



Strategic Risk and Cost Modeling:

> From Source to Sea

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> Background

Predictive and prescriptive analytics to address narrow elements of risk are well established. The real challenge is developing holistic, end-to-end management of all risk (asset, operational, regulatory, environmental, financial, regulatory, reputational and safety risks) at an enterprise scale.” (Dr Craig Mauelshagen).

To date, risk analysis in water utilities has remained in the domain of specialised quantitative risk modelling while enterprise risk management has been dominated by qualitative or semi-quantitative risk assessments. This has meant that while specific business functions such as water resource planning and asset management have robust, data and risk based decision making capabilities, at an enterprise level risk information is often at a very low granularity with risk categorised into 25 box matrices. The impact of this on a utilities’ risk management capability is that A) quantitative risk assessment is constrained within departmental siloes with limited visibility of wider systemic risk (Mikes, 2009), and B) strategic risk information is at too low a granularity to meaningfully inform strategy and strategic investment planning (Cox, 2008). This disconnect between risk and strategy does not allow boards to effectively manage the risk and reward balance. This gap is being answered by a new generation of holistic risk analytics tools that use prescriptive analytics to quantify end-to-end risks and provide risk-based optimisation of investment programmes. While adoption has been greatest in the financial sector (Bisias et al 2012) this approach is being applied in other industries such as healthcare (Howard and Felton 2013), mining (Lai 2012) and supply change management (Olson and Wu 2010).



Our vision of a ‘Source to Sea’ risk and cost modelling capability

This project developed out of Yorkshire Water’s vision for a capability to quantify the cost and performance impact of risk scenarios taking into account interdependencies between risk drivers, asset connectivity, regulatory accounting and shareholder value, and the hydrological cycle from catchments and raw water sources through to waste water treatment and sludge disposal.

Rationale for the ‘Source to Sea’ risk and cost model

A single holistic representation of the business will allow risk analysis that bridges organisational and knowledge silos, and captures the complicated relationships between networked assets. This model will add capability to quantify systemic risks and develop optimal solutions to those risks. Further, by providing a single view of risk, cost performance the Source to Sea model will help ensure that decisions can be made that optimise the balance between risk and reward while ensuring regulatory and service commitments are met.

> Model Data

Model scope

Water processes

•	All raw & treated Water Processes represented
•	Representation of customers (circa 5 million) down to production management zone level (circa 45,000 customers)
•	Representation of water network connectivity and water flow
•	All water treatment works represented individually

Sewage treatment

•	All sewage treatment works represented
•	Surface water and infiltration represented

Time

•	40 years represented in annual time steps
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Financial

•	Operational accounts for Raw Water, Treated Water, Sewage and Sludge
•	Wholesale/retail accounting separation represented
•	Regulatory accounting (including Regulatory Capital Value)
•	Quantification of financial risk (Value at Risk)

Sludge

•	All sludge processes represented, including sludge tankering
•	All sludge import sites individually represented
•	Sludge treatment variations by site represented

Sewerage

•	Representation of customers down to a sewage treatment works catchment area
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Model Application

The model will be directly used by group risk and assurance, group strategy and strategic investment planning through the following applications (Table 1).

User Group	Uses
Executive board and audit committee	The model will be used to provide Board and Audit Committee with enhanced oversight of current Strategic risks and control effectiveness.
Group risk and assurance	Identify and quantify strategic risk and multi risk event scenarios. Enable better reporting to Board, and support/challenge risk owners across the business.
Group strategy	Stress test group strategy, for example, under different population growth and climate change scenarios (raw water resource).
Strategic investment planning	Optimise strategic investment decisions in the context of the operation, maintenance, growth (development) and decommissioning of the asset base, set within a changing environmental, social, regulatory and economic context, forecasting how costs and risks will change over the long term (40 years).

Table 1: User Application

The Technology

Enterprise Optimiser (EO) is a flexible and industry agnostic optimisation and planning tool. The underlying methodology is multiple-time-period, mixed-integer linear programming (LP) with stochastic capabilities. The two unique aspects of EO that made it the ideal choice for this project are that (A) building EO models does not require writing code and (B) it can represent the asset base, operational processes and company financials in one integrated model. With regards the first point, models are built using icons and populating data tables with the underlying mixed integer LP model built in the background. This avoids the need for specialised developers and allows users with risk, engineering and financial backgrounds to build models and apply their expertise directly. This has allowed Yorkshire water to quickly & efficiently build an in-house capability to maintain and develop the model. The second unique aspect of EO allows users to view the impacts of risk events (or investment options) simultaneously on financial and operational performance. Finally, the objective function in EO is flexible and can be set to, for example, profit maximisation, Totex minimisation, risk minimisation, energy consumption minimisation, carbon emissions minimisation or any combination therein. This was important to support Yorkshire water's commitment to a socially, environmentally and economically sustainable future.

Implementation and integration with wider model landscape

In parallel to the risk modelling and analytics BMA also supported Yorkshire Water in redesigning their strategic risk management processes and existing tools to align with the new modelling and analytics capability. Running risk scenarios on the Source to Sea model will be initially offered as a service to risk owners. The model will be used to help individual risk owners quantify risk impact(s), understand systemic impacts and quantify the uncertainty around risk. This in turn will be aggregated to provide senior decision making with an overall view of the Yorkshire Water Risk Profile including their 'value at risk', a single monetary value indicating their overall financial risk profile (Mauelshagen et al 2014). The model will also allow senior decision makers to ask a wide range of 'what if questions', in this function the model will perform a vital role in informing the groups risk appetite and strategy. The ultimate vision is for all risk owners and risk champions to have 'self-service' access to the model.

The Source to Sea model itself sits within a growing model landscape of tactical and operational models also using EO as the core analytical and optimisation engine (figure 1). Currently operational models to optimise sludge tankering and sludge treatment are in active use. Implementation of these models involves 300 plus individuals, for example tanker drivers who receive daily work schedules produced and optimised by the EO sludge tankering model. A key next step towards this going is to build a series of tactical models that will allow scenario analysis and planning over a five year time horizon at a more granular level (but integrated with the S2S model) to support annual business planning. These models will be integrated, using common data sources and feeding each other information. For, example outputs from tactical models will be aggregated and fed into the Source to Sea model to determine the impact on the whole business.

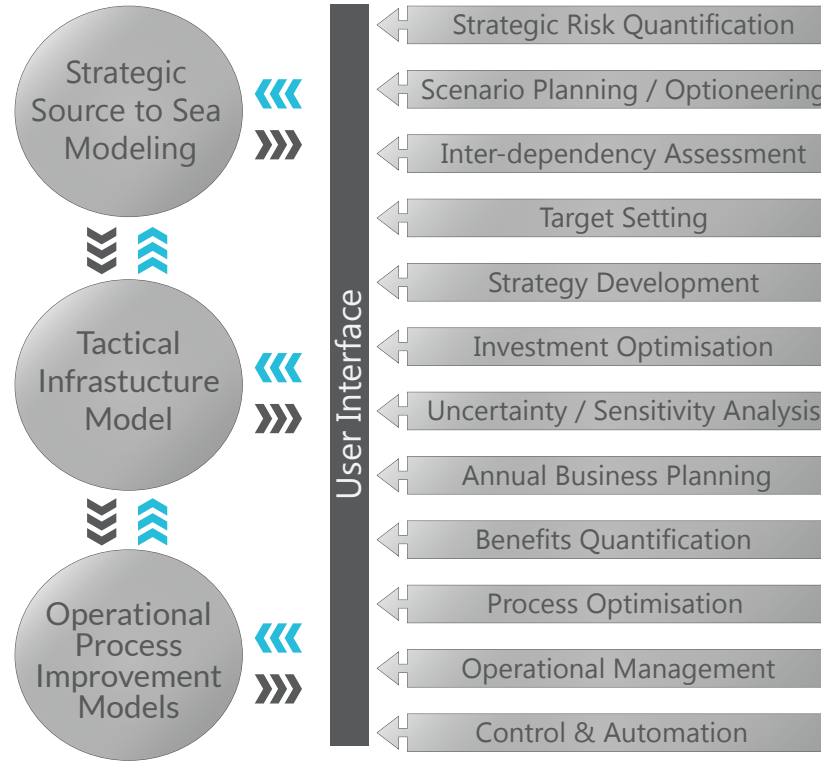


Figure 1: Developing model landscape using advanced predictive and prescriptive analytics at Yorkshire Water

Another key element of model implementation was development of a set of interactive risk dashboards to view and communicate the model results. These include dashboards showing the operational and financial impacts of scenarios and dashboards showing the impact on the company's overall risk profile (using the company's existing corporate risk scales) (Figure 2).

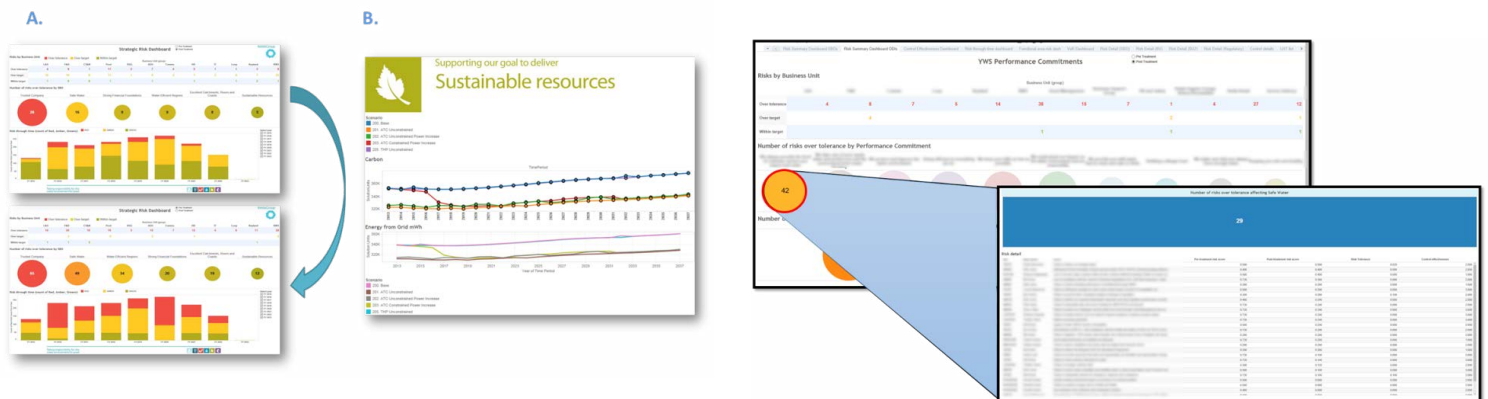


Figure 2: Source to Sea model risk dashboards, showing (A) impact of multi event risk scenario on overall risk profile and (B) impact on carbon emissions and energy consumption under multiple investment scenarios. (C) drill down functionality allowing user to bring up detail (risk owner, control effectiveness, treatment plan, review data etc.) for selected risks

> Looking forward

The Source to Sea model build with Yorkshire Water is a significant step towards a fully integrated risk, cost and performance management system that spans the business, supported by modelling and analytics. While further progress needs to be made in integrating this modelling approach with key business functions, we are confident that we will achieve our vision. The ultimate prize is that all decision makers are able to understand the systemic impact of their decisions in terms of risk, cost and performance. We believe such an ability to ubiquitously and dynamically model enterprise risk is essential to allow all employees to collaborate in optimising the balance of risk and reward.

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> About River Logic

Founded in 2000, River Logic is a privately held technology firm with a mission to establish Cloud Based Prescriptive Analytics (optimization) as the leading scientific approach to business planning and decision support. Its focus is on helping customers and business partners increase their performance, decision-making agility and ability to predict business outcomes through Enterprise Optimization™.

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