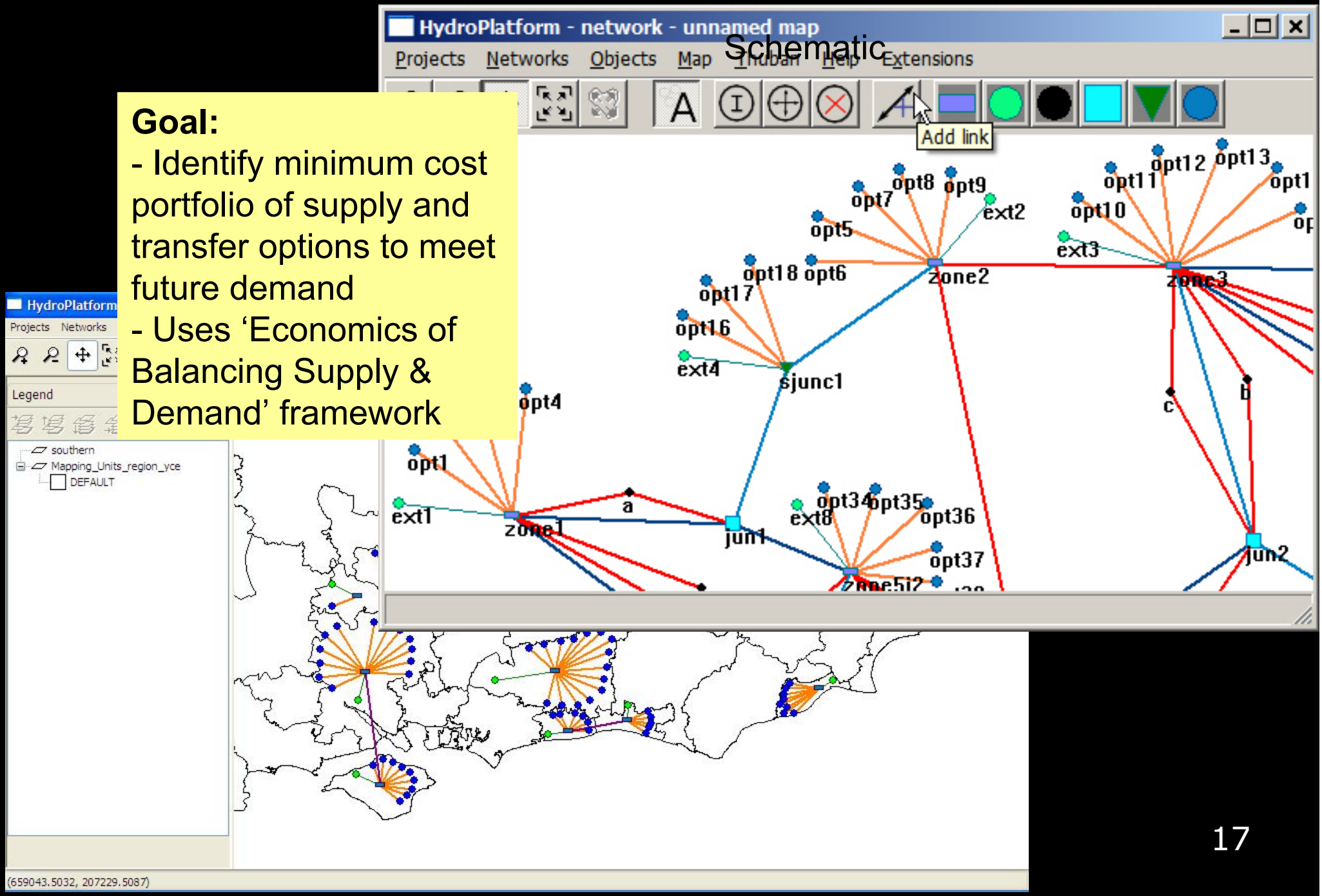
Gauged flow at Teddington

IRAS-2010 and AQUATOR show same flows and follow trend for gauged flow

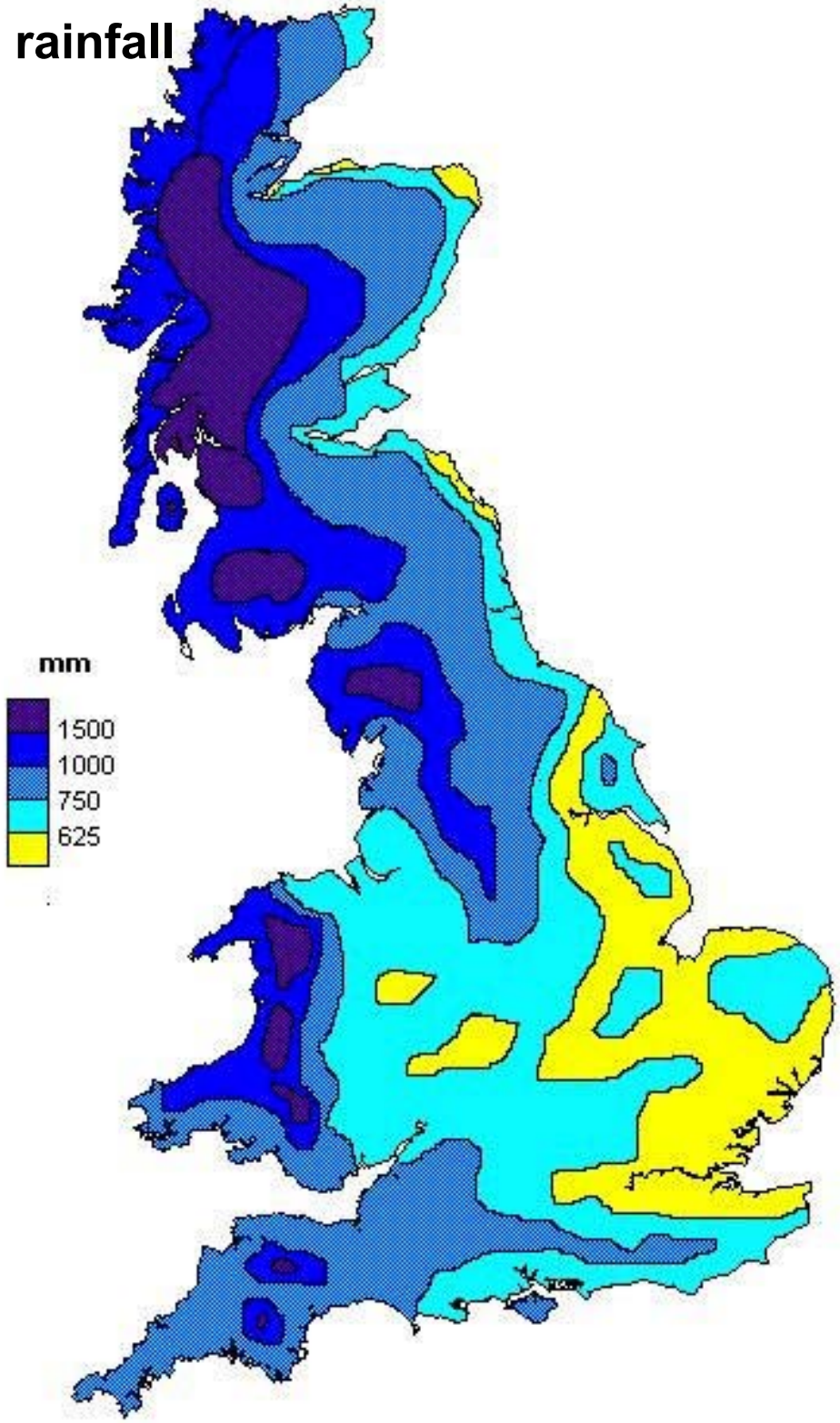


Capacity Expansion and Water Trading

Goal:
- Identify minimum cost portfolio of supply and transfer options to meet future demand
- Uses 'Economics of Balancing Supply & Demand' framework



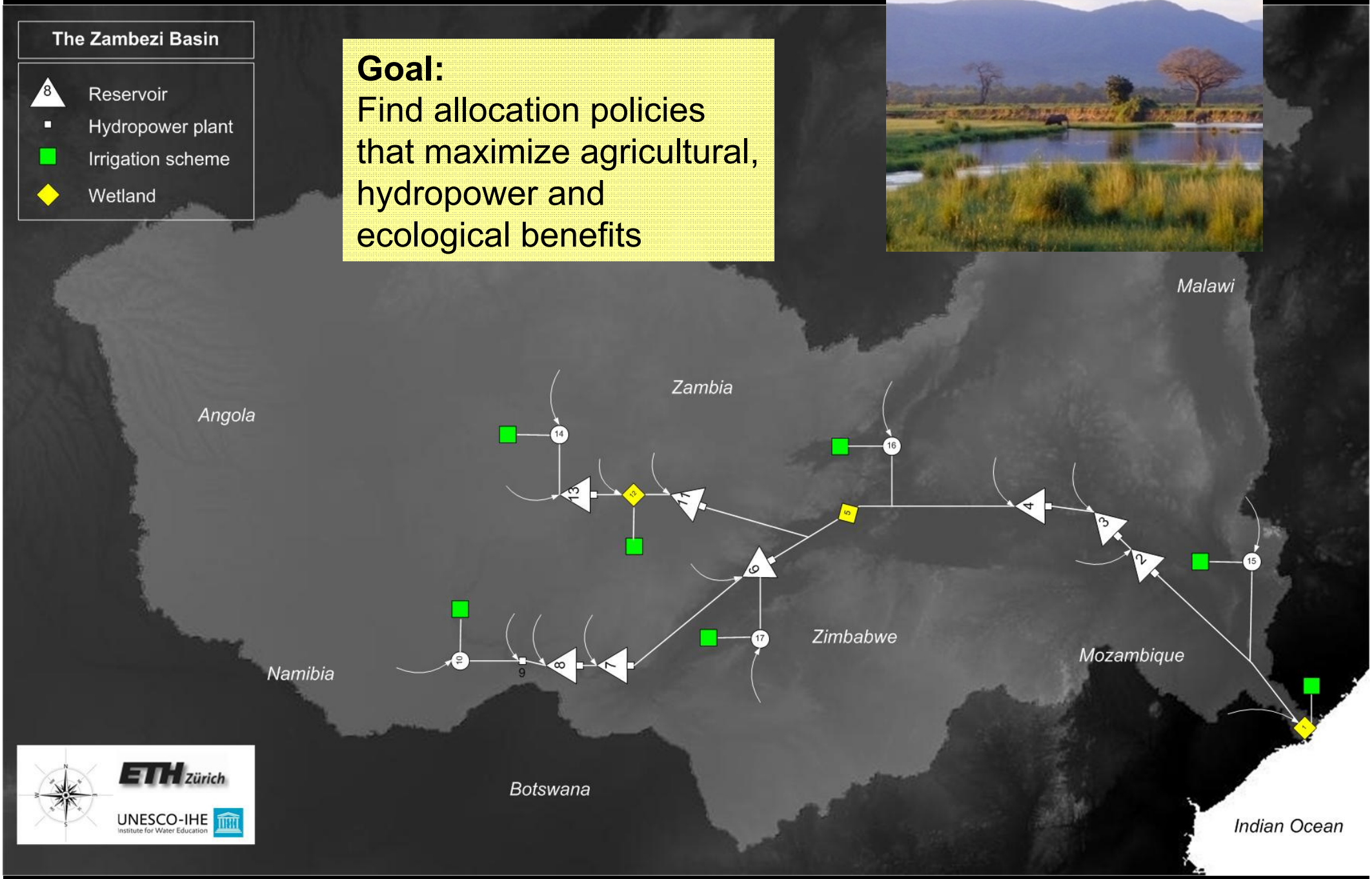
Annual rainfall



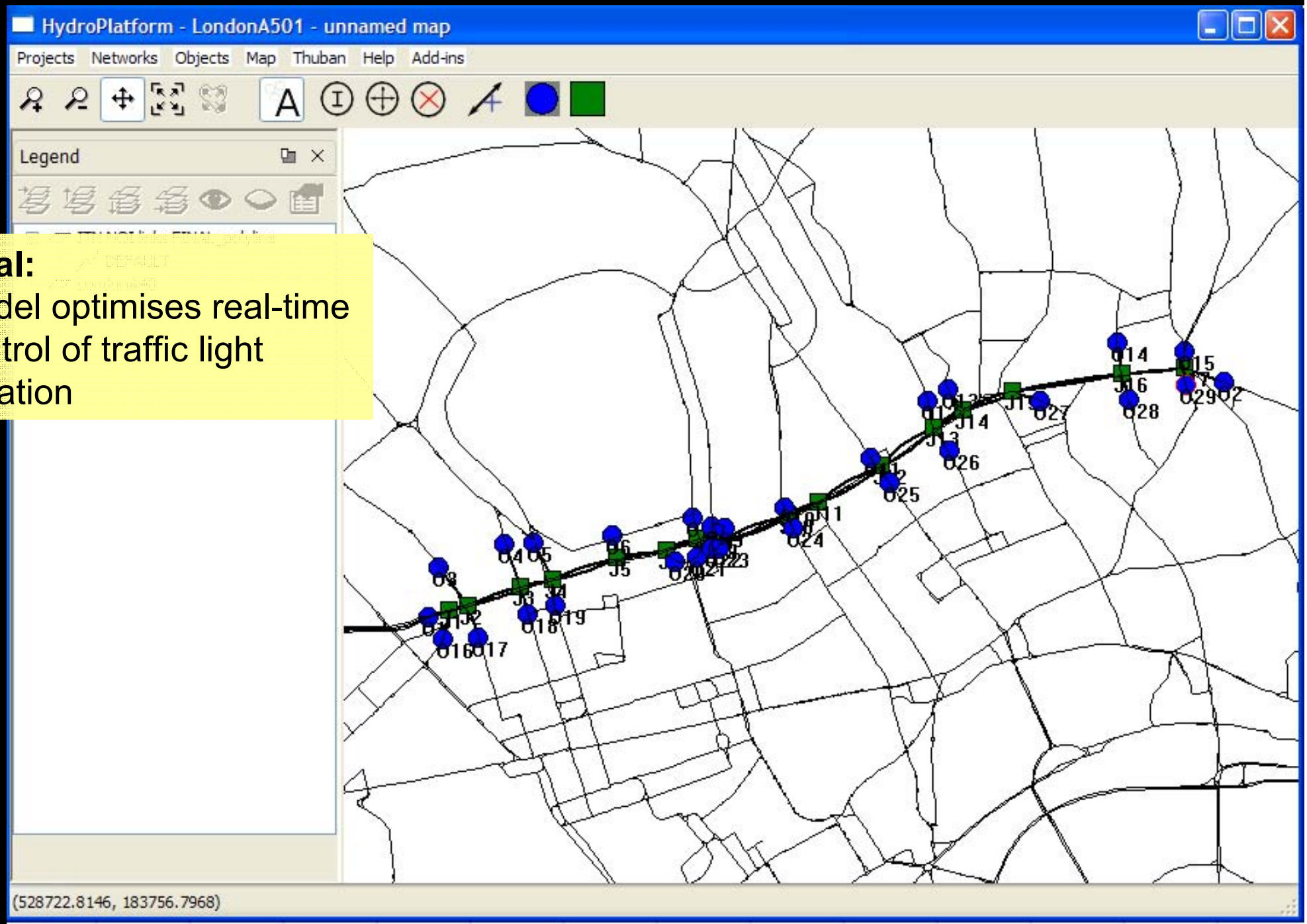
Water companies

Zambezi Basin Hydropower dam operation

Goal:
Find allocation policies that maximize agricultural, hydropower and ecological benefits



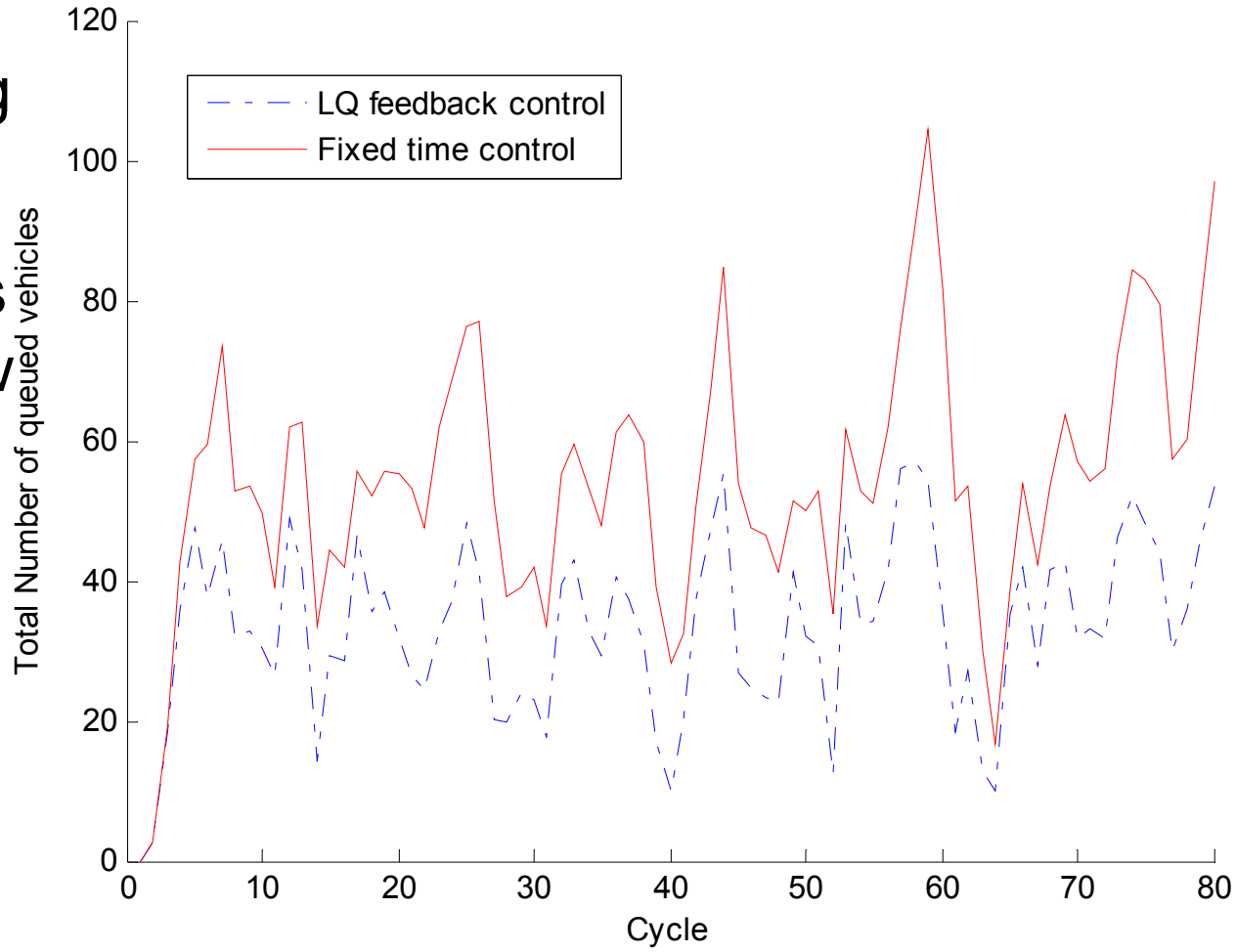
Linear-Quadratic traffic signal control



Goal:
Model optimises real-time control of traffic light duration

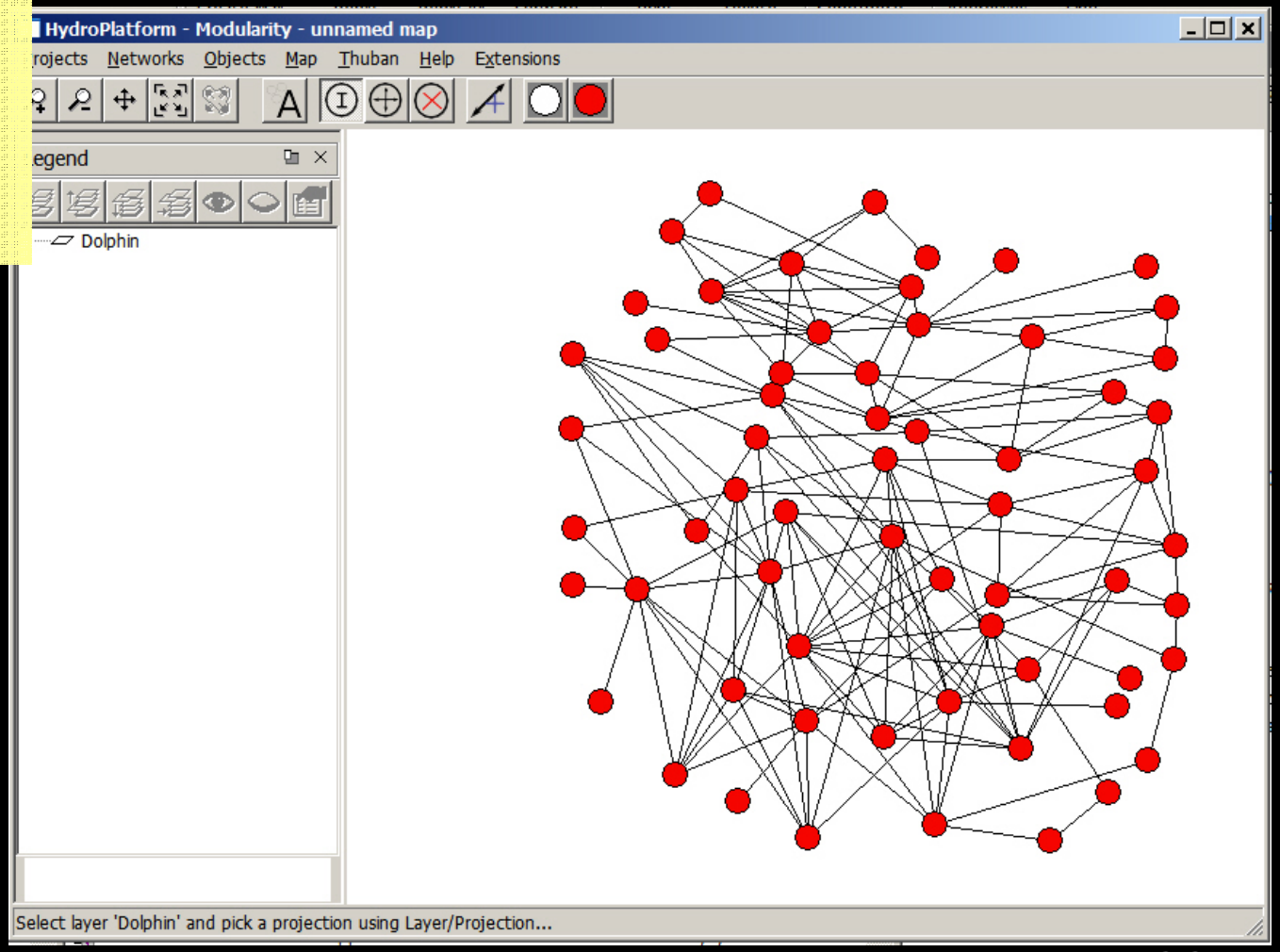
Linear-Quadratic traffic signal control

- Input
  - Traffic inflow
  - Nominal ‘fixed’ timing plans
  - Traffic light cycle time, green durations
  - Max storage and flow of each link
- Output
  - Queue lengths
  - Optimal ‘dynamic’ timing plans



Finding community structures in complex networks using mixed integer optimisation

Goal:
reveal the relationships between individual objects and their groupings in networks

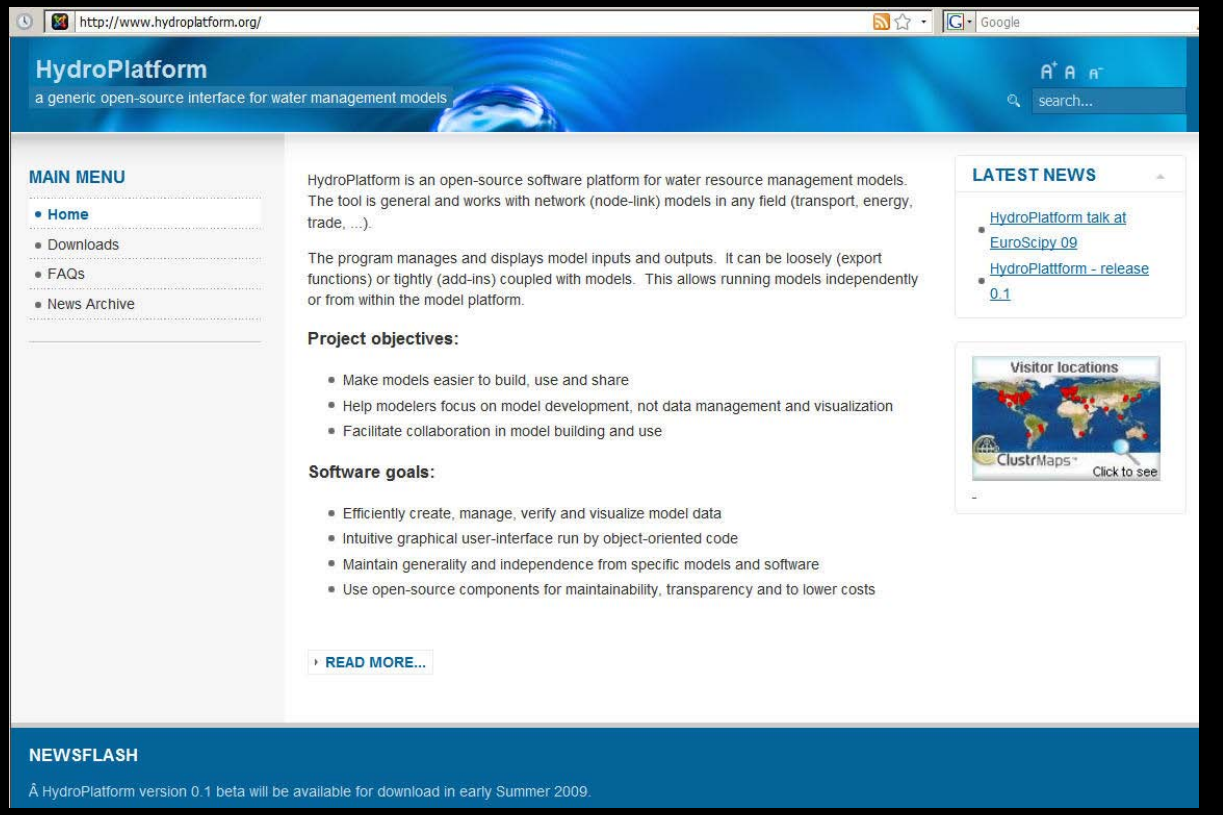


Community of 62 bottlenose dolphins living in Doubtful Sound, New Zealand

Each node represents a dolphin and the links in the network are identified based on the significantly frequent communications among them.

Project organization

- www.hydroplatform.org
- Wiki, code, and bug reports
- Pre-release available
- Future app store
  - open-source,
  - proprietary,
  - freeware models



Conclusions

- Model platform = user interface + data manager
- Helps focus on model development rather than software
- Efficient, flexible, scalable, open-source platform
- Goal: catalyze model innovation and use
- Coming soon: ‘App store’ for HydroPlatform add-ins
- Applications: general simulation, capacity expansion optimisation, water trading, traffic control, network analysis, etc.