OPTIMISATION OF STRATEGIC NETWORKS

Planning for resilience, business risk, cost and network performance | Twenty65 – 26th March 2019

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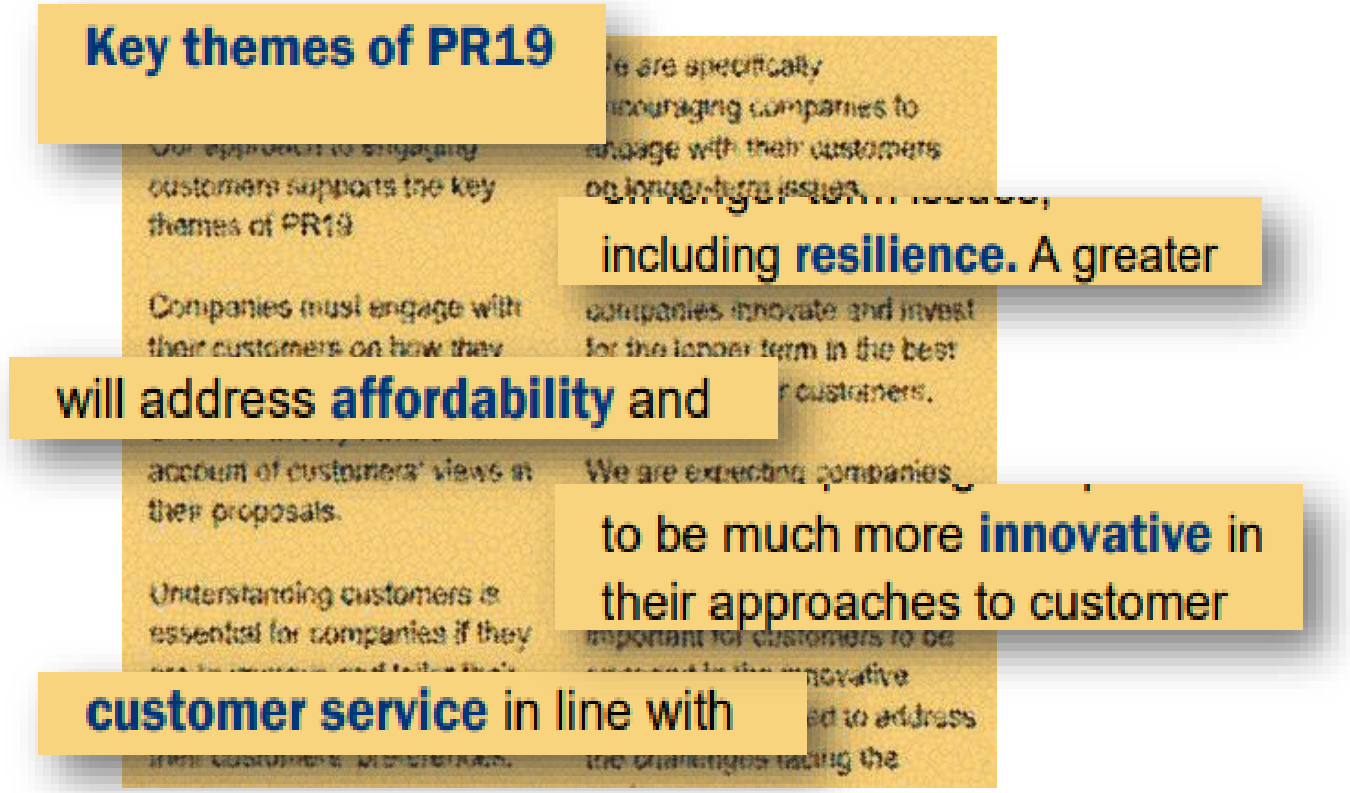
INNOVATING PLANNING FOR EFFICIENCY GAINS

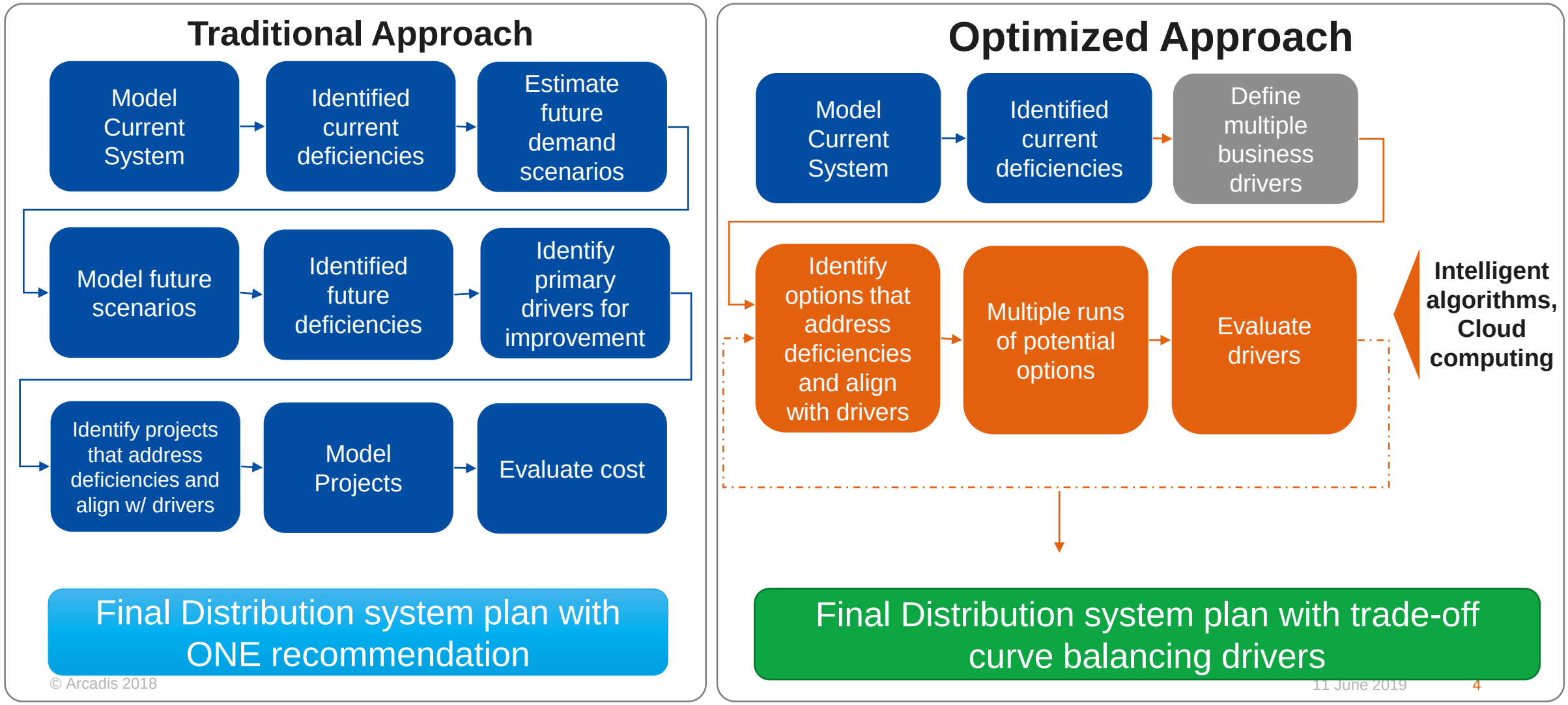
- Planning and investment processes of water supply networks are generally manual and iterative exercises.
- Successful pilot – new optimisation methodology for strategic planning
- Addresses the challenges set by Ofwat.



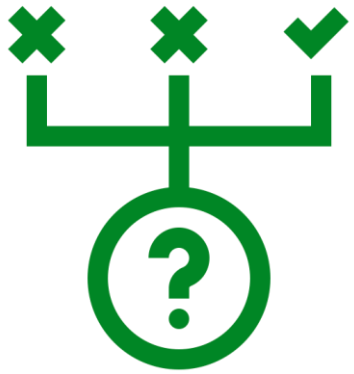
INNOVATING PLANNING FOR EFFICIENCY GAINS

- The planning process – traditional vs optimised planning
- The pilot project – the supply zone
- The challenge is complex – our objectives
- Setting up the hydraulic and optimisation model
- The results – our findings
- Other applications

TRADITIONAL VS OPTIMISED PLANNING



CAPITAL AND OPERATIONAL ASSET SELECTION PROCESS



- Provide insight into the **transparent and robust** investment decision making,
- Demonstrate that **exhaustive options** have been considered with understanding the cost and customer benefit of each, and
- **Create efficiencies** to the strategic planning process.

WHAT IS THE OPTIMAL LEVEL OF INVESTMENT?

WHAT DOES A **BALANCED PLAN** LOOKS LIKE?

WHAT IS THE **BUSINESS RISK EXPOSURE** FOR A GIVEN PLAN?

WHAT IS THE **SENSITIVITY** OF THE PLAN TO CHANGING PARAMETERS?

WHAT IS THE **COST OF IMPROVING RESILIENCE**?

HOW DID WE FIND THE OPTIMAL LEVEL OF INVESTMENT?

INPUTS

- Business Risks
- Asset Options
- Cost of Assets
- Hydraulic Model

EPANET, Infoworks, Optimizer

100,000 simulations of asset mixes computed via cloud

OUTPUTS

- Optimised ‘Best plans’
- Hydraulic results
- Asset mix plans
- Cost breakdown

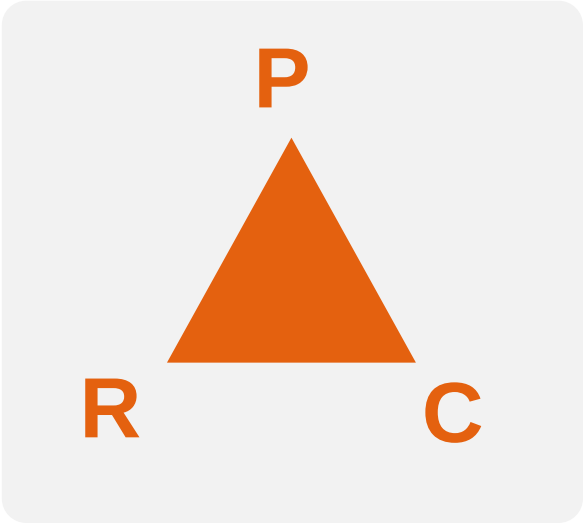
Optimizer

EVALUATE

- WHAT DOES A BALANCED PLAN LOOKS LIKE?
- WHAT IS THE BUSINESS RISK?
- WHAT IS THE SENSITIVITY OF THE PLAN?
- WHAT IS THE COST OF IMPROVING RESILIENCE ?

Optimizer, Excel

The Challenge is Complex – MULTIPLE OBJECTIVES



Network performance and address groundwater nitrate concentration risks

Improve system redundancy as a component of resilience

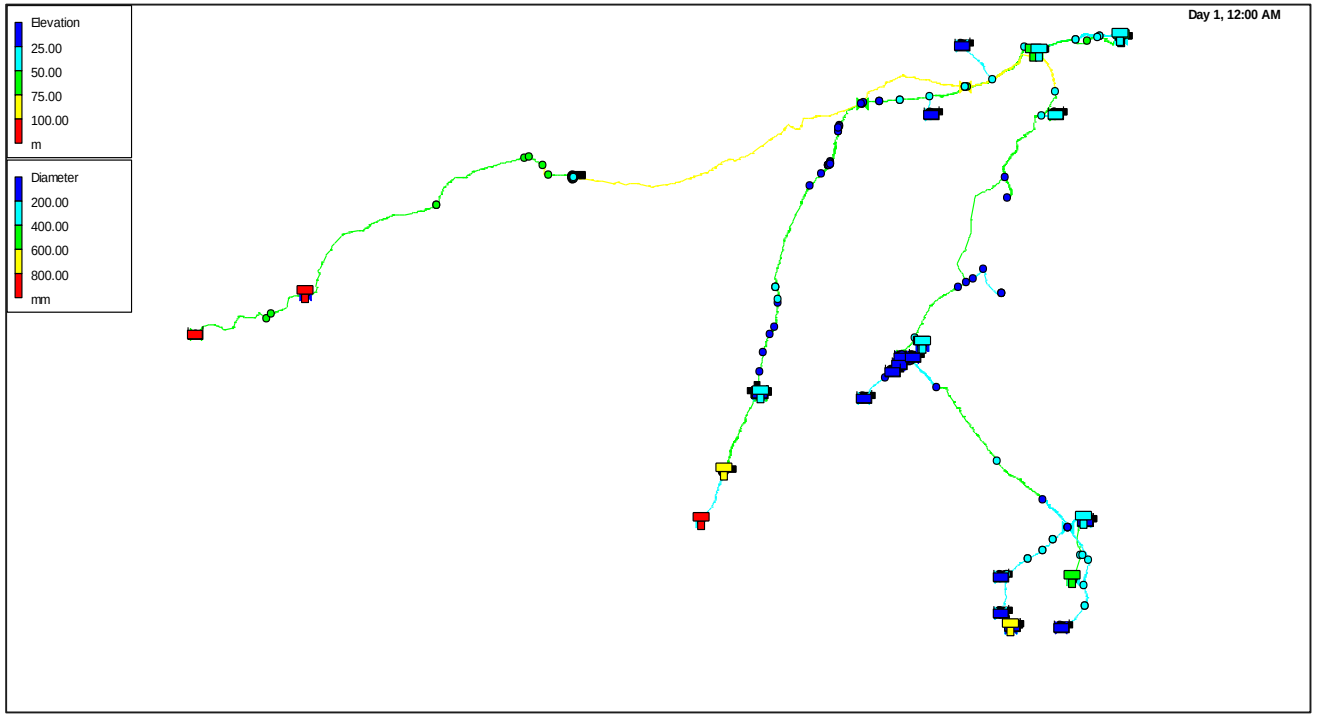
Address rising costs of capital assets

THE WATER SUPPLY NETWORK

Key Facts:

- Strategic network length: 118km
- Diameters range: 150-700mm
- Number of Reservoirs:13
- Number of groundwater sources:11
- 1 major import from neighbouring water company
- Properties: 96,000
- Average Day Demand: 480l/s (41.5Mld)

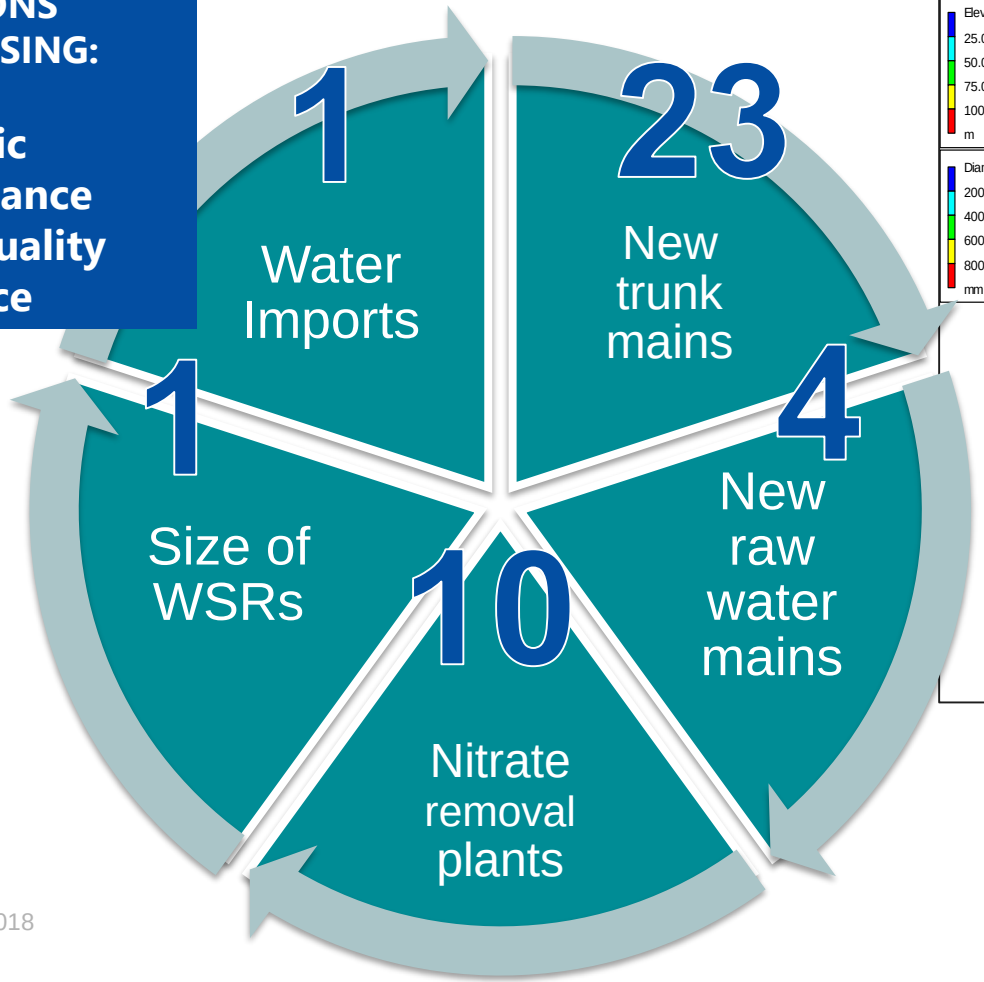
Baseline Epanet Model



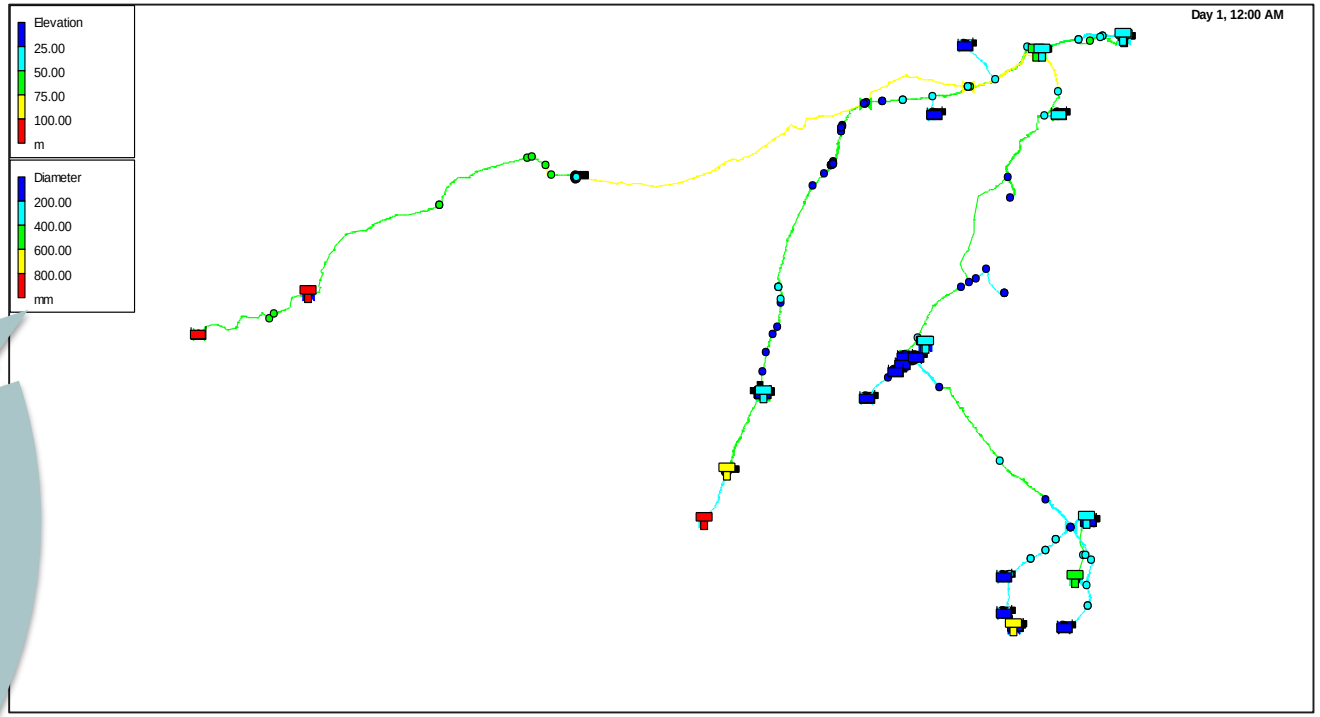
The Challenge the Complex – The OPTIONS

CAPITAL AND OPERATIONAL ASSET OPTIONS ADDRESSING:

- ❑ **Hydraulic performance**
- ❑ **Water quality**
- ❑ **Resilience**



Baseline Epanet Model



The Challenge is Complex – RESILIENCE

METHODOLOGY

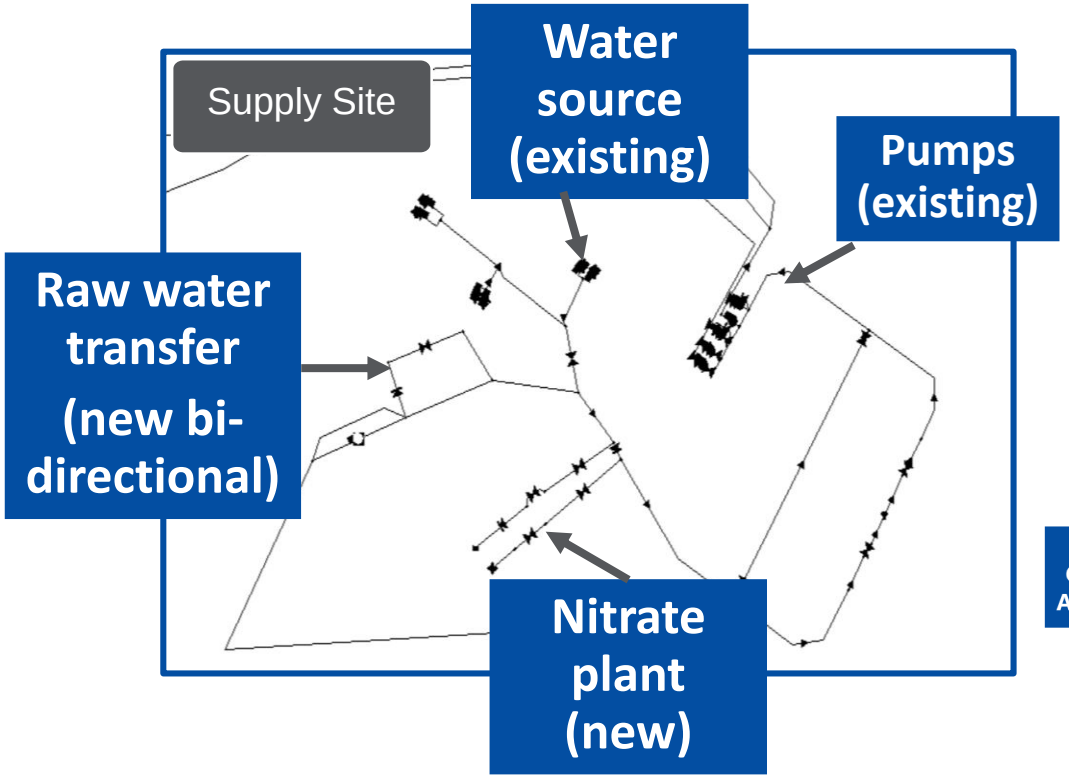
1. Definitions
2. Assessing risk score
3. Assessing control factor
4. Outputs

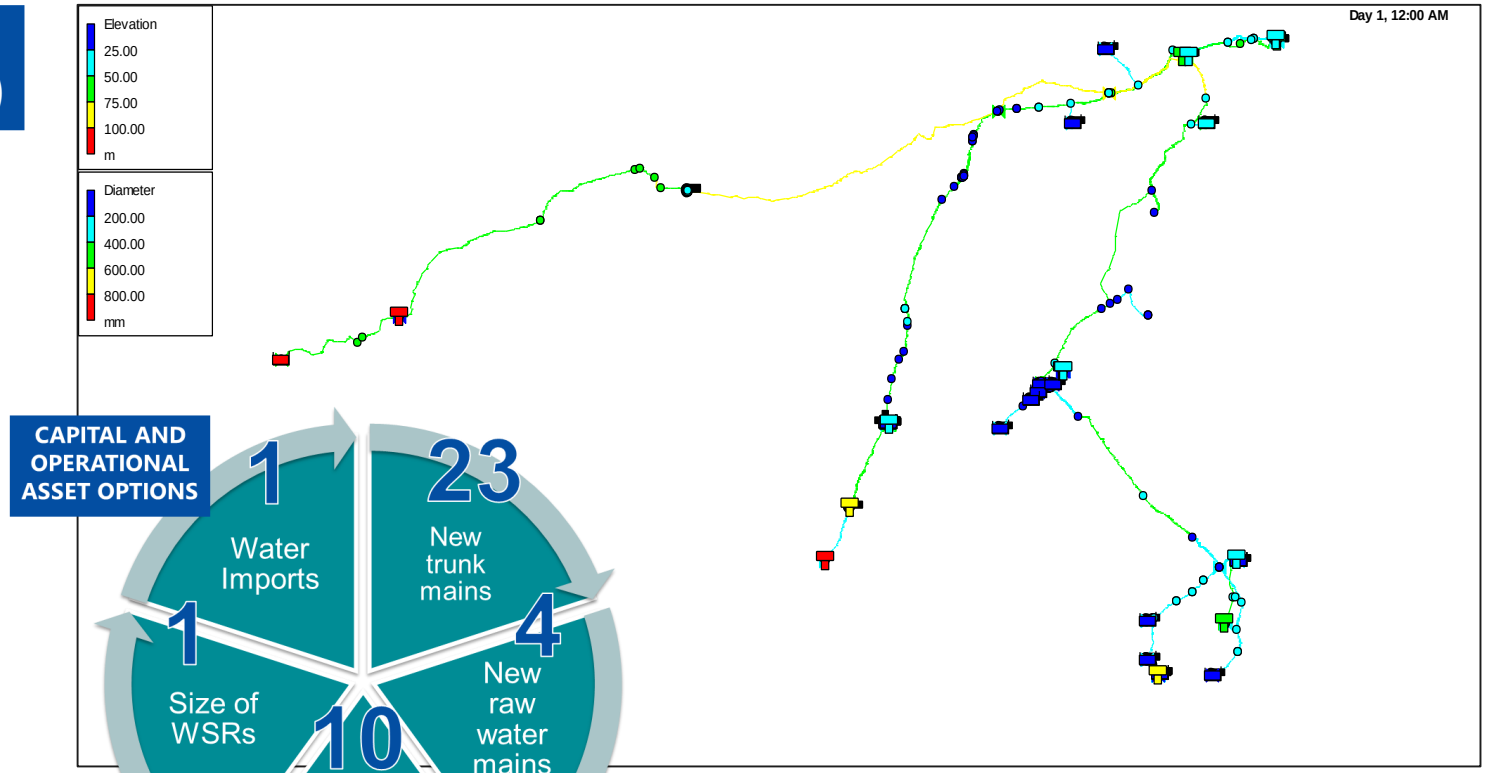
HAZARDS & SITES

SCALE OF IMPACT	REDUNDANCY
DURATION OF IMPACT	RESPONSE & RECOVERY
LIKELIHOOD	RESISTANCE
VULNERABILITY	RELIABILITY

RESILIENCE SCORE

SETTING UP THE HYDRAULIC MODEL





SETTING UP HYDRAULIC MODEL - CONTROLS

EPANET Water transfer and nitrate facility controls (new)

EPANET Water transfers controls (transferred from original site controls)

EPANET Outage controls (new)

```
IF VALVE New_ValveWingham_Dumping SETTING < 0.01
AND VALVE New_ValveWingham_NF SETTING < 0.01
AND VALVE NEW_ValveFlemmings_NF SETTING > 0.01
AND VALVE New_Valvefleming_Dumping SETTING > 0.01
AND VALVE New_ValveRW_FtoW SETTING > 0.01
THEN PUMP NEW_RW_WF STATUS IS CLOSED
AND PIPE New_11.New_12 STATUS IS CLOSED
AND PIPE New_11.New_19 STATUS IS OPEN
AND VALVE New_ValveRW_FtoW STATUS IS OPEN
AND PUMP NEW_RW_FW STATUS IS OPEN
AND PIPE New_15.New_16 STATUS IS OPEN
AND PIPE NEW_RW2.New_15 STATUS IS CLOSED
AND VALVE New_ValveRWFC2 STATUS IS CLOSED

RULE RW-Flemings-Export-isZero
IF VALVE New_ValveRW_FtoW SETTING < 0.1
THEN PIPE New_11.New_19 STATUS IS CLOSED
AND VALVE New_ValveRW_FtoW STATUS IS CLOSED
AND PUMP NEW_RW_FW STATUS IS CLOSED
AND PIPE New_15.New_16 STATUS IS CLOSED

; Controls for when there are both Flemings and Wigham have (no) nitrate p
; located under "Wingham" control

;*************************************************************************
;Wingham
; Wingham no Nitrate Facility on (off)
; when there is (no) flow from Wingham source
; and/or (no) flow from Flemings raw water
; and not connected into the network

RULE Wingham-NitrateOn
IF PIPE New_20.WINGHAM_WFM_KA0115_A FLOW > 0.01
THEN VALVE new_81.New_25 STATUS IS OPEN
AND VALVE New_1.New_nitrateWingham STATUS IS OPEN
;AND PIPE WIN_WFM_KA0115_B.WIN_WSW_N36.1 STATUS IS OPEN
```

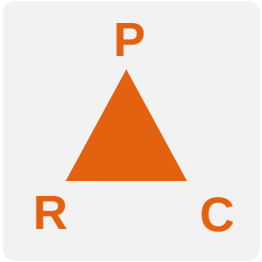
```
Wingham pumps to the north
LINK WINGHAM-WBS-N1 OPEN IF NODE WINGHAM_WBS_N8 BELOW 43
LINK WINGHAM-WBS-N1 CLOSED IF NODE WINGHAM_WBS_N8 ABOVE 45

Operated Wingham pumps based on level in clearwell
Now expressed as rule-based controls
LINK WINGHAM-N19 OPEN IF NODE WINGHAMX_CWT B
LINK WINGHAM-N19 CLOSED IF NODE WINGHAMX_CWT
LINK WINGHAM-N20 OPEN IF NODE WINGHAMX_CWT B
LINK WINGHAM-N20 CLOSED IF NODE WINGHAMX_CWT
LINK WINGHAM-N21 OPEN IF NODE WINGHAMX_CWT B
LINK WINGHAM-N21 CLOSED IF NODE WINGHAMX_CWT
```

```
;*********************************
;***RESILIENCE OUTAGE CONTROLS***
;*********************************
;--------------
;Outage 25 TX05
;--------------
LINK 5717906.5747814.1 OPEN AT TIME 3528
LINK 5720988.5717906.2 OPEN AT TIME 3528
LINK TX9290.TX9288.1 CLOSED AT TIME 3528

;-----------------------
;Outage 16 - Wingham WSW
;-----------------------
LINK WING_WSW_N50.WING_WSW_N48.1 OPEN AT TIME 3360

;-----------------------
;Outage 5 - Matin Mill WSR
;-----------------------
;LINK MARTMILL_WSR_N10.MARTMILL.2 OPEN AT TIME 3528
;LINK MART_WSR_N16.MART_WSR_N15.1 OPEN AT TIME 3528
;LINK MART_WSR_N21.MART_WSR_N22.1 CLOSED AT TIME 3528
```

SETTING UP THE OPTIMIZER MODEL

1. Set up Objective Functions

- Maximise Zonal Resilience Score
- Minimise Totex
- Minimise hydraulic performance penalties



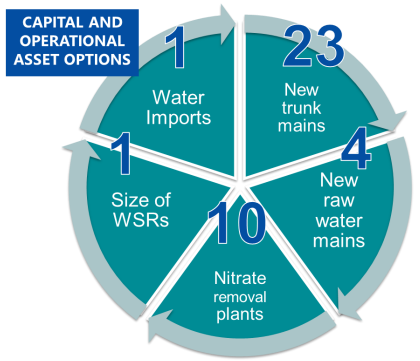
2. Design Criteria and business risk

- Water Quality
- Network Pressure
- Velocity
- Treatment works capacity

Penalties Functions:

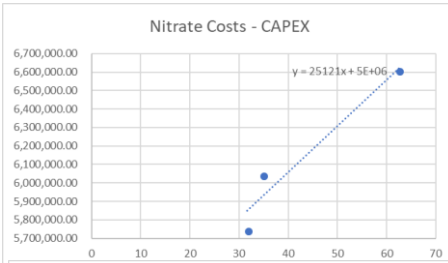
£ assigned when design criteria fall outside of the pre-defined boundaries (not yet aligned with ODIs)

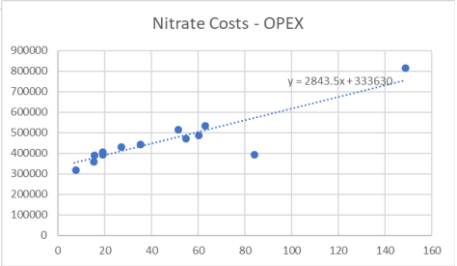
3. Decisions



4. Costs

The Costs are directly correlated to Decisions.





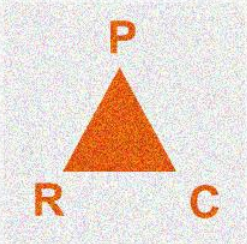
SETTING UP THE OPTIMIZER MODEL – BESPOKE SCRIPTS

1. Set up Objective Functions

- Maximise Zonal Resilience Score

Bespoke Script

- Minimise Totex
- Minimise hydraulic performance penalties



2. Design Criteria and business risk

- Water Quality
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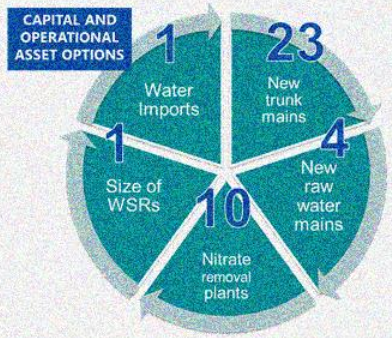
Bespoke Script

Penalties: £ assigned when design criteria fall outside of the pre-defined boundaries

3. Decisions



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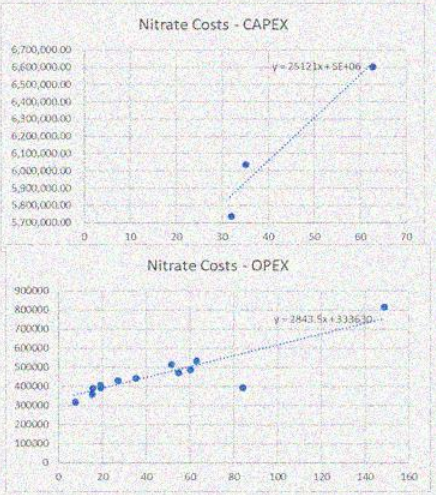
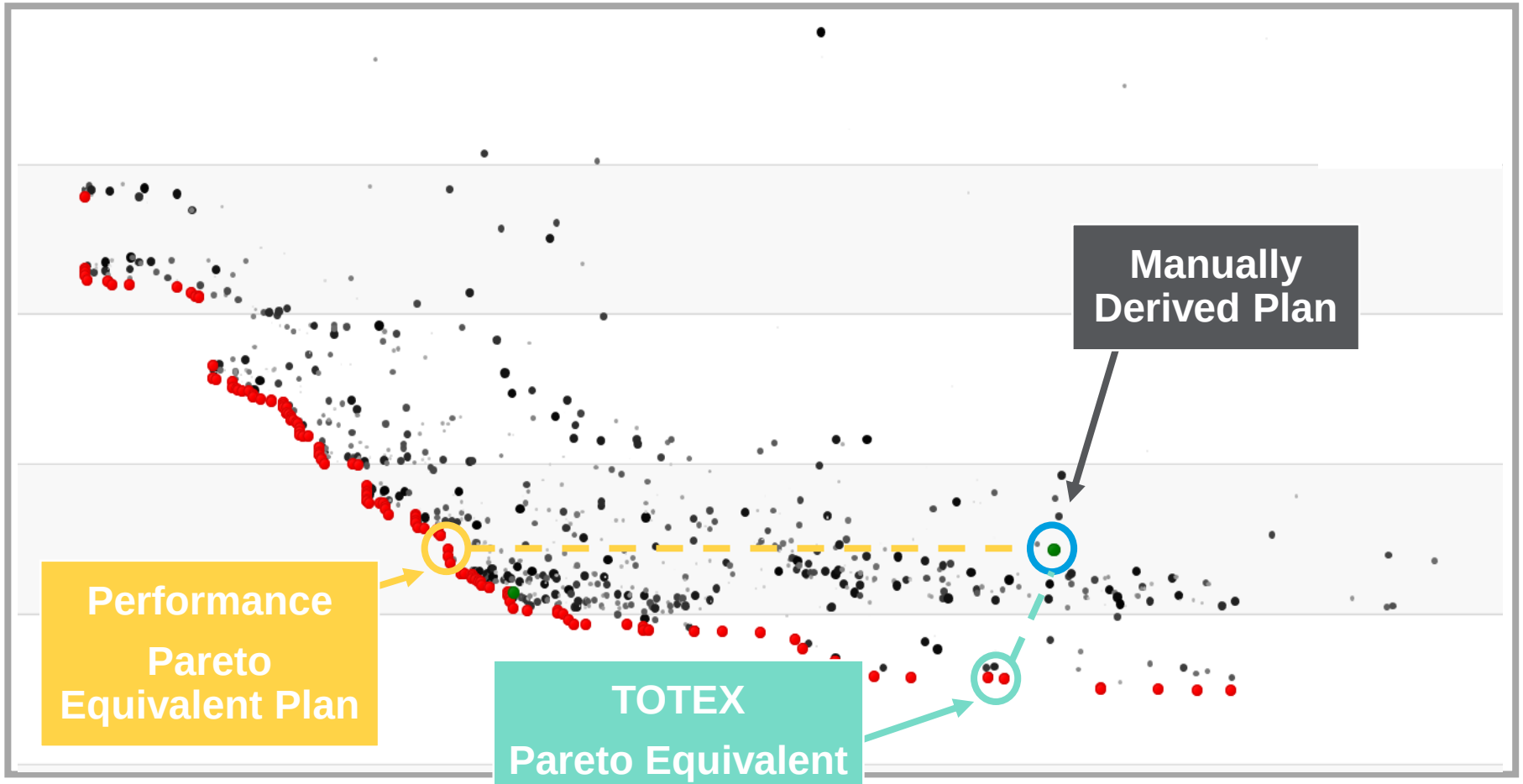
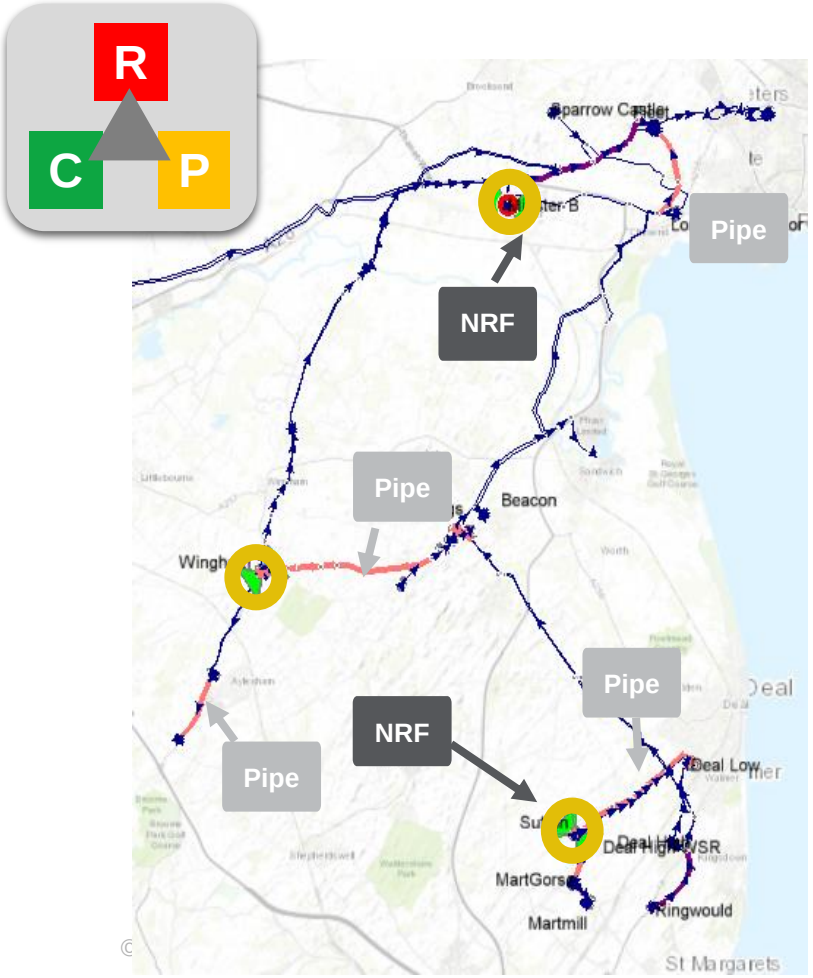


OPTIMIZER OUTPUT – 2 OBJECTIVES

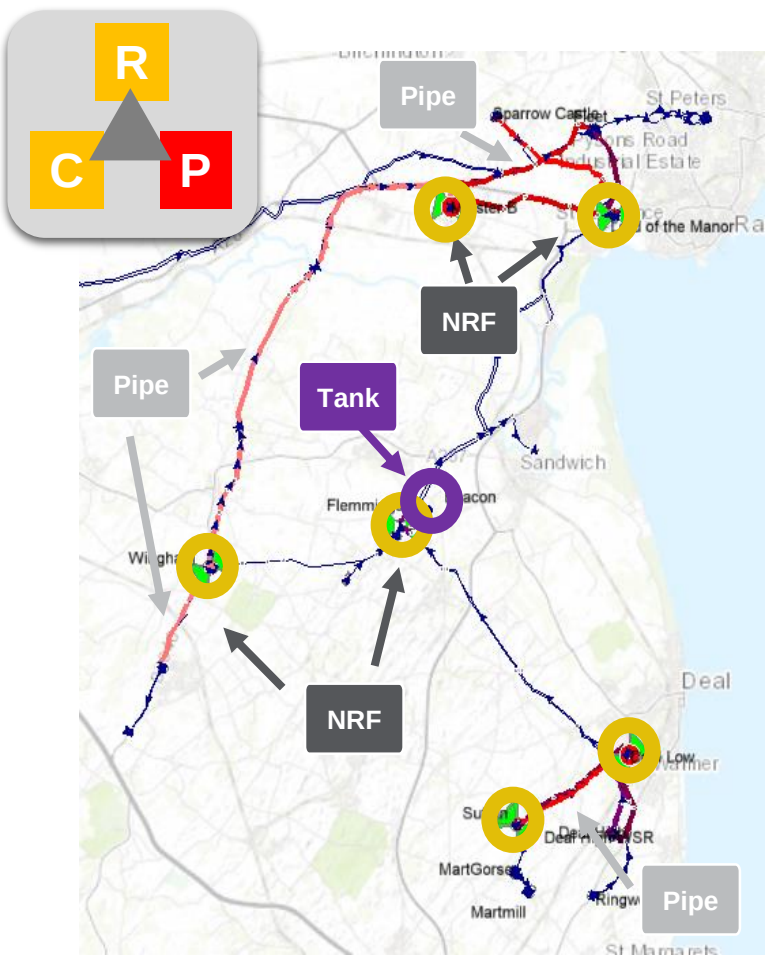


PLAN COMPARISON

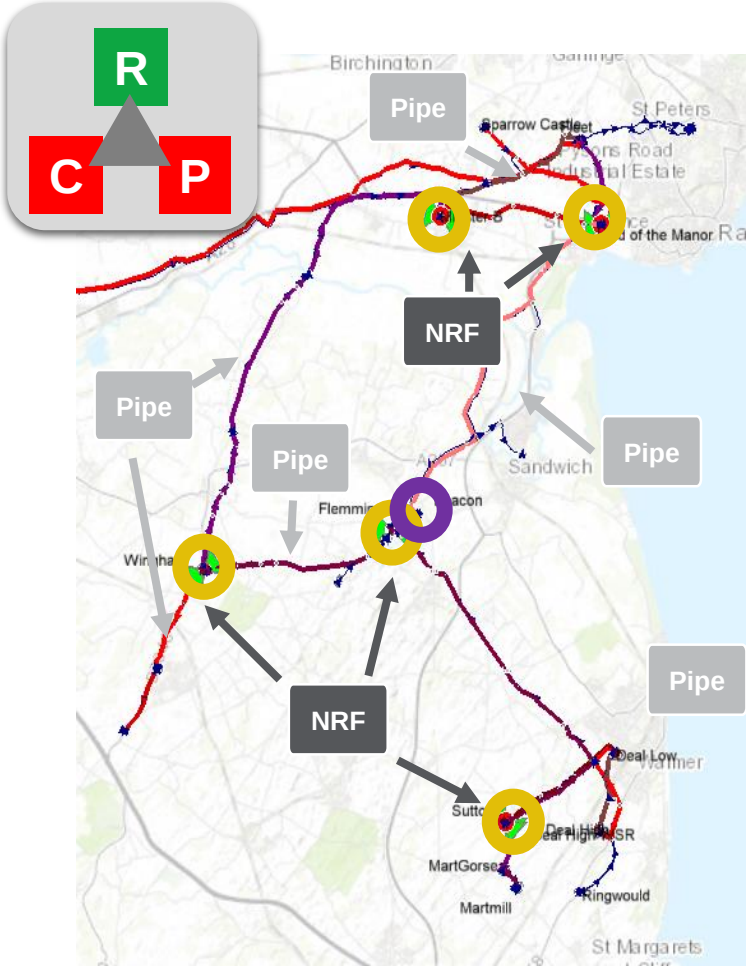
A Lower Resilience Score



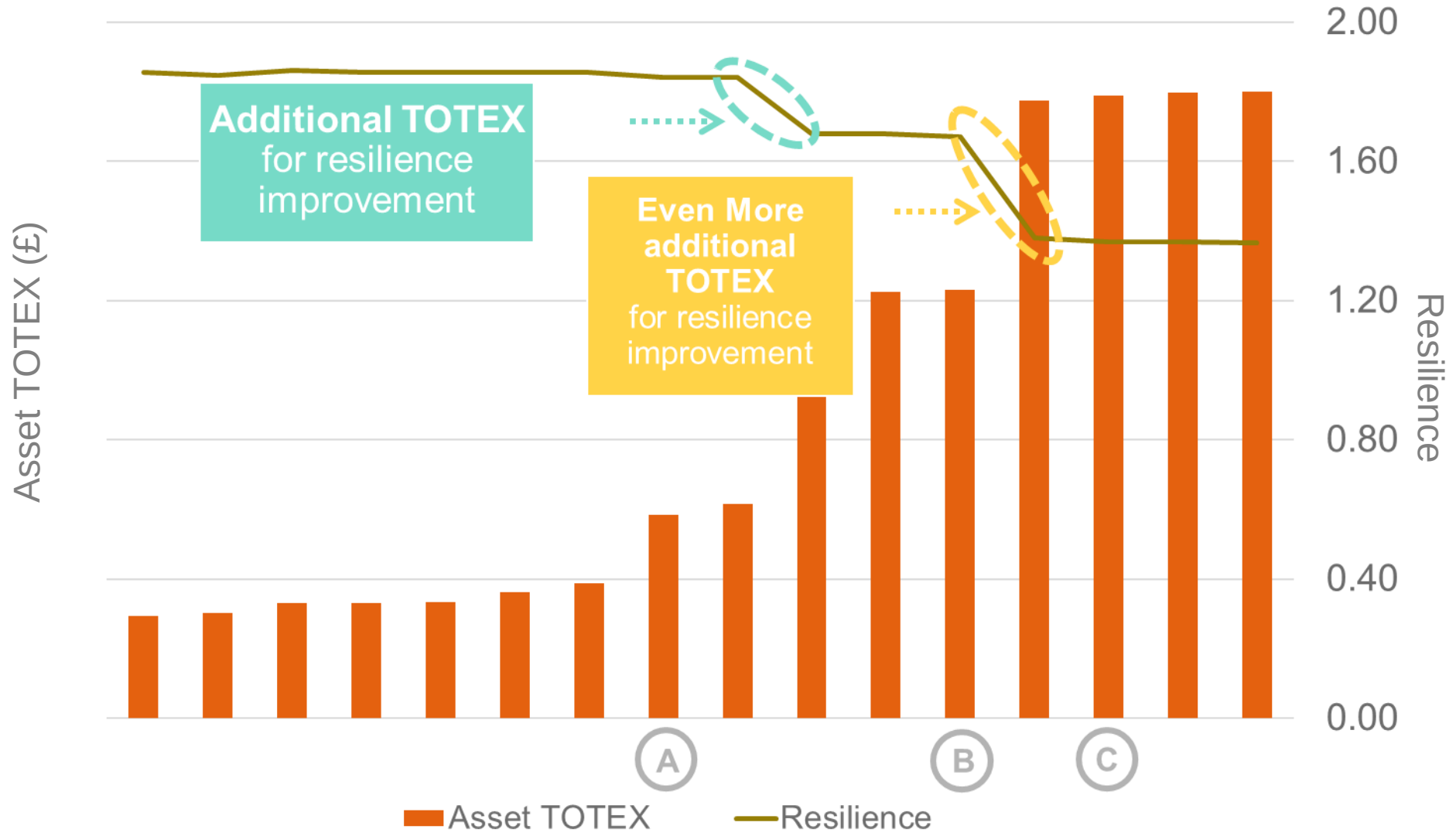
B Moderate Resilience Score



C Higher Resilience Score



COST OF RESILIENCE



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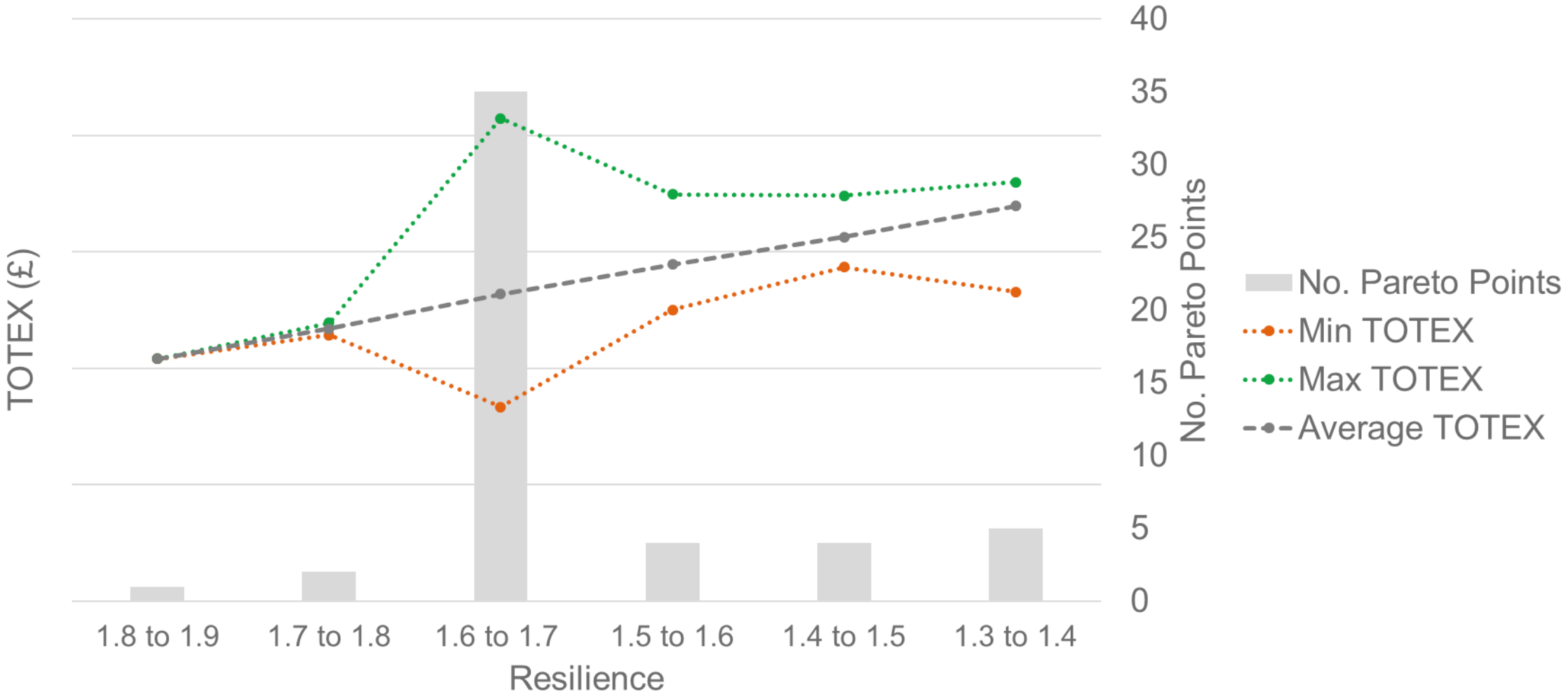


Improving Resilience

WHAT IS THE OPTIMAL LEVEL OF INVESTMENT?

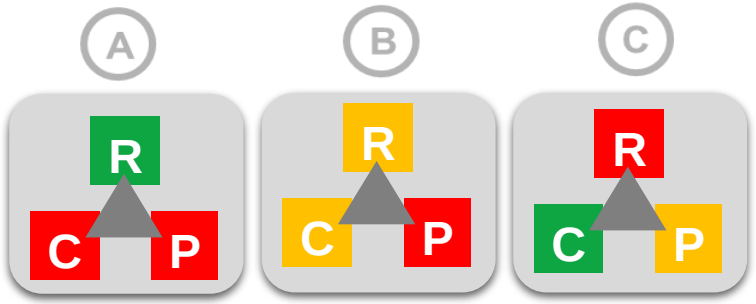
WHAT DOES A BALANCED PLAN LOOKS LIKE?

- Set of plans to be analysed further in detail and understood in the context of the business appetite for risk
- Starting point for further engineering and optioneering

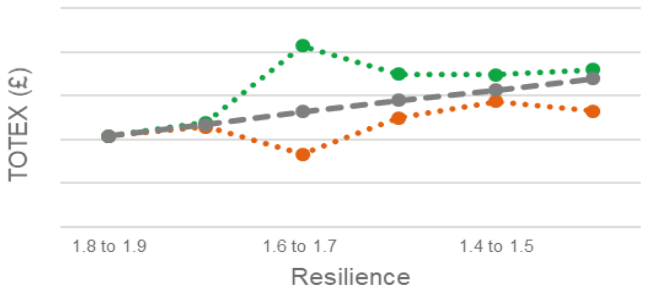
WHAT IS THE SENSITIVITY OF THE PLAN TO CHANGING PARAMETERS?

- Further refinement can be achieved
- The optimal solution may be sensitive to seasonal variations in demand.

WHAT IS THE BUSINESS RISK EXPOSURE FOR A GIVEN PLAN?

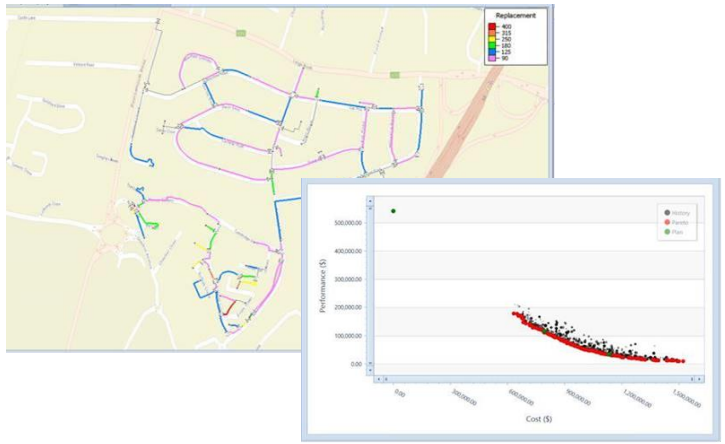


WHAT IS THE COST OF IMPROVING RESILIENCE?



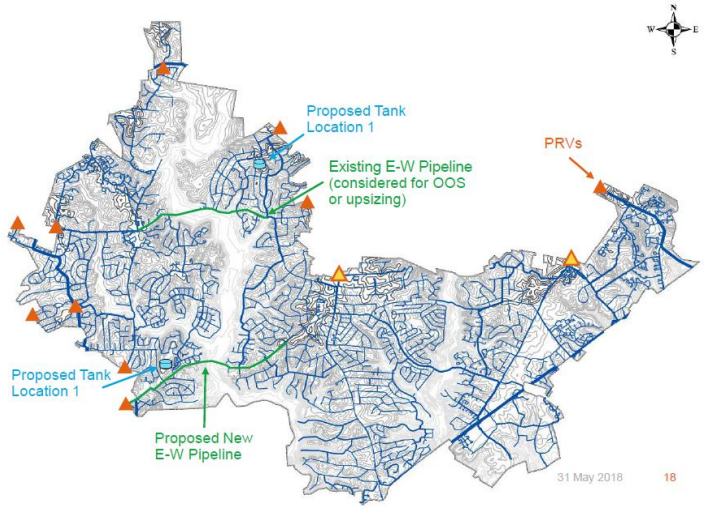
OTHER APPLICATIONS AND SUCCESSES

MAINS REHABILITATION



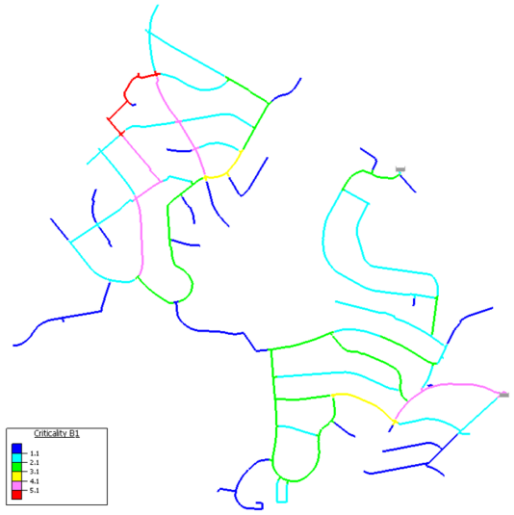
- Smart Asset Planning influenced by risks related to pipe mortality, hydraulic performance and cost simultaneously
- Up to 30% cost reduction could be achieved for the same risk reduction in Totex

PRESSURE MANAGEMENT



- Optimizer selected PRVs that could be abandoned while maintaining levels of service (3 out of 9)
- Minimised maintenance costs
- No new tanks or pipelines required

INTERRUPTIONS TO SUPPLY



- Identifying locations of cross connections to improve redundancy during mains rehabilitation work
- Via system-wide pipe criticality analysis of the water distribution system.

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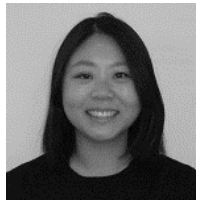

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