BALANCING WATER QUALITY AND INFRASTRUCTURE: A CASE STUDY FOR THE BOTTESFORD BECK

Optimizing CSOs, Tanks and Network Performance

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Image credit: [https://www.bottesford.org/bottesford-beck]

INTRODUCTION

2017

- Background: Catchment Overview and Regulatory Framework
- Creating the right tool
- Options – minimizing construction impact
- Hydraulic Assessment and Challenges
- Water Quality Analysis and Results
- Key Insights and Conclusion

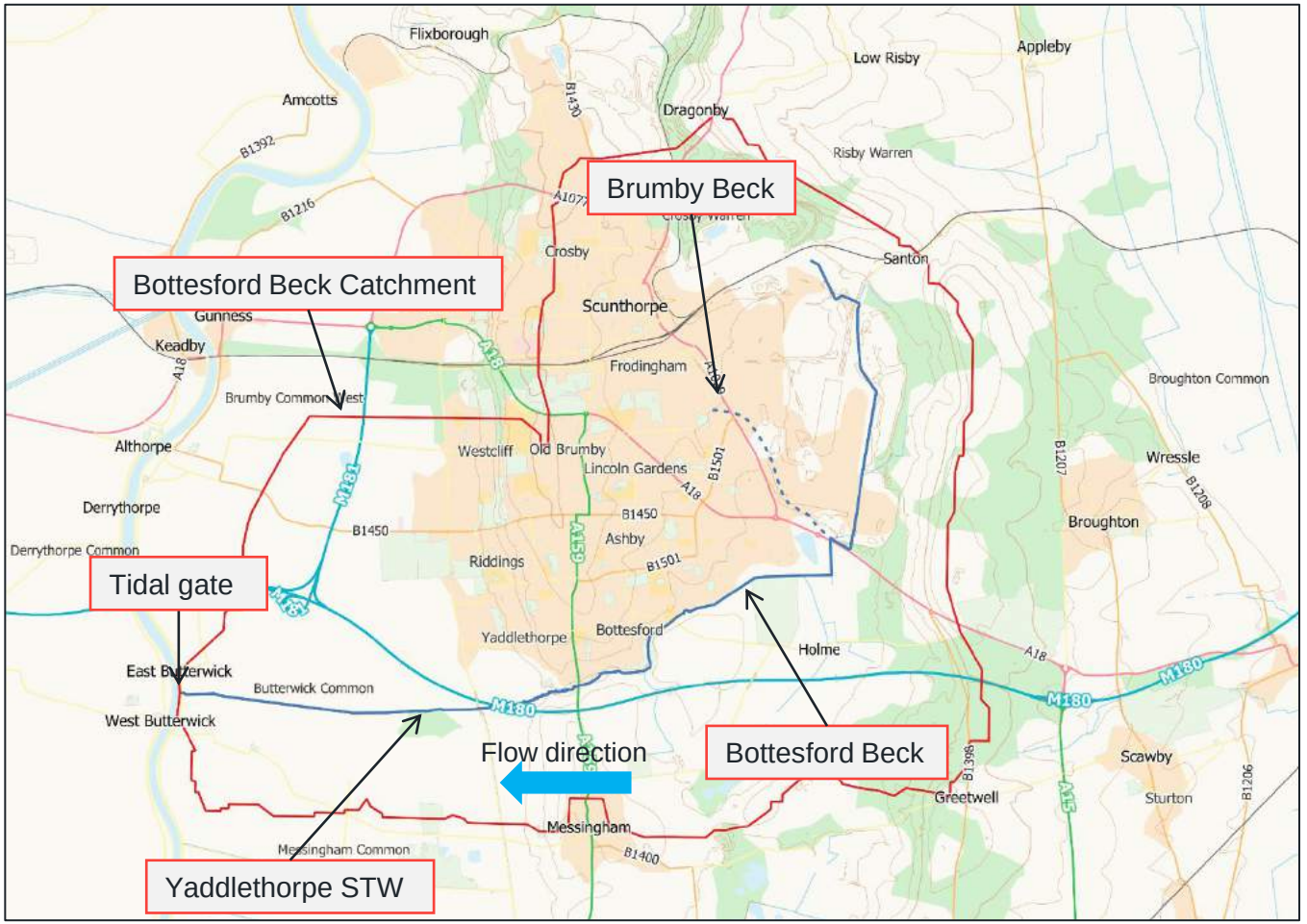
2023

WFD driver project to protect waterbodies from deterioration

BACKGROUND

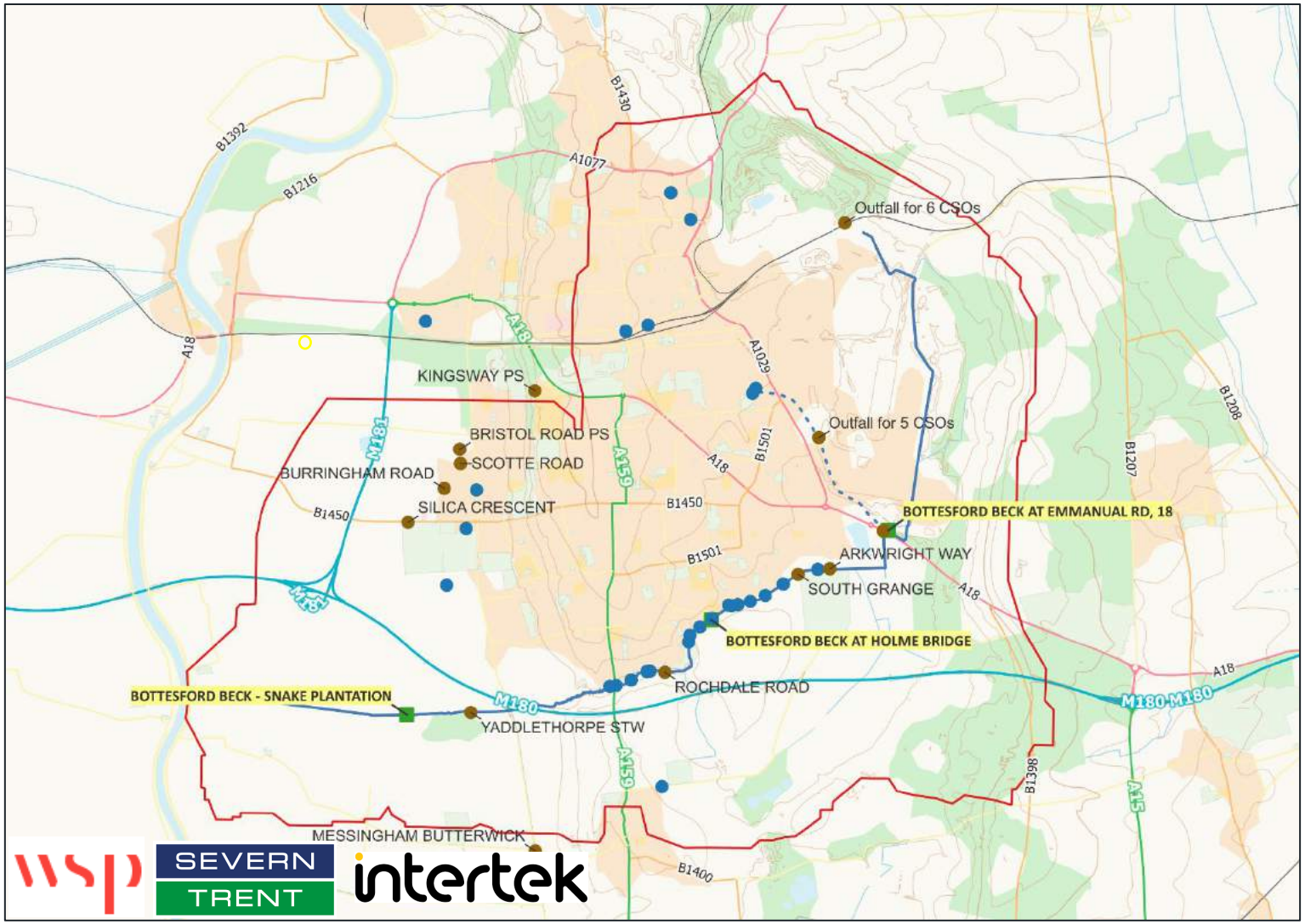
Catchment overview

- 15.7 km reach
- Catchment area (70.2 km²)
- Population – 85,200
- Upstream Network – 60% Combined, 40% Separate



BACKGROUND

Catchment overview



BACKGROUND

Regulatory Framework

Determinand	90%ile	99%ile	Fundamental Intermitent Standards	Annual Average Concentration
BOD	5 mg/l	11 mg/l		
Un-ionised Ammonia (NH_3)	0.6 mg/l	1.5 mg/l	Sustainable Cyprinid fishery	
Dissolved Oxigen (DO)			Sustainable Cyprinid fishery	
Phosphate				0.069 mg/l

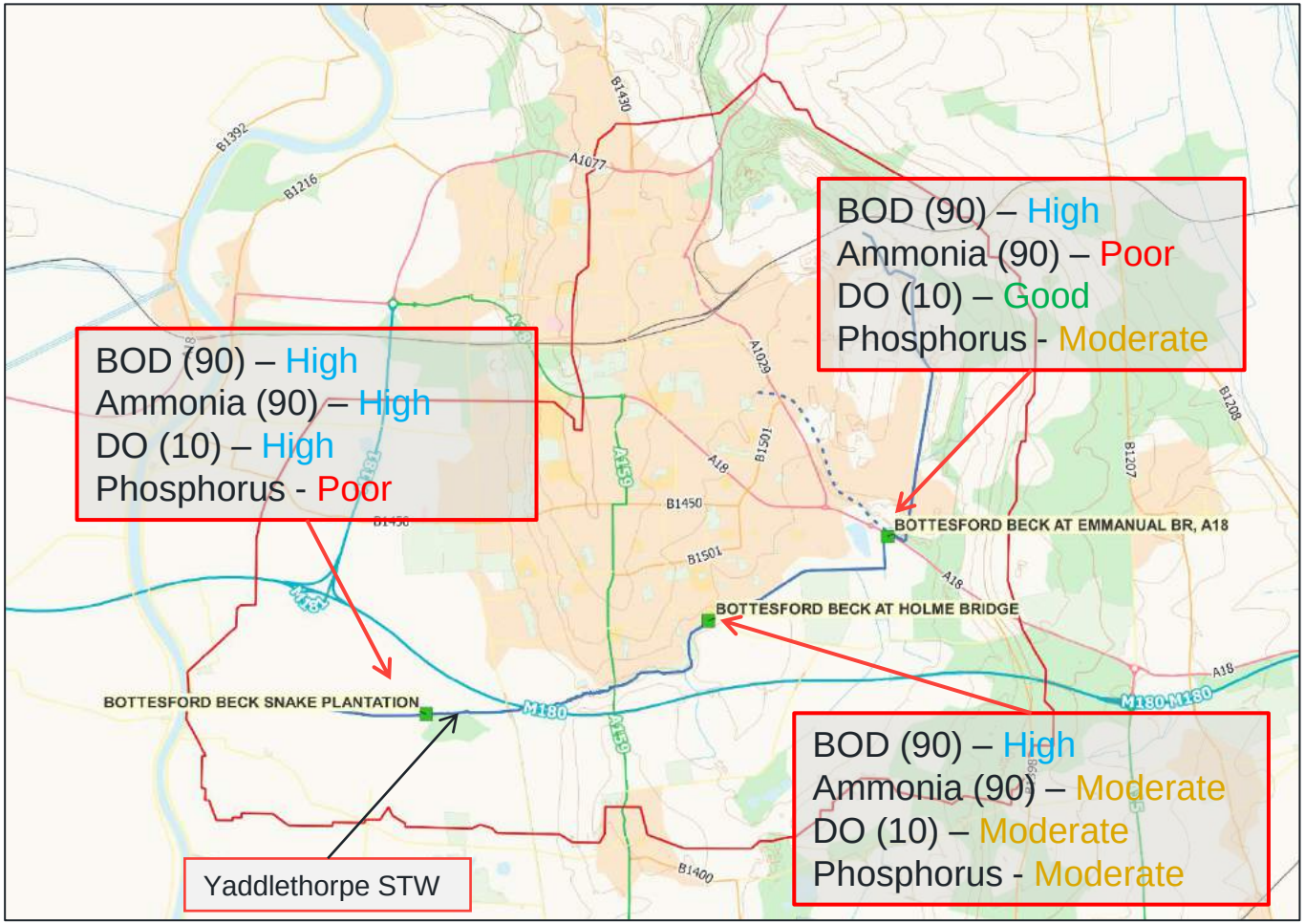
Looking for a Good or High value for each determinand

Bottesford Beck:

- Type 7 river (lowland high alkalinity)
- Sustainable Cyprinid fishery

BACKGROUND

Historical Water Quality Data



Data from samples taken between 2012 and 2017.

BOD was sampled for 1 year in 2 of the 3 sampling locations.

To determine 99%iles, samples are recommended to be taken regularly

Water Quality Model

CREATING THE RIGHT TOOL

Model parameters

$[PO_4]^{3-}$

Yaddlethorpe STW Final Effluent

NH_3

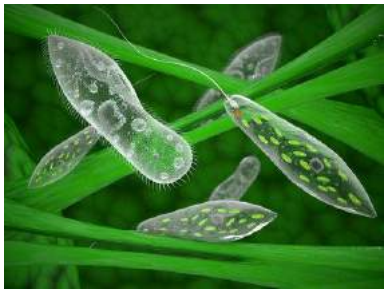
BOD

Surface water runoff

Combined Sewer Overflows

Flow direction

Bottesford Beck

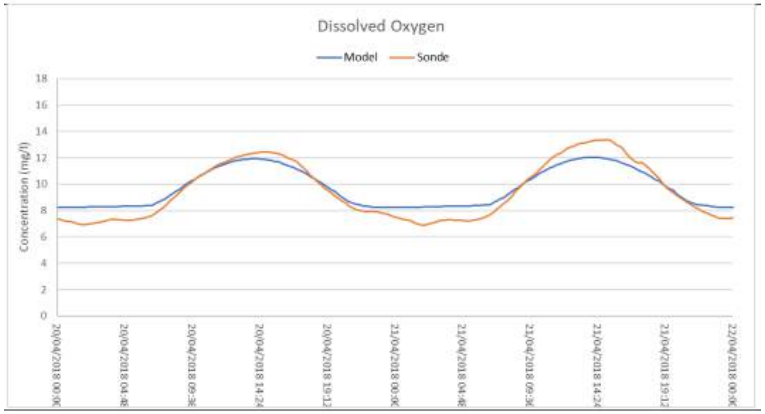


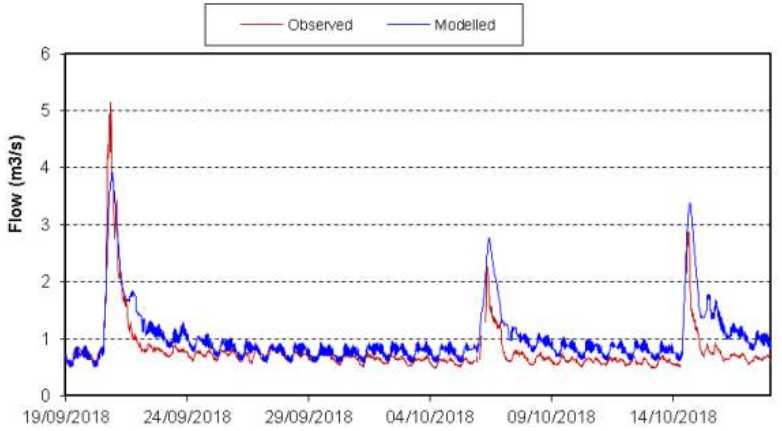
- *BOD Decay rate*
- *Ammonia Decay rate*
- *Nitrification of Ammonia*
- *DO Reaeration rate*
- *Photosynthesis and respiration*
- *Sediment Oxygen Demand*
- *Phosphorus Uptake*

CREATING THE RIGHT TOOL

Model Calibration (2017/2018) – 4 WQ sampling points and gauge stations

Asset type	BOD (mg/l)	NH_3 (mg/l)	SRP (mg/l)	Temperature (°C)	DO (mg/l)	Source
CSO	90 mg/l	6.3 mg/l	1.05	Variable	Variable	Default
Surface Water	8 mg/l	0.2 mg/l	0.0105 mg/l	Variable	Variable	Default
Yaddlethorpe STW	4.17 mg/l	0.27	1.8	Variable	Variable	Measured

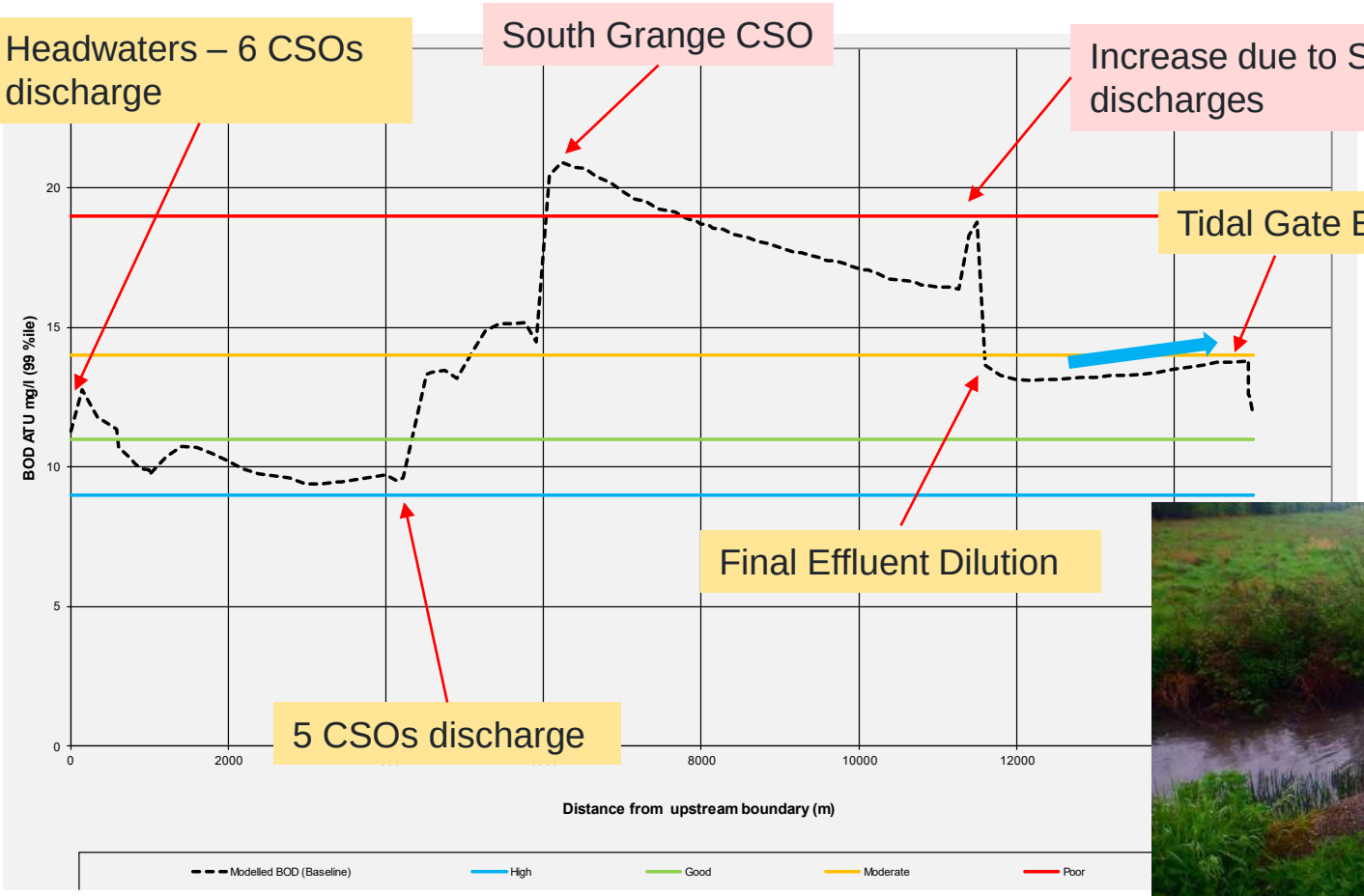




Hydraulic model to be run for 10 years series as a standard

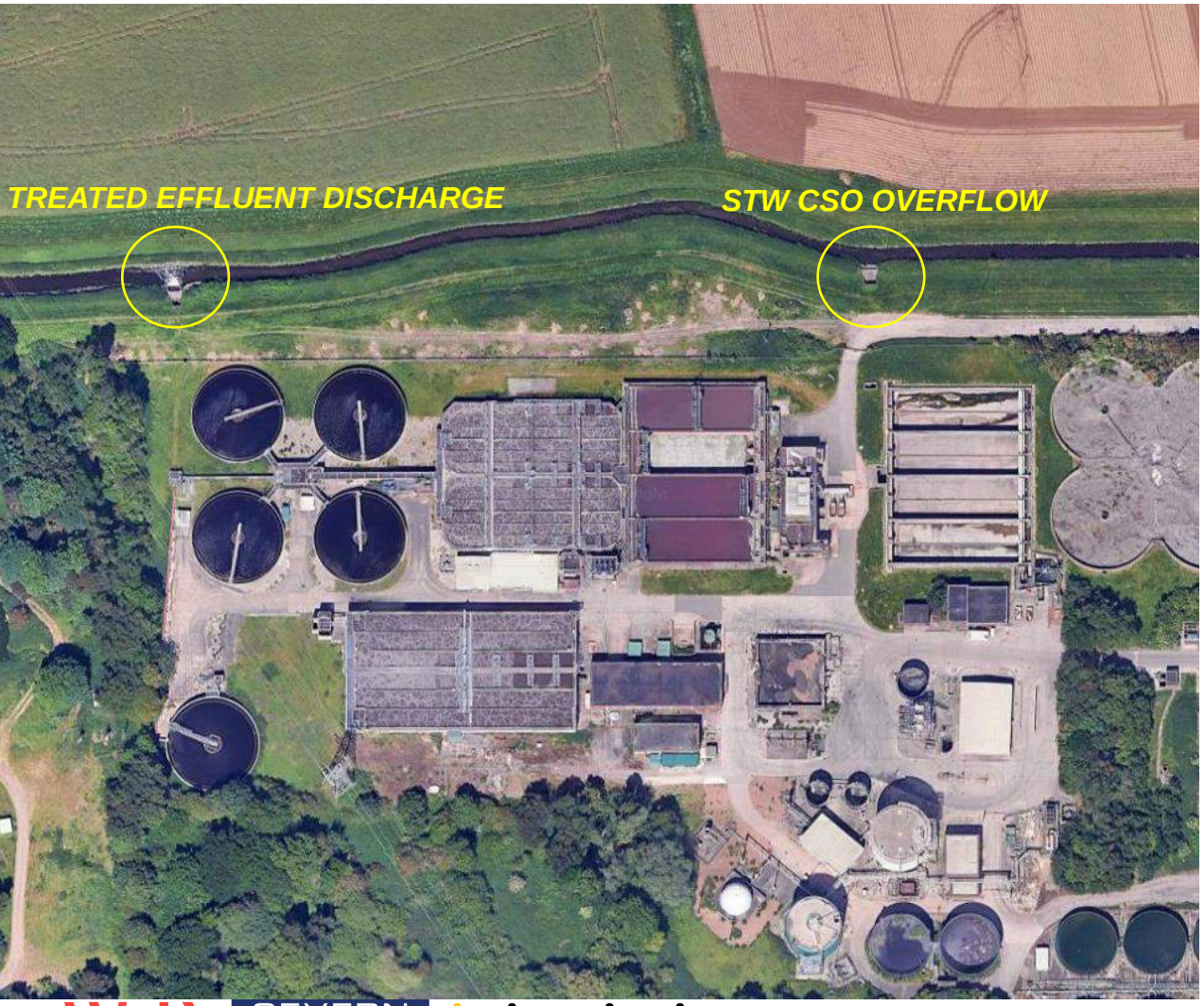
CREATING THE RIGHT TOOL

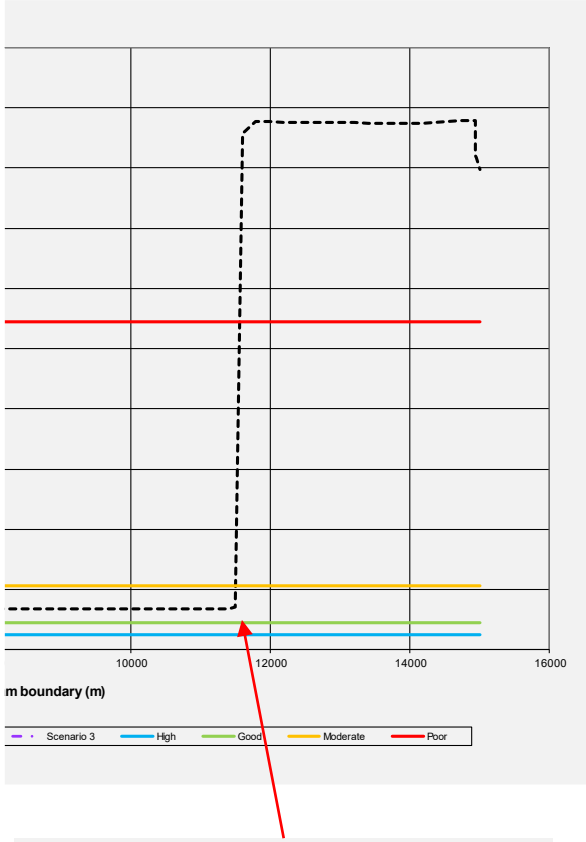
BOD 99%ile hydrograph post re-calibration



South Grange CSO outfall

CREATING THE RIGHT TOOL

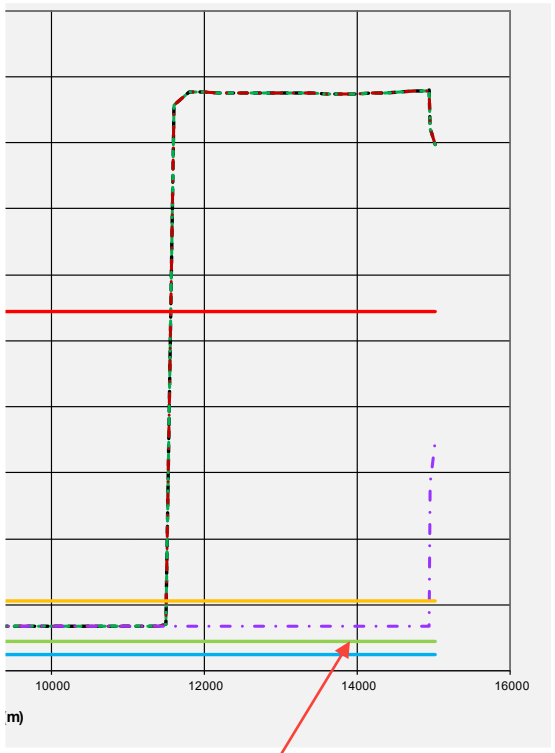




Final Effluent increases SRP

GENERIC OPTIONS

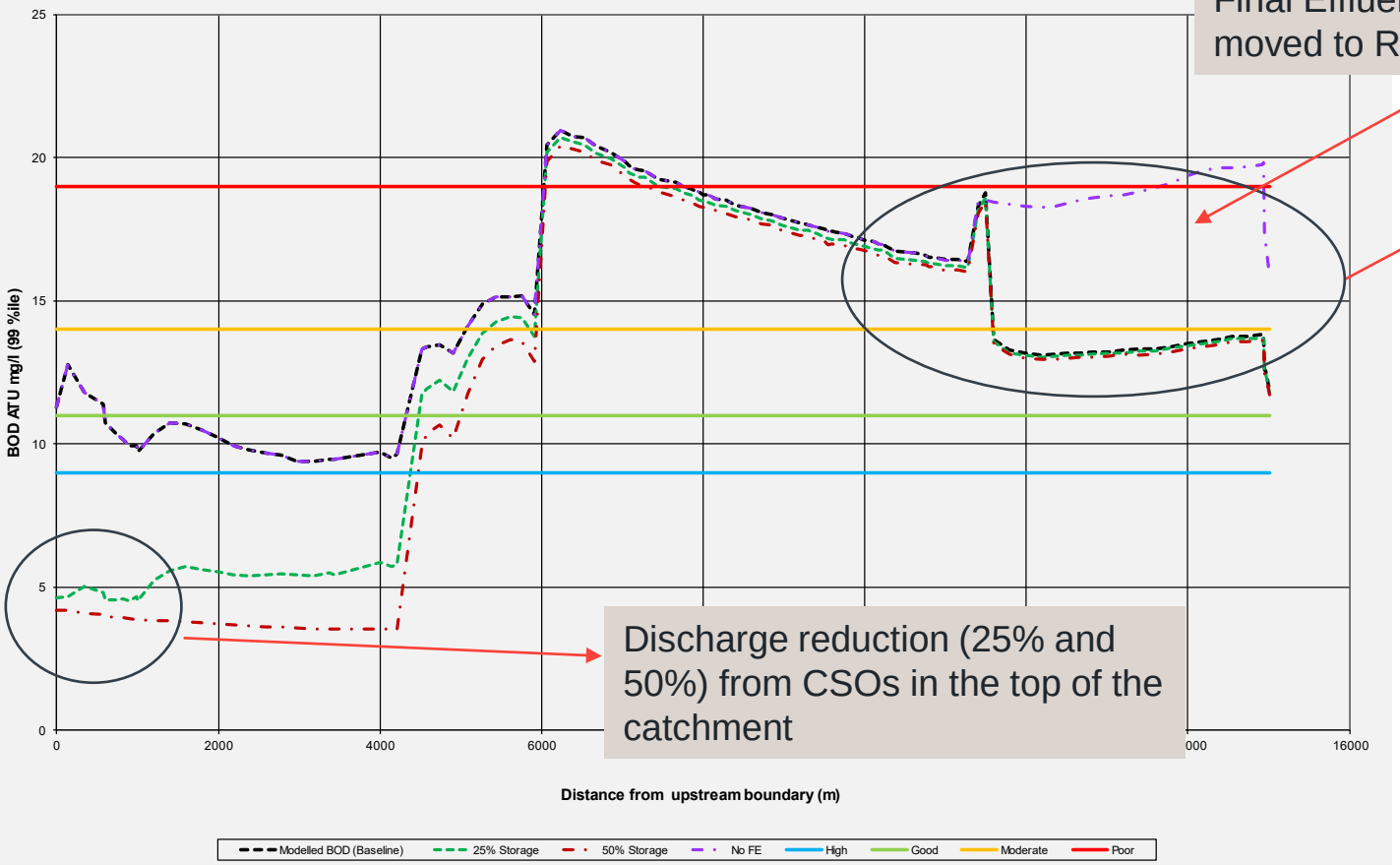
Improvement of SRP – Final Effluent Transfer to the River Trent



Final Effluent Transfer to River Trent

GENERIC OPTIONS

Improvement of UPMs and FIS – Decrease CSO discharges along the Beck



OPTIONS

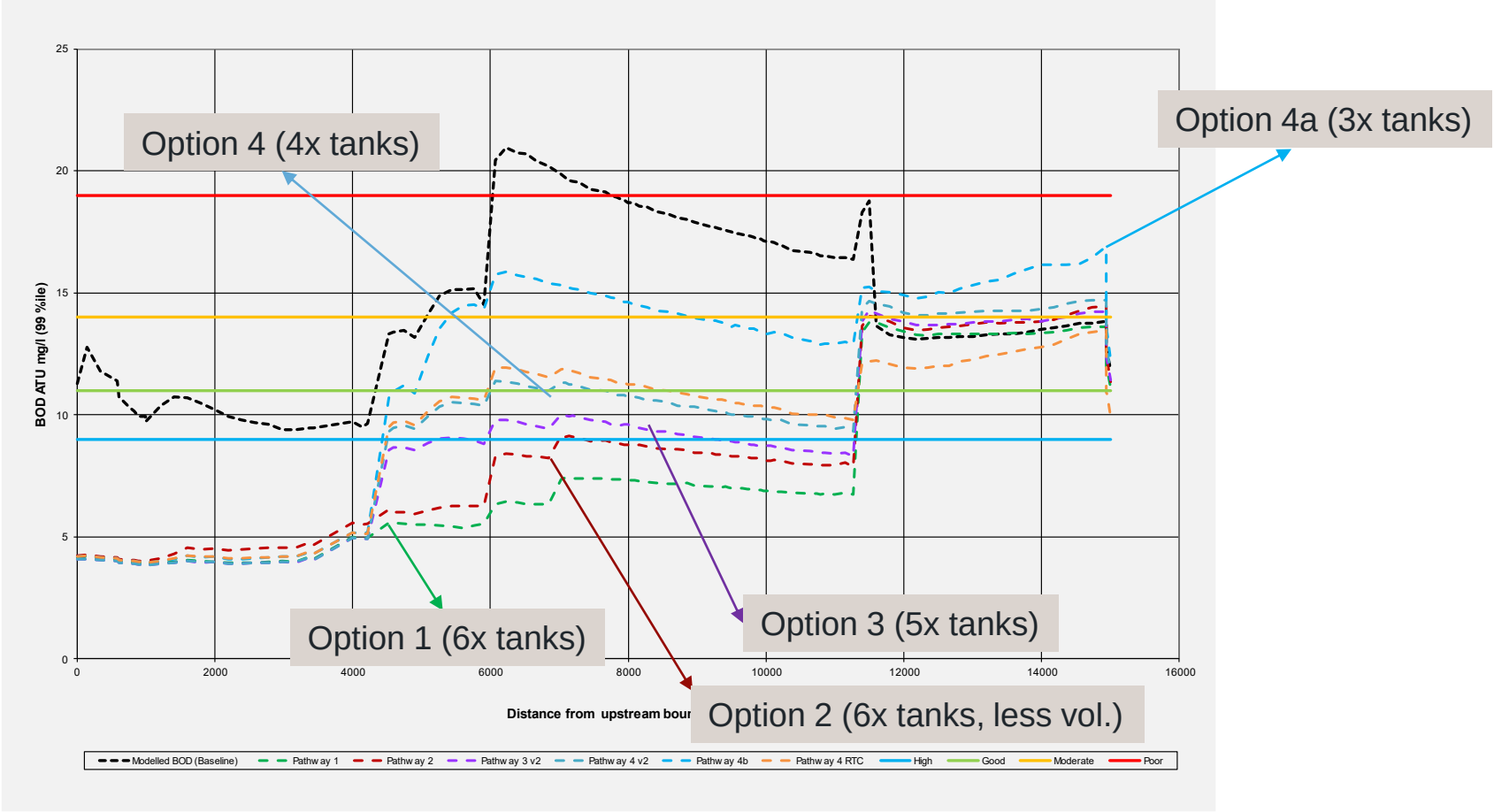
Minimise construction impact and achieve a good WQ status

Asset	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Brigg Rd / Station Rd CSO	1,040	850	1,040	1,040	1,040	1,040	1,040
E. C. Lane & E. C Lane 122 CSO	1,495	600	NS	NS	ANMC	NS	ANMC + SWS
Queensway CSO	1,040	850	1,040	NS	ANMC	1,040	ANMC + SWS
Grange Lane North CSO	3,250	2,600	3,250	3,250	3,250	3,250	3,250
South Grange CSO	3,510	2,750	3,510	3,510	3,510	3,510	3,510
Yaddlethorpe STW	3,120	3,120	3,120	3,120	3,120	5,000	3,120

NS – No solution
ANMC – Active Network Management Control
SWS – Surface Water Separation

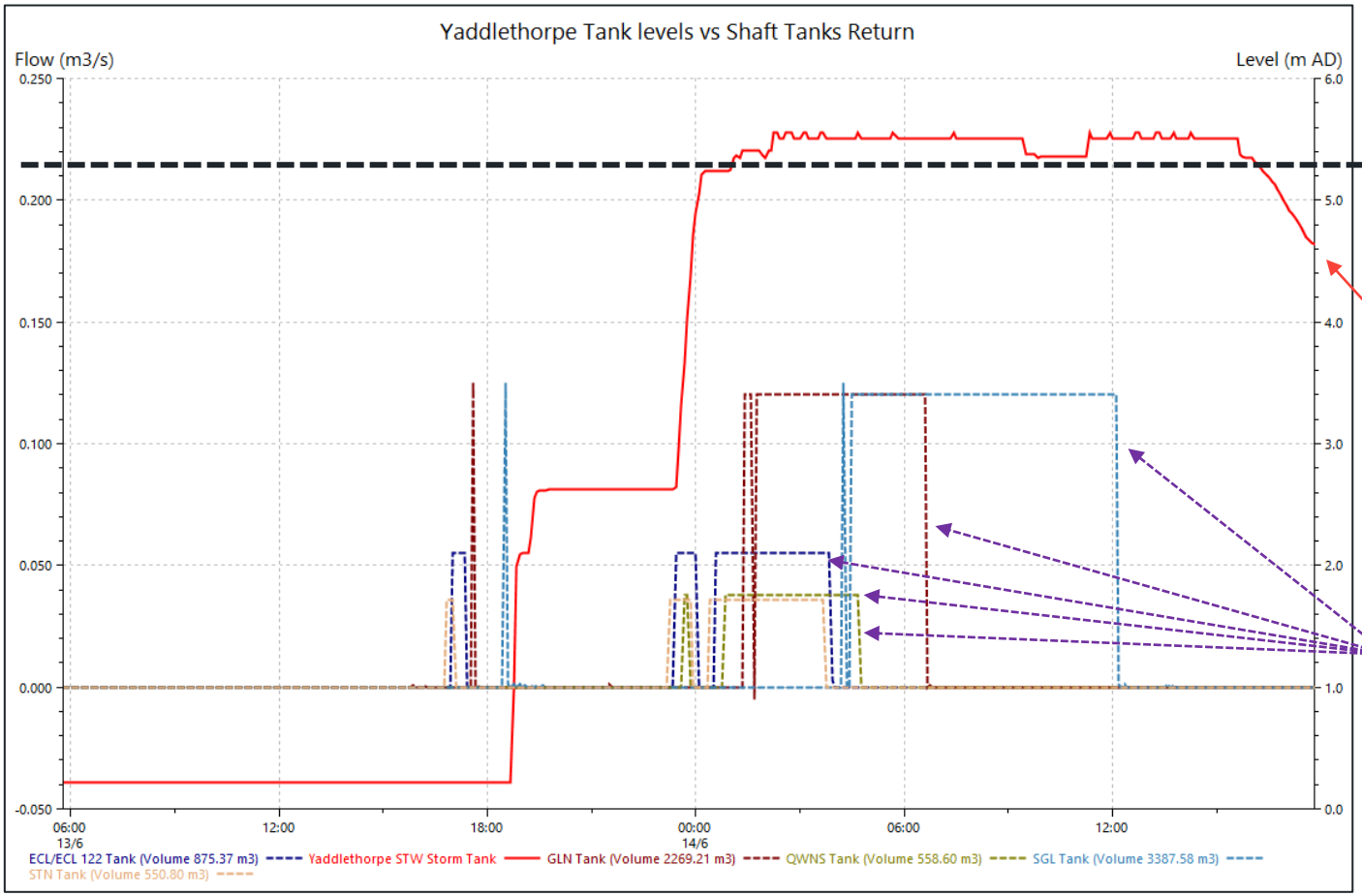
OPTIONS

Tank interactions with Yaddlethorpe STW worsened BOD results



OPTIONS

Shaft tanks' return flows with the STW tanks are still at max. capacity

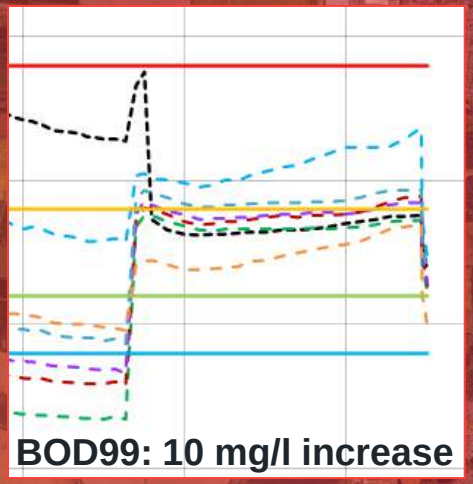


Spill level

STW Tank level

Shaft tanks pump return active when STW storm tanks still spilling

OPTIONS – RTC INHIBITION



BOD99: 10 mg/l increase

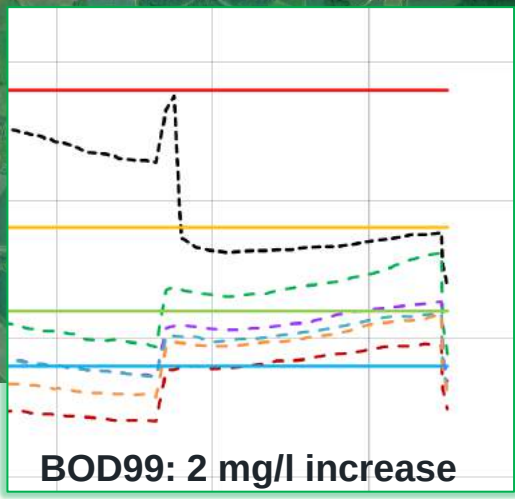
STATION ROAD SHAFT TANK

GRANGE LANE NORTH SHAFT TANK

SOUTH GRANGE SHAFT TANK

YADDLETHORPE SHAFT TANK

Telemetry system to coordinate pumps and STW



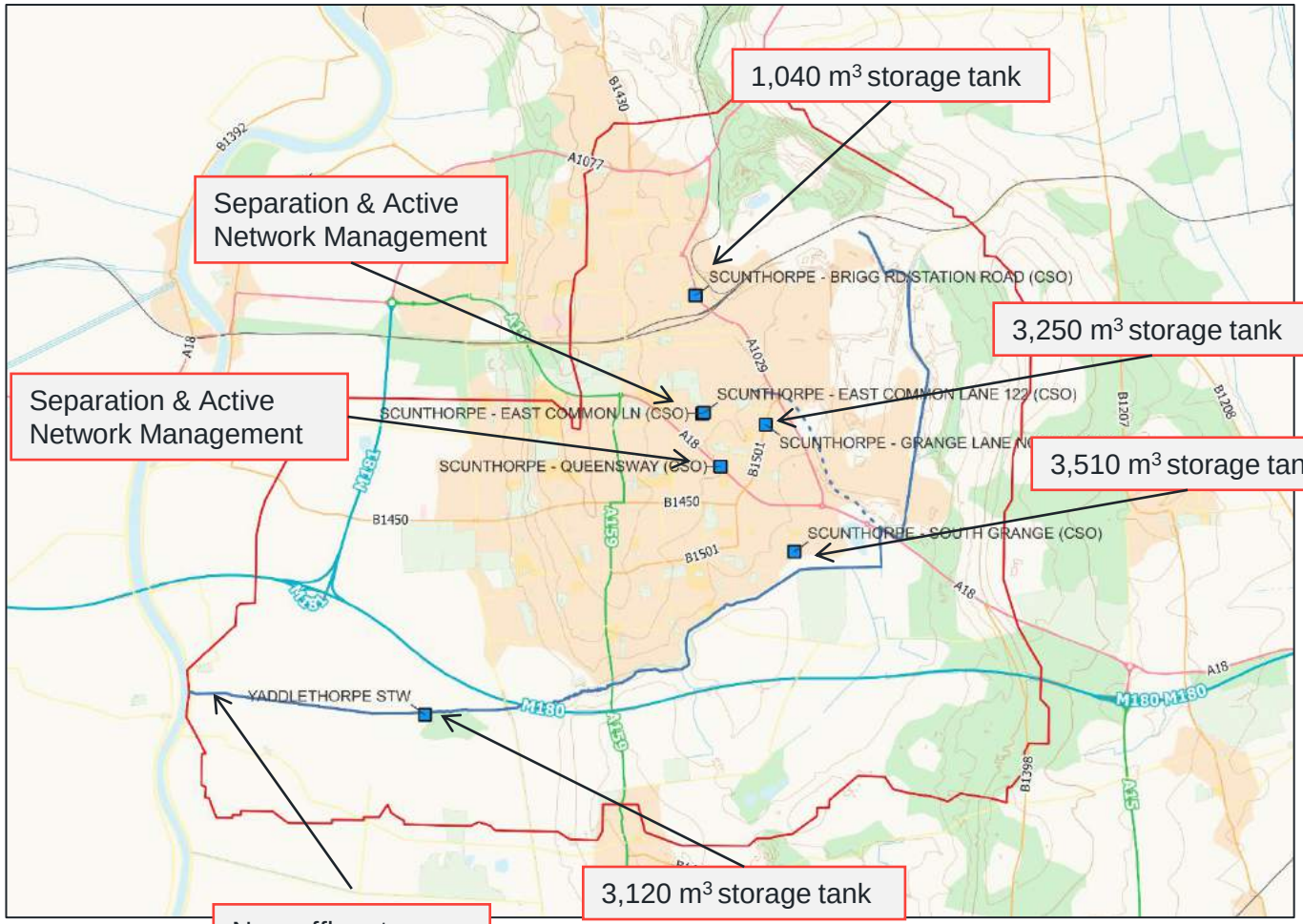
BOD99: 2 mg/l increase

FINAL RESULTS

% Spill Volumetric reduction in 10 years

Asset	Option 1	Option 3	Option 4	Option 5	Option 6	Option 7
Brigg Rd / Station Rd CSO	73%	73%	73%	73%	73%	73%
E. C. Lane & E. C Lane 122 CSO	55%	0%	0%	20%	0%	33%
Queensway CSO	55%	55%	0%	17%	55%	20%
Grange Lane North CSO	52%	52%	52%	55%	52%	55%
South Grange CSO	54%	54%	54%	54%	54%	54%
Yaddlethorpe STW	33%	33%	33%	33%	45%	31%
Achieves Good Status	Yes	No	No	Yes	Yes	Yes

FINAL PREFERRED OPTION



- BOD 99%ile improves to 'Good' WFD status

- BOD 90%ile remains 'High' WFD status

- NH_3 99% improves to 'High' WFD status

- SRP improves to 'Moderate' WFD status

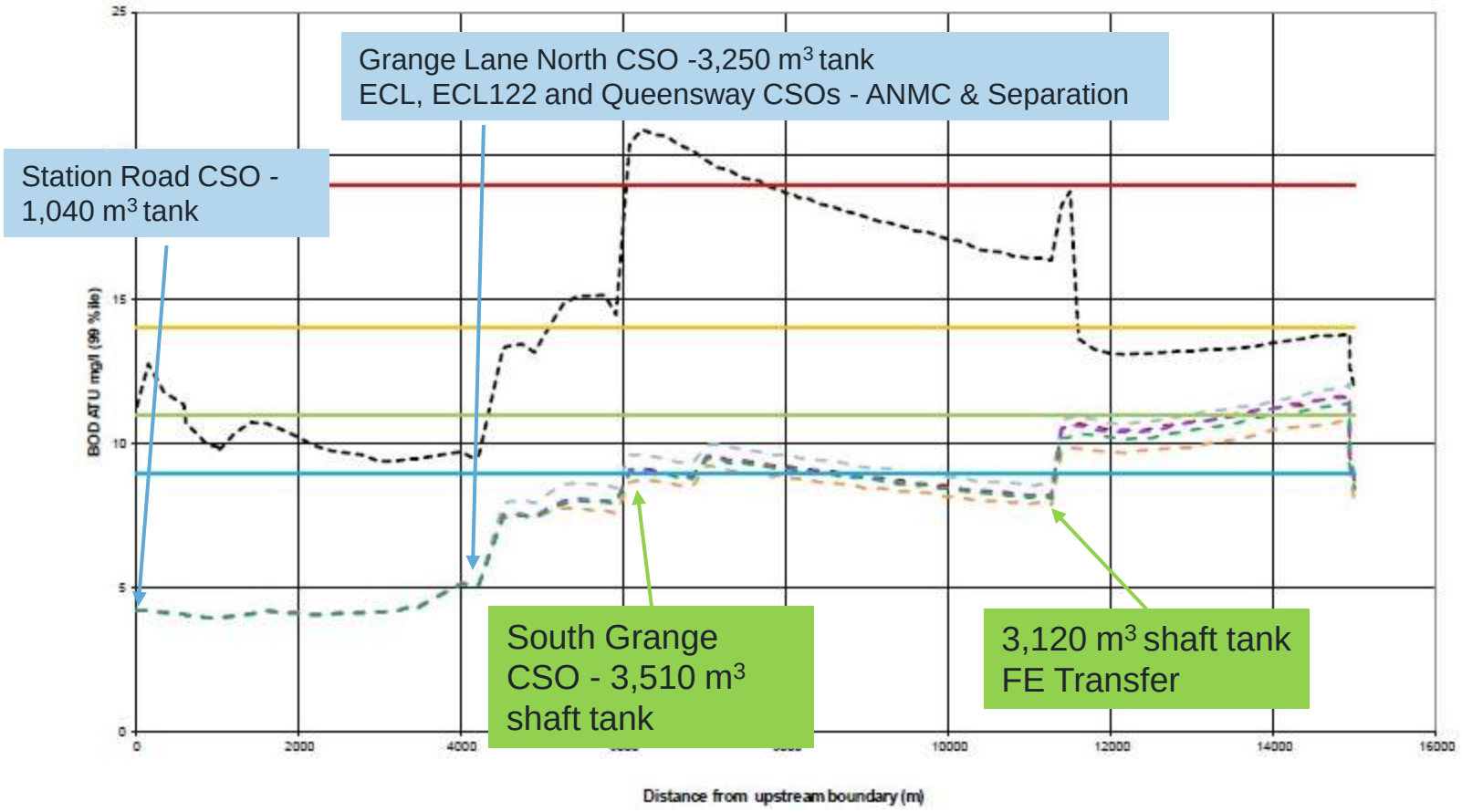
- ANMC to mobilise 16,000 m^3/year

- 1,000 m^3 of SW (1:1 yr) separated (peak of 150 l/s)

ANMC – Active Network Management Control
SW – Surface Water

FINAL PREFERRED OPTION

A mix of shaft tanks, pipes, active network management and separation



KEY INSIGHTS

FE Transfer – Improving SRP	↔	FE Transfer – No dilution for BOD
6x Shaft Tanks – Increased Carbon Footprint	↔	6x Shaft Tanks – Best WQ results
Pump Inhibition System (RTC) – Improves WQ at STW	↔	Pump Inhibition System (RTC) – Higher Retention Times
ANMC – Maximises capacity	↔	ANMC – Little experience
Separation – Delivery constraints	↔	Separation – Sustainable option
CSO spill transfer to Trent – Does not decrease spills	↔	CSO spill transfer to Trent – Best WQ results for the Beck

Finding the right balance

Thank you

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