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A framework for the production of
Drainage and Wastewater Management Plans

Appendix C
Baseline risk and vulnerability assessment; and problem characterisation

Commissioned by Water UK in collaboration with Defra, Welsh Government, Ofwat, Environment Agency, Natural Resources Wales, Consumer Council for Water, ADEPT and Blueprint for Water

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C.1. Introduction

This appendix supplements the information provided within the main framework document for drainage and wastewater management plans (DWMPs). The main document (and appendices) aim to provide water and sewerage companies (hereinafter referred to as 'companies' or variations thereof), operating within England and Wales, with a framework within which DWMPs can be developed. The DWMP framework is also expected to be of relevance to other parts of the UK.

In defining the DWMP framework the following planning areas have been defined:

> Level 3 (L3) tactical planning unit (TPU) – the basic TPU will be the wastewater treatment works (WwTW) and its catchment (or aggregations thereof for small catchments, or discrete sub-catchments for larger WwTW catchments).

> Level 2 (L2) strategic planning areas (SPAs) – an aggregation of L3 units into larger L2 SPAs.

> Level 1 (L1) water company DWMP – planning at L2 and L3 to be brought together within an overarching company level DWMP to provide a strategic, long-term plan for drainage and wastewater resilience and associated investment over the plan period.

For consistency the same terminology as used in the main document will be applied here.

This appendix provides further detailed information on:

> The baseline risk and resilience assessment outlined in the main document in section 4.4; and

> The problem characterisation step outlined in the main document in section 4.5.

C.2. Baseline risk and vulnerability assessment

C.2.1 Introduction

The objectives of the baseline risk and vulnerability assessment (BRAVA) are two-fold:

> To assess the baseline position of system performance:

- For the base year assumed for the DWMP (for the DWMP produced to support PR24 this is assumed to be 2020; companies can select an alternative base year provided this is clearly documented and justified);
- Against planning objectives arising from future changes to the system (to the defined planning horizon).

> To understand wider resilience issues within each catchment that could impact on maintaining compliance with planning objectives.

The baseline position of system performance is reported in this section with the wider resilience in section C.5.

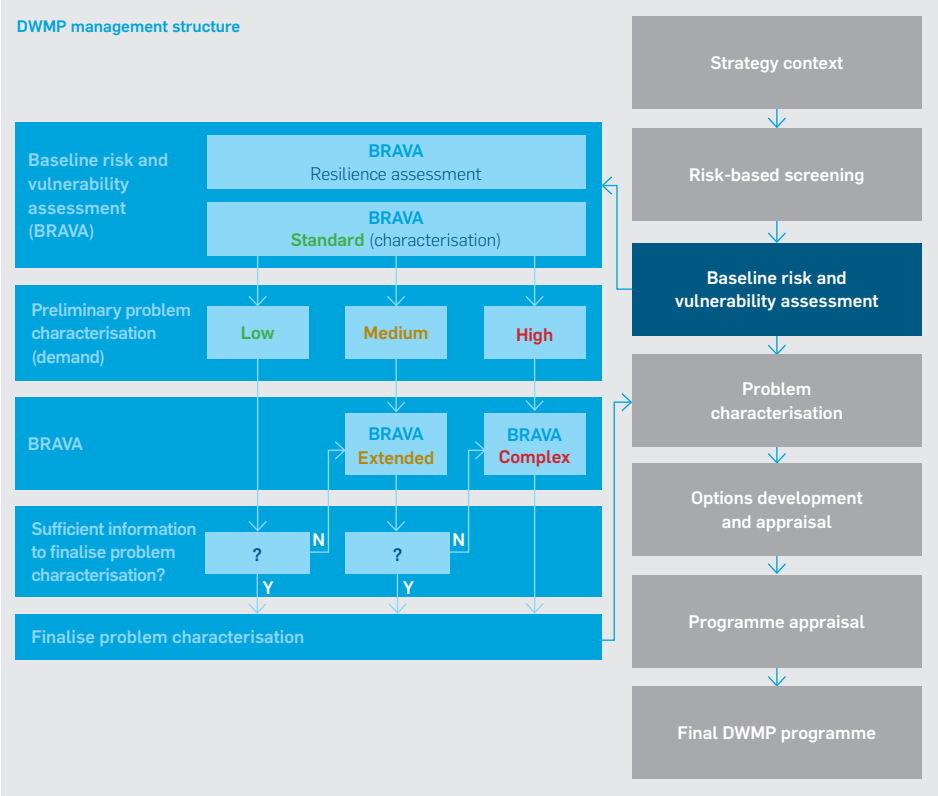

Figure C-1 - Schematic of the BRAVA process

As outlined in section 4.3 of the main framework document, only those L3 catchments that meet one or more of the screening criteria conditions (excluding sewer collapses and blockages) will require baseline risk assessments; however, all L3 catchments will require a wider resilience assessment. The schematic shown in Figure C-1 outlines the overall BRAVA process.

The baseline risk assessment is designed to provide a mechanism that will focus effort as a function of both the complexity of any problems identified and the confidence in the information that is fed into the assessment. The standard, extended and complex approaches are defined as a function of future uncertainty and reflect a step-wise approach that moves through different levels of complexity that are appropriate to the planning unit uncertainties. However, where companies have confidence that a more complex approach will be required, then there is flexibility to move straight to a more complex assessment. Further details on the approaches are provided in section C.2.5.

C.2.2. Application of the BRAVA as a function of risk-based screening issues

Where L3 areas have been captured within the risk-based screening process based on a single issue (e.g. WwTW flow compliance is a risk but there is no evidence that other aspects are a concern), companies will need to take a view on the extent of the wider assessment that is undertaken.

In taking such a view, companies will need to consider:

- The primary issue specific driver (e.g. in the case of dry weather flow compliance this is residential/non-residential growth, asset deterioration (e.g. causing infiltration), or ingress from other drainage systems);
- Whether the assessed primary driver is likely to have had 'capacity' impacts elsewhere in the system but for which there is no current evidence of exceedance in the area being assessed?
  - If no, then it would be pragmatic for the company to focus effort solely on the extent of the problem (and subsequently developing options) associated with the single issue;
  - If yes or there is uncertainty then companies would need to undertake a wider assessment to ensure that what is driving the single-issue risk is not impacting on other elements in the system.

The DWMP is about understanding system risks: while a single-issue concern might suggest that a localised single-issue solution is all that is required, the wider system risk cannot be ignored unless there is evidence to the contrary. Where it is pragmatic for the single-issue risk to be assessed in isolation, companies will still need to undertake a long-term approach in defining the management requirements.

C.2.3. Planning tools

In developing a detailed understanding of system risks it is envisaged that a range of tools will be required:

- WwTWs – it is anticipated that companies will have process models for their WwTWs; the complexity of the models will likely vary from simple, Excel based tools to those that use proprietary modelling software. It is important that the tools available can be used to provide at minimum indicative changes to discharge quality based on changes to flow/load inputs. Regardless of the tools used, a key element of the DWMP will be to communicate the data/evidence that is used, how it has been assessed, and the outcomes of that assessment so that customers and stakeholders gain an appreciation of the robustness of the assessment and the plan.
- Networks (infrastructure and non-infrastructure components) – hydraulic models will be the primary tools required to understand the impacts on the network and its associated components. A key issue is that not all L3 catchments will have models and where models do exist, the quality may vary depending on the purpose for which they were developed in the first place. In addition, not all models will include for wider surface water drainage assets. It is not the intention of the DWMP to develop a cottage industry around modelling.

  However, where a catchment has been captured by the risk screening as requiring a BRAVA, then there is likely to be a driver for development of a model appropriate to that situation, the drivers, risks and uncertainties identified. Companies already apply a risk-based approach to sewer modelling and as part of determining whether this approach is appropriate then it is anticipated that companies will already have undertaken a BRAVA-type assessment (in full or in part).
- Receiving water quality – it is not proposed that all scenarios should be examined using water quality models (e.g. SIMCAT-SAGIS). Indicative risks can be examined using, for example, the Environment Agency's River Quality Planning tool or Excel based mass balance approaches. Alternative approaches have already been devised (by the Environment Agency and others) that utilise outputs from existing SAGIS models which collate the contributions to a waterbody from works discharges upstream of a monitoring point; varying the outputs from the works (as a function of future scenario discharges) can be rapidly assessed based on the changes in contribution at the monitoring point. This process removes the need to re-run water quality models for all scenarios.

C.2.4. Inputs to the assessments

Where companies have accepted procedures for assessing future system impacts these should be used provided they meet the minimum requirements outlined in the following sections.

C.2.4.1. Growth (residential and non-residential)

Companies will already have in place procedures for developing growth forecasts across their operating areas. The following are provided for consideration:

> Companies will need to engage early in the planning process with local planning authorities (LPAs) on their L2 strategic planning groups (SPGs) to identify and ensure 'buy-in' to forecasts to be used for each L3 catchment that requires assessment.

> Companies should allow for a baseline level of infill growth which can be assessed and included based on historical information.

> Companies should make use of the long-term forecasts developed as part of the water resources management plan (WRMP) process to ensure consistency and robustness of both approaches. While these are developed at WRMP or water resource zone (WRZ) level, there are mechanisms that can be used to allocate the growth down to L3 TPUs:

- The capacity assessment framework (CAF)[1] includes a simple uplift approach based on either:
  - The population projection for the WRMP planning period be used to determine the population uplift (or reduction) to be applied to the catchment. Where more than one population projection is provided in the WRMP, the projection deemed "most likely" or whichever has been used for demand forecasting should be used; or
  - Where different population projections are available for each WRZ in the WRMP, these can be used to provide an uplift rather than the average across the whole of the WRMP; and that
  - Whichever approach is used, it should be applied consistently for all drainage systems being assessed.
- An alternative approach would be to use the same analytical approach used for the WRMP to derive population data for each L3 and L2 area, and for the L1 as a whole. GIS tools can be used to overlay growth projections at enumeration district or other levels with L3 and L2 planning areas and in consultation with LPAs agree allocations to specific catchments. The advantage of this approach would be to ensure that, for example, small catchments are not artificially impacted by growth (arising from the use of general uplifts) which is highly unlikely to arise.

> The spatial allocations of growth within the context of the long-term are clearly an issue. Companies can develop their own approaches:

- The uplift approach described above is useful in understanding high level risks; however, it is anticipated that where problem characterisation is more complex, companies will need to develop spatially coherent projections, using demographic modelling to reflect potential changes at L3 and more refined planning resolutions for drainage and wastewater. Such approaches have been developed within the context of the WRMPs; following a similar process for L3 catchments would, in the longer term, provide a greater degree of confidence in the projections. This will be especially important where long-term growth is impacting on system performance.
- In consultation with LPAs, agree potential uplifts to residential populations on a catchment by catchment basis reflecting agreed planning and socioeconomic scenarios.

> Changes in non-residential inputs should consider:

- Econometric forecasts of growth by sector in their area over the longer term;
- Proposed developments (and redevelopment where sectors are in decline) as identified in Local Development Plans (LDPs);
- Potential for development of high non-consumptive water use industries and/or switching from trade to self-treatment and discharge;
- In consultation with LPAs agree potential uplifts to non-residential populations on a catchment by catchment basis. Planning policies will likely limit growth in commercial inputs to specific areas and LPAs will be best placed to advise.

Whatever approaches are followed by companies, it is important that procedures are described in the DWMP and applied consistently across all L3 TPUs, aligned with LPA planning processes and robust to scrutiny by stakeholders. Where alternative approaches are developed within specific L3 or L2 areas, these should be in consultation with relevant L2 stakeholders.

[1] https://www.water.org.uk/policy-topics/managing-sewage-and-drainage/drainage-and-wastewater-management-plans/

C.2.4.2. Urban creep, infiltration, per capita consumption changes and climate change

It is recommended that, as a minimum, companies follow procedures as outlined in the CAF for the future scenarios; these are summarised as:

- Urban creep - should be applied based on the method that uses property density described in the UKWIR report 'Impact of Urban Creep on Sewerage Systems' (2010)[2], unless there is an alternative method specified within company's own procedures. For the 25-year planning horizon, sensitivity testing at ±30% of the estimated urban creep should be evaluated. Companies can apply similar sensitivity testing for other planning horizons if this is likely to be significant.
- Infiltration – companies should follow their own existing procedures for assessing future system integrity and infiltration allowances.
- Per capita consumption (PCC) – it is recommended that these are determined based on the future average household PCC used in the latest available WRMP that covers the catchment being assessed.
- Climate change – companies should follow their own existing procedures and be consistent with those applied to the WRMP, modified as required should there be any national changes; as a minimum, companies should apply the procedures as outlined in the CAF:
  - Design storms - an uplift of 20% to all design storms (i.e. a 1.2 multiplier should be applied across the full rainfall hyetograph) for assessing the 25-year time horizon. No distinction is made between return periods or between summer and winter design storms. This is based on the high emissions P50 projection for 2100, scaled down to 2050. Sensitivity testing should be carried out by applying ±30% to the 20% climate change uplift for future design storms. This equates to a lower estimate of 14% uplift and an upper estimate of 26% uplift. No climate change uplift should be applied to design storms for assessing the 10-year time horizon.
  - Time series rainfall - future time series rainfall based on a processed uplift frequency curve developed for the region. It is likely that only one regional curve will be needed for the future epoch (i.e. 25 years for the framework) per company operating area, but this might be increased to three or four where analysis indicates that there are significant regional differences in projections for future rainfall.
    - The future climate should be based on a P50 analysis for the 2080s high emissions scenario and interpolation carried out for 2050s based on a linear trend from present day set at 1990 and 2100.
    - The methodology for modifying the time series events should be applied separately to the four seasons, as the effect of climate change is very different across the seasons. If this is not done, the results will incorrectly represent the effects of the expected changes in the future climate.
    - To carry out sensitivity testing of the assessment of storm overflow spills, it is recommended that the same approach as described above is used to generate two additional future time series based on the P75 high emissions scenario and the P50 medium emissions scenario. It is not appropriate to apply a simple multiplication factor, as used for design storms.

The approaches outlined here provide a high levels assessment. Where areas are considered vulnerable and have extended/complex status, companies may want to draw on the climate impacts approaches developed for their WRMPs, using stochastic data and/or climate scenario data to assess climate risks in more detail. This would be essential where the risk and vulnerability assessment shows distinct changes that will be affected further by climate change. The potential for developing company/catchment specific stochastic rainfall events, supported by national 'libraries' of data, should be considered.

C.2.4.3. WwTW discharges and receiving water quality

Companies should apply their standard practices to assessing the additional loads arising from changes in populations and consider impacts of flow changes from modelled scenario outputs. In understanding the impacts of system changes, companies will need to consider:

- Impacts on existing permit conditions;
- Long term planning objectives as outlined in river basin management plans;
- Existing status of receiving waterbodies;
- The presence of SSSIs and SACs downstream of any discharges and potential impacts on quality that could affect their viability;
- For coastal discharges, the impact of changes in discharge quality on the status of bathing and shellfish waters.

[2] UKWIR Report Ref No. 10/WM/07/14, 2010, Impact of Urban Creep on Sewerage Systems

C.2.5. Undertaking the BRAVA process

As outlined in Figure C-1, the step wise approach to the BRAVA process focuses effort as a function of input uncertainties and system complexity. The following sections describe the requirements of the standard, extended and complex approaches. It is acknowledged that companies will already have developed their own approaches; as such, the following should be considered as minimum requirements and that companies have the flexibility to utilise their own processes provided the general principles are followed and that a consistent approach is applied across all planning areas and that they are appropriate to the risks identified.

C.2.5.1. Base year

The first element is to establish system understanding in the base year for the planning period. This will be determined by the timescale agreed for DWMP delivery and will typically be the last full year of reported performance data prior to the plan process. The base year should reflect existing demand (load/flows) from populations (resident/transient) in the catchment and reflect known issues associated with infiltration and groundwater risks. In understanding the flow elements, it is anticipated that companies would run, as a minimum, the storm events and time series rainfall as outlined in the CAF 'present day' scenario through available models. The outputs (flow/load) should be used to confirm the performance of the WwTW.

It is anticipated that the outputs will define:

- Current performance against all relevant planning objectives;
- Where there are system constraints and/or available capacity;
- Appropriate thresholds against which future pressures could be rapidly assessed e.g. in the case of WwTWs this could be available process/permit capacity which could be translated to a population that could be accepted. Thresholds are a useful tool to provide a rapid indication as to whether future pressures are likely to be a significant factor in impacting system performance.

As indicated previously, where no hydraulic models are available companies will need to consider the need for such developments and the level of complexity that should be applied. Where it can be justified based on the understanding of risk in the planning area, high level assessments in the absence of, for example, hydraulic models can be an acceptable approach subject to endorsement by L2 SPG stakeholders.

Generally, the smaller the catchment (in terms of population equivalence), the lower the likelihood of availability of a hydraulic model. For small catchments, in the absence of a hydraulic model, a high-level assessment could entail assessing sewer capacities in relation to the design flows for the number of dwelling connected, taking into account the system type present (combined, partially combined or separate). This could then be reviewed in light of any observations from operatives and recorded incident/asset performance data.

C.2.5.2. Future pressures

The key step in the BRAVA process is developing the understanding of how changes in system inputs in the future might impact on system performance against relevant planning objectives. The DWMP should be an integrated plan across the planning horizon that shows the direction that the company is taking; however, it may be useful in aligning the overall strategic plan to the business planning process to consider changes/impacts that occur:

- Within a 5-year horizon – the 5-year horizon provides a focus for prioritising investment in the near term where there are greater levels of confidence around all potential factors affecting the plan.
- Within a 10-year horizon – the 10-year horizon has the advantage of lower levels of uncertainty over growth, climate change and other related regulatory factors. The horizon also provides an opportunity to balance investment needs over two AMP periods which could help in addressing affordability issues but also, where complex interventions may be required, enables investment to spread across longer project implementation timescales.
- Within a 25-year horizon – this represents the minimum 'long-term' horizon. Through understanding potential impacts in the long-term the aim is to drive appropriate 'least regret' and best value investment that encompasses a range of approaches to future uncertainty.
- A longer-term horizon may also be appropriate where longer-term drivers of change are evident but uncertain, and the planning problem that results is complex and potentially significant. This may drive more extensive investment in an adaptive planning approach.

A three-tiered approach that varies in complexity has been developed to focus effort; however, as already outlined, companies can adopt their own existing practices subject to the minimum requirements outlined in the following sections.

Standard BRAVA

The standard BRAVA is designed to provide an understanding of the primary drivers behind potential exceedance in the L3 TPU. The standard BRAVA involves:

> Examining future scenarios based on the planning horizons within and up to the 25-year planning period (and beyond, if a longer planning period has been deemed appropriate), As a minimum, the future scenarios should be based on the CAF 'future' requirements and, where appropriate, the wastewater resilience metric, but initially only using a **central estimate** for growth projections; however, companies can go further if this is standard practice. The outputs from the future scenarios as applied to the networks should subsequently be tested within the context of WwTW performance and the impacts on discharges and receiving water quality.

> An assessment of the outputs against the defined planning objectives.

> An evaluation of the outputs to determine the nature of any problems identified (severity/consequence, timing) and the primary drivers. Growth is likely to be a key factor in the level of certainty associated with the outputs. At this stage it is considered that companies should test the certainty of the growth forecasts against the extent of exceedance of planning objectives. This preliminary problem characterisation makes use of a strategic needs score (see section C.3.1 for a definition and the question set from which the score is defined) assessed against growth uncertainty (this will involve some subjectivity and companies should seek endorsement for their approach in consultation with L2 SPGs). Table C-1 provides an example of the output.

- Where the output from the preliminary problem characterisation is 'green', i.e. the problem is well defined and there is confidence in the growth forecasts such that further sensitivity testing is not considered necessary, the assessment moves on to completion of the full problem characterisation process (see section C.3);
- Where the output from the preliminary problem characterisation is either 'amber' or 'red' i.e. further assessment of the impacts of growth is required to provide an increased level of confidence in the impacts, the assessment moves on to a higher level of complexity.

Table C-1 - Preliminary problem characterisation as a function of growth uncertainty

		Strategic needs score ("How big is the problem")			
		Negligible	Small	Medium	Large
		1-2	3-4	5-6	7-8
Growth (demand) forecast uncertainty	High				
	Medium				
	Low				

Extended BRAVA

Where the preliminary problem characterisation assessment indicates an 'amber' then additional sensitivity testing of the uncertainties is recommended. The following is provided as an example; however, companies can take the assessment further if that nature of the risks and uncertainties warrant such an approach or if existing company practices dictate.

> Examining future scenarios based on the planning horizons. Apply ±30% uplift across all growth projections through to 25-year (minimum) horizon; undertake scenarios as per CAF 'future' (or company specific) approach. All flows/loads developed should be used to determine WwTW impacts unless it can be shown that there is adequate capacity at the WwTW to accept additional inputs and that discharge impacts can be mitigated.

> Assess outputs against the defined planning objectives.

> Assess the extent to which the outputs are sufficiently developed to understand the near, medium and long-term impacts and against which the company would have confidence that interventions could be made that would address the impacts despite the uncertainties. If yes, proceed to completion of the problem characterisation step (section C.3); if no, proceed to complex BRAVA.

Complex BRAVA

Where the preliminary problem characterisation indicates a 'red' then complex scenario developments should be considered to fully assess the impacts of wide-ranging uncertainties in the system. The following is provided as an example; however, it is likely that at this stage companies will know the extent of the additional scenarios that need investigating based on the outputs from the standard and/or extended processes. As examples companies could consider:

- Applying multiple uplifts (+/-) to all growth projections – defined in consultation with L2 SPGs based on socio-economic principles; assess using CAF 'future' (or company specific) approach. All flows/loads developed should be used to determine WwTW impacts unless it can be shown that there is adequate capacity at the WwTW to accept additional inputs and that discharge impacts can be mitigated; or
- Where there is reasonable certainty in the medium term (LDP dependent), apply selective uplifts (+/-) to these growth projections and a wider range of uplifts to all future (> LDP forecast horizon) growth estimates – uplifts to be defined in consultation with L2 SPGs; assess using CAF 'future' (or company specific) approach. All flows/loads developed should be used to determine WwTW impacts unless it can be shown that there is adequate capacity at the WwTW to accept additional inputs and that discharge impacts can be mitigated.
- Developing bespoke scenarios for the relevant L3 TPU; these could be based on WRMP projections (that use a wide range of data sources) and modified in agreement with L2 SPGs.

Whatever scenarios are developed companies ultimately need to have a good level of confidence that the uncertainties have been well represented and that the impacts derived are those that will require interventions to mitigate. Once complete, companies should engage with L2 SPGs to agree the range of plausible scenarios to be considered with a view to focussing the problem characterisation process. Taking forward multiple scenarios to the optioneering process should enable, for example, adaptive pathway approaches to be developed and for multiple planning objectives to be addressed.

C.2.5.3. Scenarios for problem characterisation

It is likely that in the majority of cases, engagement with L2 SPGs will lead to a single or limited set of scenarios that will need to be addressed within the problem characterisation and options development process based on an agreed 'most likely' case(s). For complex L3 TPUs it is possible that a range of scenarios will need to be assessed.

The problem characterisation step that follows is designed to focus the options development process to ensure that the process followed is proportionate to the risks identified and, importantly, the timing of the need. It is important that L2 SPGs are actively engaged at this stage to ensure that a pragmatic and proportionate approach is taken.

C.2.5.4. Outputs of the assessment

It is anticipated that the outputs from the BRAVA should be an indication of:

- Exceedances (or changes from baseline – delta) against planning objectives;
- Timing of exceedances (or delta) within the planning horizon;
- Primary drivers behind the exceedance.

The assessments undertaken during the BRAVA process step will also complement existing regulatory planning requirements, e.g. the requirement to classify storm overflows as unsatisfactory, substandard or satisfactory[3]. The BRAVA output will provide an evidence base to support completion of such requirements. As companies develop their processes to adhere to the framework, the potential for standardisation of output arising from the various DWMP process steps (above that currently described in the framework) should be considered, particularly where output is also used to satisfy regulatory planning requirements.

[3] https://www.gov.uk/government/publications/water-companies-environmental-permits-for-storm-overflows-and-emergency-overflows/water-companies-environmental-permits-for-storm-overflows-and-emergency-overflows

C.3. Problem characterisation

The preliminary problem characterisation process (section C.2.5.2) was aimed at defining the need for more detailed approaches to understand the nature of any problems as a function of growth uncertainties. The final element of the problem characterisation is aimed at ensuring that the approach to the options development and appraisal process is proportionate to the nature of any problems identified.

Where L3 TPUs have been subject to extended BRAVA assessments, engagement with L2 SPGs will lead to a single or limited set of scenarios that will need to be addressed by the problem characterisation and options development process based on an agreed set of plausible scenarios. For those L3 TPUs subject to complex BRAVA assessments, engagement with L2 SPGs will likely require that a broader range of scenarios will need to be assessed. For complex systems, having a range of scenarios is considered a necessity to enable multiple option (e.g. adaptive pathway) type interventions to be evaluated and developed.

In undertaking the problem characterisation companies will need to define the level of risk around the exceedances identified e.g. does a 5% increase in the risk of internal sewer flooding represent a high, medium, or low, risk? In addition, consideration would need to be given to whether timing influences the risk level e.g. 5% exceedance risk in a 10-year horizon may be considered medium risk but could be considered low within a 25-year horizon – in terms of when the planned risks are likely to occur (the potential need to develop more consistent approaches to risk across companies needs to be considered as the DWMP process evolves). Companies will also need to consider wider issues associated with the exceedances (e.g. tie in with other risk management authorities (RMA) plans, opportunities for partnership working as a function of the primary driver) and have a view (expert judgement) on the potential complexity of solutions (a function of the number of planning objective exceedances but including timing of need and potential lead in times).

The problem characterisation step draws heavily from established WRMP processes as detailed in the UKWIR report 'WRMP 2019 Methods – Decision Making Process: Guidelines[4] (subsequently referred to as 'WRMP guidance'). It has been used as the basis for this section and modified to suit drainage and wastewater needs. The WRMP guidance advises that:

*'The **problem characterisation assessment is a tool for assessing a company's vulnerability to various strategic issues, risks and uncertainties**, to allow the development of a proportional response in terms of the effort and cost devoted to adopting the selected decision making tool. Its purpose is thus to **help guide planners to the most appropriate decision making tools given the planning problem** that they face.*

The problem characterisation assessment provides a documented and auditable trail that planners can use to explain decisions to regulators and stakeholders. Planners should document the rationale and reasoning for their assessment.'

The approach is considered equally applicable to the DWMP, noting that this stage will guide companies towards the appropriate level of optioneering complexity, when using the available tools that predict risk, and identify interventions to resolve them (i.e. it is envisaged that the same tool may be used across groupings of characterised problems, but with varying levels of sophistication). This may also point to the need for development of more advanced analytical tools similar to those developed for the WRMP process, acknowledging this will be a challenge to the conventional approaches and detail used in wastewater planning.

Companies may need to undertake several iterations of the problem characterisation assessment to develop the supporting case for the classification of vulnerability. It therefore requires expert judgement from within a company (potentially across a range of teams) to complete the assessment and present the results to L2 strategic planning groups (SPGs) for consultation. Where that is the case, the key factors and considerations in determining vulnerability should be clearly demonstrated in the DWMP.

The assessment examines both current and future needs and complexities. It is generally to be undertaken at the level at which the BRAVA assessment has been undertaken (for the majority of cases this is likely to be at L3 TPU but could also be applied where L3 TPUs have been aggregated). Companies may aggregate further beyond the approach taken during the BRAVA stage (dependent on the outcome of the BRAVA, e.g. where there is limited variation in the risks present and the extent of deviation from achievement of planning objectives across a wider area). Within each given aggregation, the same decision-making approach should be applied, to ensure consistency.

There are two elements to the problem characterisation assessment:

- Strategic needs ("how big is the problem?") – a high-level assessment of the scale of need for interventions to address near, medium and long-term performance concerns, and
- Complexity factors ("how difficult is the problem to solve?") – an assessment of the complexity of issues that affect investment in a drainage and wastewater planning area.

In many cases water companies will only need to carry out the problem categorisation based on their own needs. However, where wider system interdependencies extend beyond company boundaries (e.g. coastal areas affected by discharges from more than one company), or there are opportunities to maximise supply surplus, then the characterisation may need to account for potential future cross-boundary strategic options.

[4] UKWIR, 2015-2016, WRMP 2019 Methods – Decision Making Process: Guidelines (16/WR/02/10)

A simple, additive matrix is presented in section C.3.4 based on the responses to the complexity and strategic needs questions. This will provide direction for the commencement of the option development stage. Beyond certain thresholds of complexity and need, there may be value in considering an 'extended' method for developing robust options to inform investment decisions. In addition, beyond a certain level of complexity and need, there may be value in considering a combined approach, which incorporates more than one 'extended' approach, or considers more complex methods

It is acknowledged that companies may have existing processes that are used to inform optioneering complexity. The availability of such a supporting evidence base will facilitate rapid progression through this process step. As with other aspects of the framework, it is likely that companies will not need to adopt such a staggered approach, if the route through the process is clearly identifiable and justified from the evidence base produced prior to the decision-making points within the framework.

C.3.1. Assess strategic needs ("how big is the problem?")

The first part of the problem characterisation stage is an assessment of 'strategic needs'. This entails answering simple 'headline' questions that explore the extent to which the objectives of the DWMP will not be achieved without intervention.

The BRAVA process step will identify, for each L3 TPU and DWMP planning objective, the extent to which there is a current or future forecast deficit in achievement (against stated targets) over the selected planning horizon.

As defined during the strategic context process step, DWMP planning objectives will include but not be limited to:

- Common performance commitments;
- Asset health metrics (other than those included within the common performance commitments) selected by companies to become bespoke performance commitments;
- Other bespoke company performance commitments that will contribute to achievement of outcomes related to drainage and wastewater services.

This ensures that the DWMP supports achievement of the higher-level objectives (i.e. outcomes) valued by customers and society.

It can be expected that these will be further developed during subsequent price reviews[5]; to assist in companies' planning approaches it would be useful for companies to have early sight from Ofwat of emerging thinking on performance commitments for PR24 (and subsequent) business plans. However, the principle of inclusion of all service level pledges that are deemed to contribute to outcomes related to drainage and wastewater services should be adhered to.

In undertaking the initial problem characterisation stage, the level of concern that planning objectives could be significantly affected by current or future risks, without interventions, is to be assessed, with responses providing an overall 'strategic needs score'.

Whilst some companies may wish to assess each planning objective individually (to provide an initial view on likely option development and appraisal effort), it is considered that this could result in a significant amount of undue effort, especially considering that subsequent option development approaches for some planning objectives should be considered in an integrated manner, to foster identification of interventions that have multiple benefits / address multiple planning objectives.

Planning objectives might better be aggregated to derive a strategic needs score (per aggregation), considering logical groupings of objectives that are typically assessed using common (integrated) decision support tools; for example:

- Flow and network assets including intermittent discharges at WwTWs;
- Issues associated with capital maintenance;
- Issues relating to WwTWs (as a function of inputs from the networks).

The 'strategic needs score' is developed from question sets defined around 'demand (flow/load) risks' and 'supply (capacity) risks'.

Demand (flow/load) risks:

For each aggregation of DWMP planning objectives (or individual, if assessed separately):

a. Level of concern that planning objectives could be significantly affected by near or medium-term demand (flow/load) risks, without interventions?

b. Level of concern that planning objectives could be significantly affected by future demand (flow/load) risks, without interventions?

For clarity, demand refers to the flows and loads that drain to / enter drainage (and hence wastewater) systems.

Supply (capacity) risks:

For each aggregation of DWMP planning objectives (or individual, if assessed separately):

a. Level of concern that planning objectives could be significantly affected by near or medium-term supply (capacity) risks, without interventions?

b. Level of concern that planning objectives could be significantly affected by future supply (capacity) risks, without interventions?

For clarity, supply refers to the available capacity (both hydraulic and process) within drainage and wastewater systems.

The scoring to be applied to each question set is outlined in Table C-2.

[5] Suggested that consideration be given to a performance commitment that accounts for the impact on and from other RMA assets. This might provide an opportunity to include a commitment that binds RMAs to collaborative delivery

Table C-2 - Assessment of the strategic needs score ("How big is the problem?")

Strategic needs factors	Not significant (Score = 0)	Moderately significant (Score = 1)	Very significant (Score = 2)	Don't know
Demand (flow/load) risks	2 questions: > Minimum score = 0 (no significant concerns for all planning objectives) > Maximum score = 4 (very significant concerns for all planning objectives)			
Supply (capacity) risks	2 questions: > Minimum score = 0 > Maximum score = 4			
Total	**4 questions:** > **Minimum score = 0** > **Maximum score = 8**			

Notes

The term 'risk' here relates to either uncertainties in the current estimates of deficit in achievement of planning objectives, or the potential size and impact of forecast changes (e.g. due to climate change, growth).

Companies may consider relative priorities between planning objectives, based on, for example, customer preferences (willingness to pay valuations), to inform the score, with the final score to be reflective of the higher priority objectives.

The questions in the strategic needs assessment use a scale of significance to characterise the answer for each aggregation of DWMP planning objectives. The following general points should be followed when categorising:

> If there is a sustained exceedance caused by a combination of changes in both the supply and the demand elements, then this represents a 'moderately significant' concern for both elements.

> Concerns become 'very significant' where there is a risk that either element could cause a sustained, significant exceedance by itself or in combination, so that there is a large exceedance that is likely to fundamentally change levels of service to customers or present an unacceptable risk of failure.

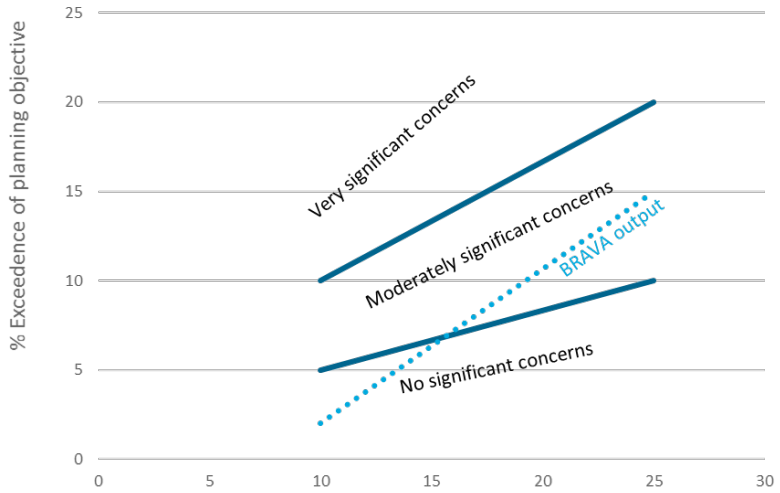

Figure C-2 - Example of BRAVA findings supporting assessment of strategic needs score

Whilst there is a degree of subjectivity when categorising, it is expected that the responses will be supported by evidence from the BRAVA and the key points captured in a narrative within the DWMP. For example, the following diagram (Figure C-2) shows how the high-level BRAVA findings can be used to inform the strategic needs score, by defining levels of exceedance that relate to the levels of concern in achievement of the planning objective.

Companies should document the rationale for the scoring they have used, to aid explanation and justification to L2 SPGs.

C.3.2. Assess complexity factors ("how difficult is the problem to solve?")

The second part of the problem characterisation stage is an assessment of the 'complexity factors'. The purpose of this is to explore the nature of the risks and vulnerabilities that exist within the DWMP, with an emphasis on identifying whether these complexities, in combination with the level of strategic risk, indicate that methods beyond standard planning approaches may be required. These factors are then used to provide general direction on suitable option development approaches.

It is recommended that companies record any other concerns that they identify during the assessment of complexity factors. These may need further discussion with regulators and DWMP SPGs, for their views to be considered in determining the degree of optioneering complexity required.

The "complexity factors" use two types of risk:

- Demand (flow/load) risks; and
- Supply (capacity) risks

All the questions in the complexity factors assessment use a scale of significance to characterise the answer. This will involve significant elements of engineering judgement; as such, it is important that outputs to the question set are documented. The question set is to be answered for each (or aggregation thereof) planning objective.

The following two listings present the complexity factor questions for the demand and supply sides respectively.

Demand (flow/load) risks:

a. Are there concerns about near or medium-term system performance, primarily due to uncertain impacts of:

   i. climate change, and

   ii. new development and urban creep

   on vulnerable supply systems, but also including associated deterioration (e.g. increasing flows due to infiltration), impacts of other drainage systems, or poor understanding?

b. Does uncertainty associated with forecasts of demographic/economic/behavioural changes over the planning period cause concerns over the level of investment that may be required?

Supply (capacity) risks:

a. Are there concerns about near or medium-term supply system performance, either because of recent level of service failures or because of poor understanding of system reliability/resilience under different circumstances than those contained in the historical record?

b. Are there concerns about future supply system performance, either because of predicted level of service failures or because of poor understanding of future system reliability/resilience under different circumstances than those contained in the historical record?

c. Are there concerns about near, medium or long-term system performance, primarily due to uncertain impacts of supply (capacity) issues (chronic and/or acute) on vulnerable systems, due to:

   i. asset deterioration;

   ii. the misuse of the system; or

   iii. poor understanding?

d. Are there concerns about the potential for 'stepped' changes in regulation (e.g. pharmaceuticals/microplastics) necessitating a significant change in supply-side approaches to managing demand, in the near or medium term that are currently very uncertain?

e. Are there any opportunities to increase capacity or provide alternative means of addressing flow/load needs, in the near or medium term, that warrant assessment of cross-catchment interventions (that are currently very uncertain)?

The responses to each question are to be scored as shown in Table C-3:

Companies should consider recording the rationale for the scoring they have used, to aid explanation and justification to L2 SPGs and wider stakeholders.

Table C-3 - Assessment of complexity factors for DWMP purposes

Complexity factors	Not significant (Score = 0)	Moderately significant (Score = 1)	Very significant (Score = 2)	Don't know
Demand (flow/load) risks	3 questions: > Minimum score = 0 > Maximum score = 6			
Supply (capacity) risks	5 questions: > Minimum score = 0 (no significant concerns for all planning objectives) > Maximum score = 10 (very significant concerns for all planning objectives)			
Total	**8 questions:** > **Minimum score = 0** > **Maximum score = 16**			

C.3.3. What to do with any "don't knows"

In completing the strategic needs and complexity factors assessments presented above, there may be some circumstances under which the answer is "don't know". Where this occurs, it should act as a trigger, prompting companies to ask a number of additional questions that could include:

- Why don't we know (lack of data, not been regulatory pressures to understand the component, not previously been a need to investigate the element in question)?
- Is there any evidence that this could be a concern (e.g. from regional studies, 'near misses', etc.)?
- How long and what resources will it take to investigate?
- Is our organisation comfortable with a "don't know"?

If there is time to investigate at low cost, then it would generally be appropriate to do so. If not, then consider using the above questions to make a best estimate, with a possible default position of selecting 'moderately significant'. As part of the consultative process with L2 SPGs, companies will be required to explain the findings, issues and assumptions from the problem characterisation step. This step will also help identify where significant investment in monitoring and investigations may need to be identified and tested as part of the DWMP investment programme.

C.3.4. Identify the optioneering and decision-making approach

The final step is to complete the problem characterisation assessment, by using the 'scores' from the questions stated in previous sections to populate the matrix detailed below (Table C-4), which in turn provides an assessment of the required complexity of subsequent approaches to optioneering and decision making).

Table C-4 - Problem characterisation matrix

		Strategic needs score ("How big is the problem?")			
		Negligible	Small	Medium	Large
		1-2	3-4	5-6	7-8
Complexity factors score ("How difficult is it to solve")	High (8+)				
	Medium (5-7)				
	Low (<4)				

Required complexity of optioneering and decision-making approaches

Level of concern	Optioneering and decision-making approach	
Low	Standard	Generally, 'current' approaches should be adequate to determine and justify interventions and resultant investment proposals to ensure planning objectives are met (noting earlier guidance on the usage of additional future scenarios, as defined within the CAF).
Medium	Extended	'Extended' approaches to optioneering may add considerably to a company's understanding. 'Extended' refers to methods not previously widely used in drainage and wastewater planning, but which have been utilised previously on specific catchment investigations that are deemed to be at the 'leading edge' of current planning approaches, or tested to at least the 'proof of concept' stage for actual UK drainage and wastewater systems and have outputs that can be readily understood by planners.
High	Complex	Consider whether it would be useful to go beyond the 'extended' approaches to decision making (referred to a 'complex'), as this could add considerably to the company's understanding. Here, 'complex' approaches refer to more advanced, conceptually complex methods not yet applied to the UK drainage and wastewater planning context, although these may be under current investigation in academia/currently developed by companies.

The purpose of the matrix is to assist in identifying whether optioneering approaches over and above that currently applied is justified and, if so, to guide companies as to the level of complexity that might be appropriate. Having established the degree of optioneering complexity that is appropriate, the company needs to consider the choice of decision support tools, and the level of sophistication used when deploying them. If the problem characterisation suggests a low level of concern, or only a moderate level of concern as a result of specific issues (e.g. around the understanding of supply or demand uncertainty), the company may decide that 'current' decision making approaches are appropriate.

A degree of flexibility can be exercised in the interpretation of the outputs from the matrix, where the categorisation is marginal. The intention is not to dwell on a precise score, but to identify a justifiable course of action for commencement of option development. There will be scope for refinement as progress is made through the option development process (e.g. in moving from unconstrained option listings, to constrained, to a feasible listing).

It is acknowledged that optioneering complexity is a continuum that, for simplicity, has been represented as three distinct categories for decision making approaches.

The following diagram (Figure C-3) provides an overview of examples of approaches within 'standard', 'extended' and 'complex' categories. The subsequent DWMP process step of option development and appraisal further expands on the approach to use for the defined categories.

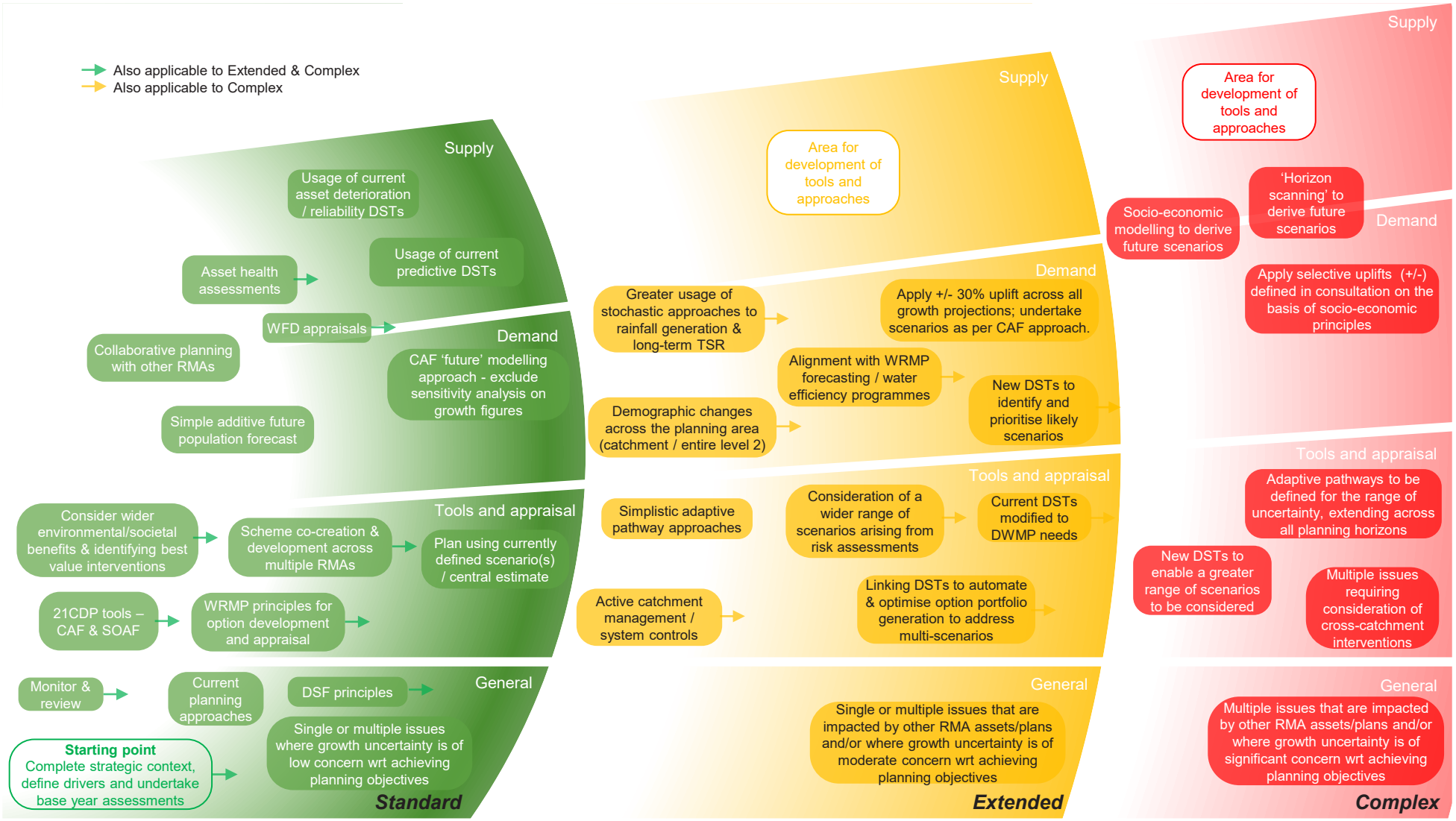

Figure C-3 - Examples of decision making approaches

C.4. Example BRAVA and problem characterisation output

The following provides an example of the types of outputs that would be anticipated from the BRAVA and problem characterisation steps. The example assumes:

- A single issue associated with a single planning objective;
- There is certainty and confidence around the growth planned for the medium term (10 years) but uncertainty around the longer-term and a sensitivity analysis (±30%) on the forecast growth projections has been undertaken;
- No issues have been identified with respect WwTWs operations based on growth forecasts and no discharges made to sensitive waters or likely to impact on Water Framework Directive objectives;
- A threshold of risk has been set at 5% exceedance of the planning objective for the first 15 years ('threshold 1') but the company has decided to accept a higher level of risk in the remainder of the planning period ('threshold 2').

The forecast growth (against axis titled 'pe increase above base year, pe being 'population equivalent') and planning objective exceedances (against axis titled '%ge exceedance of planning objective') are shown in the top half of Figure C-4.

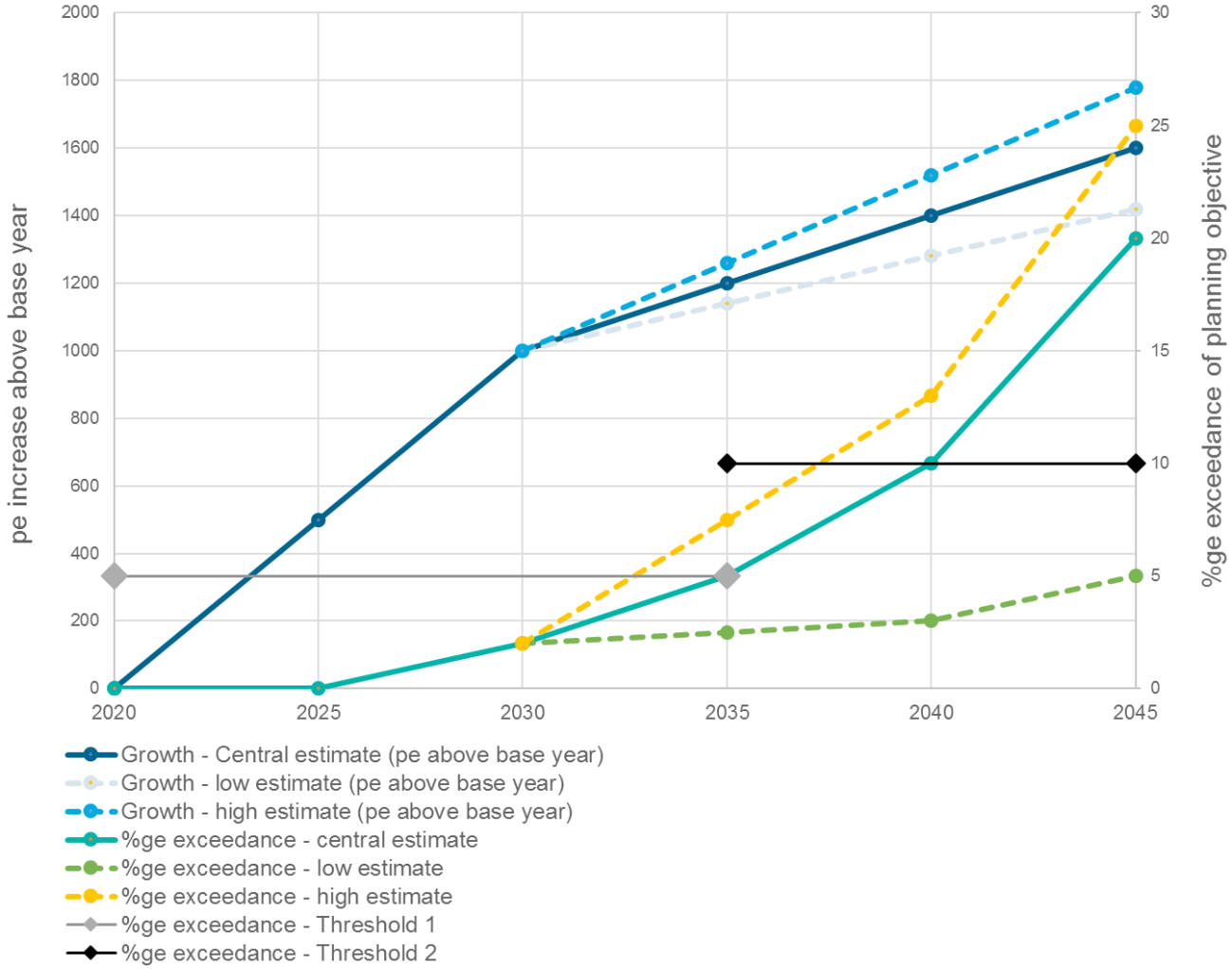

Figure C-4 - Example BRAVA outputs

The outputs from the problem characterisation steps are shown in the tables that follow.

Table C-5 – Example problem characterisation outputs

Strategic needs factors		Not significant (Score = 0)	Moderately significant (Score = 1)	Very significant (Score = 2)	Don't know
Demand (flow/load) risks	Q1 – no near or medium-term demand risks identified	Y (score 0)			
	Q2 – moderately significant future demand risks		Y (score 1)		
		Question set score = 1			
Supply (capacity) risks	Q1 – no near or medium-term supply risks identified	Y (score 0)			
	Q2 – moderately significant future supply risks		Y (score 1)		
		Question set score = 1			
Total	**4 Questions**	**Overall score = 2**			

Complexity factors		Not significant (Score = 0)	Moderately significant (Score = 1)	Very significant (Score = 2)	Don't know
Demand (flow/load) risks	Q1 – no near or medium-term demand risks identified	Y (score 0)			
	Q2 – moderately significant future demand risks		Y (score 1)		
	Q3 – moderate uncertainty in growth forecasts		Y (score 1)		
		Question set score = 2			
Supply (capacity) risks	Q1 – no near or medium-term supply risks identified	Y (score 0)			
	Q2 – moderately significant future supply risks		Y (score 1)		
	Q3 – moderate uncertainty in system knowledge		Y (score 1)		
	Q4 – step changes not considered a primary risk	Y (score 0)			
	Q5 – no cross-catchment options available	Y (score 0)			
		Question set score = 2			
Total	**8 Questions**	**Overall score = 4**			

On the basis of the outputs the 'strategic needs' / 'complexity' matrix would suggest that standard approaches would be appropriate to the optioneering. Appendix D provides details of the options development and appraisal process.

C.5. Resilience

As indicated in section C.2. as part of the BRAVA, companies should undertake a high-level evaluation of wider resilience issues across all catchments irrespective of whether the more detailed baseline risk assessment is required. In the initial stage of DWMP implementation it is considered that the resilience assessment should focus on a minimum set of events. These are outlined in Table C-6.

Table C-6 - Minimum criteria for the resilience assessment

Event/need	Consequences / mitigation measures
Fluvial and/or coastal flooding of WwTW and major pumping stations	Can significantly impact on works operations and performance leading to environmental and upstream network flooding risks. Companies should already have considered such risks and, where appropriate, have implemented appropriate solutions. Assessment designed to ensure that identified risks have been mitigated and where new risks may have become evident.
Power outages	Can impact on pumping stations and WwTWs. Companies should consider requirements/need for back-up supplies (e.g. mobile/permanent generation).
Outages to remote communications	With a move towards greater remote control of WwTWs and real-time operation of networks (predominately pumping stations) companies need to consider impacts of outages to remote communications and how to build in resilience.
Response recovery plans	Customers generally accept that occasionally there will be events that impact on them and/or the environment, but often are more understanding if there has been an effective response from the responsible body. Companies should consider whether catchment specific response recovery plans (e.g. procedures to address the consequences of sewer flooding incidents or pollution events) are required or whether a generic response recovery plan would suffice.

Companies can widen the resilience assessment to fit their specific circumstances; examples of additional events include:

- **Low flows -** under a range of climate change futures there is the potential for increased dry periods that can lead to a fall in groundwater levels significantly reducing infiltration. This can lead to significant low flow periods with the potential to increase septicity particularly in catchments with long rising mains and extensive intra-works pipework; consequences are an increased risk of deterioration to concrete assets, odour and impacts on WwTW performance. Mitigating measures include those that can be considered operational (e.g. changes in pumping regimes) or the addition of chemical dosing.
- **First flush –** aligned to the example above, intense rainfall following a period of low flows can lead to significant quantities of settled debris within sewers being flushed through to a WwTW with the potential to overload inlet screens with potential site flooding and pollution risks.

Within the context of business planning processes, companies will already have assessment methodologies in place; the requirements outlined in this methodology should complement existing processes.

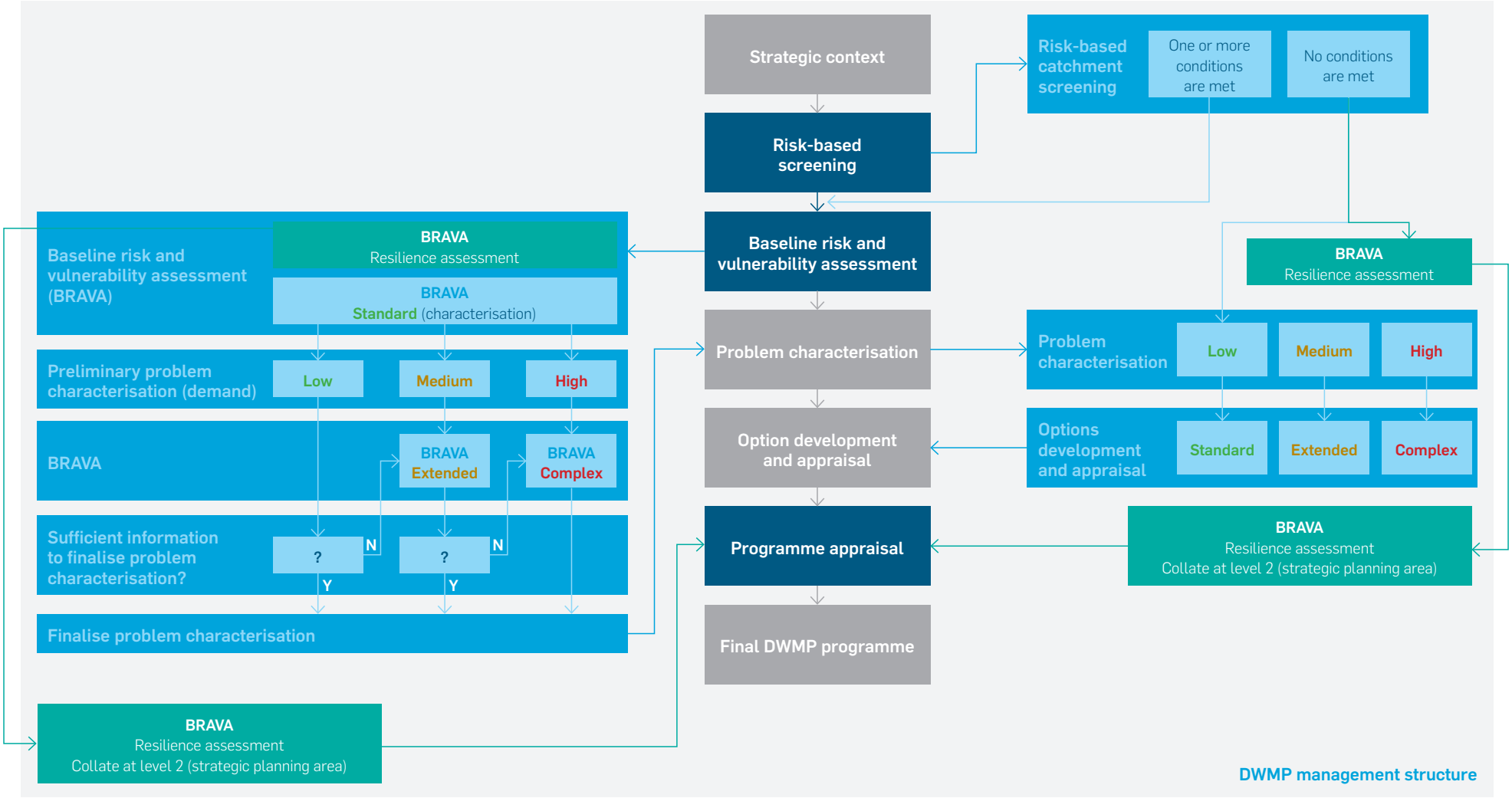

Figure C-5 - Resilience assessments within the context of the DWMP

John Sutherland / Gian Illari / Brian Arkell
Atkins Limited
Woodcote Grove
Ashley Road
Epsom
Surrey
KT18 5BW

Tel: +44 (0)1372 726140
Fax: +44 (0)1372 740055