Leakage

Purpose: This performance commitment is designed to incentivise the company to reduce leakage.

Benefits: The benefits of reduced leakage are to improve the long-term water resources supply-demand balance, reduce the need for water abstraction and increase water supply network resilience.

Version control

Version	Date of issue	Performance commitment changes
0.1	22 December 2022	Removal of text repeated in other performance commitments and other minor clarifications.
0.2	17 May 2023	Removal of red text. Section 1.2.1 Night Flow Monitoring – Removal of reference to a distinction between data improvements and methodology changes as the distinction was not used in the remainder of the definition. Section 1.2.1 Availability – Reinstated text from PR19 definition defining availability. Section 1.2.1 Operability – Clarification of definition and associated example. Section 1.2.2 Data Infilling – Clarification that leakage in areas that are inoperable shall be infilled. Section 1.2.2 Annual Distribution Leakage – Removal of text on outliers as already covered by definition of operability.

Performance commitment definition and parameters

1.1 Detailed definition of performance measure

The percentage reduction of three year average leakage in Ml/d from the 2019-20 baseline. Three-year average values are calculated from annual average values for the reporting year and two preceding years and expressed in Ml/d.

Annual average leakage is defined as the sum of distribution system leakage, including service reservoir losses and trunk main leakage plus customer supply pipe leakage. It is reported as the annual arithmetic mean (referred to as 'average') daily leakage expressed in mega-litres per day (Ml/d). It is reported as a post-Maximum Likelihood Estimation (MLE) figure.

The company shall provide a commentary in its Annual Performance Report (APR) submission if there are any differences in its 2019-20 baseline three-year average total leakage level expressed in Ml/d in comparison with its business plan. Reasons for any differences shall be clearly explained and their volumetric impacts on the baseline quantified.

Outcome delivery incentives will be applied on a Ml/d basis. The performance commitment levels expressed as percentage reduction will be applied to 2019-20 baseline. The difference between this value to one decimal place and the actual three-year average leakage will be used to calculate outcome delivery incentives.

The company is required to report against this definition and:

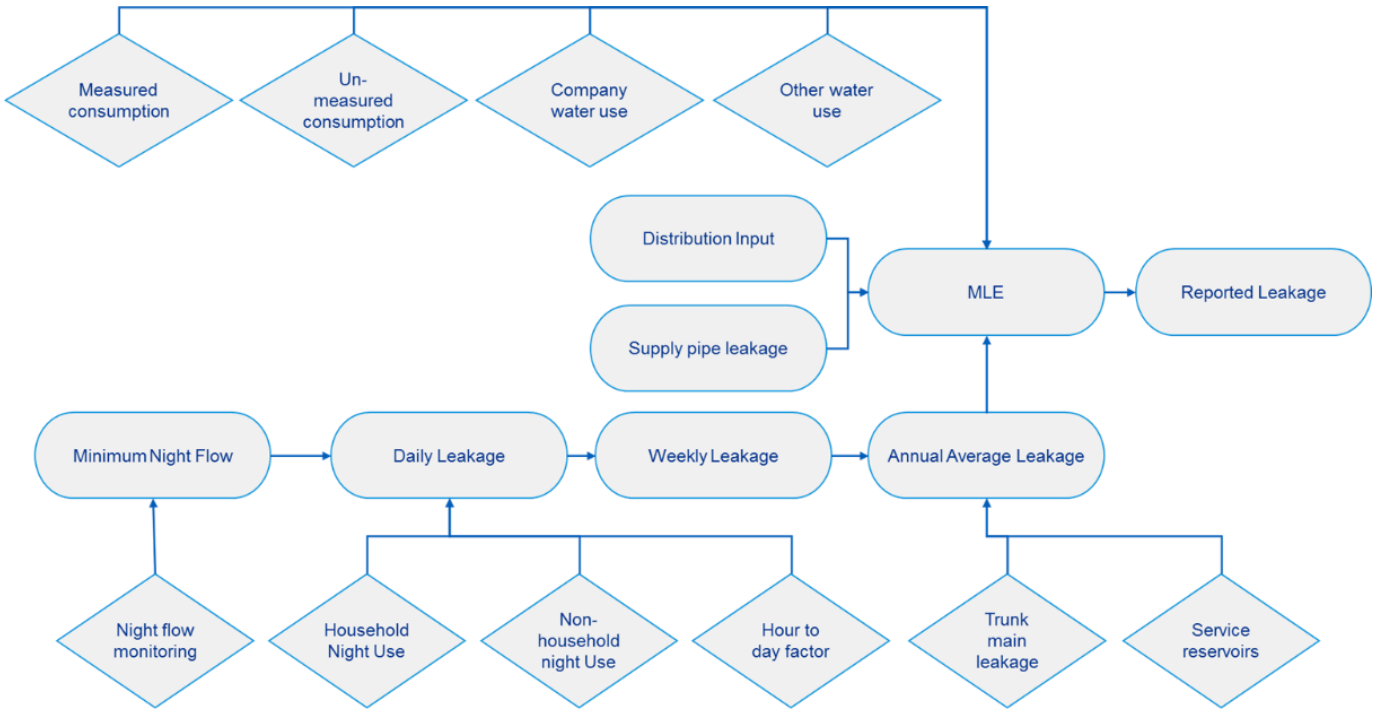
- report a post-MLE average leakage value expressed as Ml/d to one decimal place;
- disclose in its APR where its methodology does not comply, using the checklist below; and
- disclose in its APR any other factors which have an impact on the methodology for reporting leakage.

The guidance is structured in the way that leakage is normally calculated and comprises:

- a calculation of daily leakage from continuous monitoring and regular analysis of zonal or district meter area nightlines (commonly referred to as bottom up).

- an annual assessment of the distribution input and the total amount of consumption and other water use as described in this document (commonly referred to as top down).
- the water balance reconciliation using the MLE methodology.

Figure 1 – Leakage process flow diagram



1.2 Additional detail on measurement units

1.2.1 Components of the Leakage Calculation

Reporting level

The main objective is to achieve and maintain a high level of valid data in each component such that the company can report a robust calculation of annual average leakage.

The company can select to calculate leakage based on different reporting levels:

- District Meter Area (DMA) using district meters;
- Water resource zone level using distribution input meters; or
- An intermediate zone or tile using meters installed on reservoir outlets or trunk mains within the distribution network.

Regardless of the approach, the company must have sufficient coverage, operability and availability (as defined below) in its bottom up leakage calculation. Reductions in leakage should reflect a true reduction in observed nightlines that reflect actual physical improvements.

Night Flow Monitoring

Leakage from water networks shall be calculated from monitored flows during the night when demand for water is normally at a minimum and patterns of customer consumption are both more predictable and more repeatable. The company shall determine the level of legitimate night use for household and non-household customers and make allowance for this. Assessment of these night flow allowances shall be from statistically valid surveys (monitors or smart meters) which accurately represent the type and number of the company's customers. The allowances shall be subtracted from the measured Minimum Night Flow (MNF) to give a calculation of bottom-up leakage.

Calculation of DMA or zone night inflow and household (HHNU) and non-household (NHHNU) customer night use need to be aligned. The night flow analysis shall use flow data and allowances for the same time period. For example, if the MNF is determined to be between 3 and 4am then the night use allowances shall be taken for the same hour (3-4am).

The company shall analyse flow data from DMA or zonal meters to confirm its validity and, once confirmed, this data shall be used to derive minimum night flow in each monitored area.

These daily calculations will form the basis of the bottom-up leakage calculation. This bottom-up calculation will then be used in the company-wide annual water balance and hence used to derive the post-MLE figure that the company will report for annual leakage.

To provide a robust annual calculation the company is expected to comply with the following criteria:

- at least 95% of all properties served by the company shall be within networks having continuous night flow monitoring through the year (DMA, Zonal or other monitoring area);
- the company shall maintain these DMAs, zones or areas such that average availability for leakage reporting across all DMAs/zones/Areas is well above 90% for the year;

- valid data for reporting leakage shall be derived using available night flow data and allowances for legitimate night use;
- The company shall obtain independent assurance of its night use allowances. Should the company seek to change any allowances for each reporting year then the company shall seek independent assurance that the monitor remains representative of the whole population and that the new allowances are valid. ;
- assessments of legitimate night use for households and non-households shall be applied as detailed in sections below;
- the statistical assumptions for determining night flows, legitimate night use and hence leakage shall be based on good practice and consistently applied; and
- the components of reporting shall be based on the company's own data – not industry averages.

To apply these principles, definitions of 'Coverage' and 'Availability' need to be applied. For the purpose of this performance commitment:

Coverage means the percentage of the company's billed households and non-households within designated network areas where night flows can be continuously monitored and reported on a regular frequency. Coverage is measured as an annual average for the whole company. This represents the extent of the coverage of networks with designed import and export meters, boundary valves, counts of households and non-households and other asset and performance data.

Availability means the zones/ DMAs or Tiles with data that allow it to be used for regulatory reporting. The company decision whether to include trunk mains in the DMA/zone or Tiles should have no effect on this reported figure. For an area to be 'available' the installed meters and loggers are working correctly; the boundary is watertight and continuous data is provided. Availability is measured as a property-weighted annual average for the whole company.

It is expected that the company will endeavour to maintain availability in all DMAs/Zones or Tiles used to report bottom-up leakage. The supporting statement shall explain why any DMAs/zones or tiles are not available. A company should target better than 95% availability and should explain what it is doing to improve if availability is below 95%. Below 90% shall be reported as non-compliant.

The company is expected to apply its own automated validity checks, or Operability tests, within its leakage analysis software to accept or reject data for reporting. We expect this to be supported by manual detailed checks to detect any data inconsistencies on at least a weekly basis. The company must set out the operability rules (the methods and thresholds) it uses and provide supporting justification for these during annual assurance.

Where the company is not able to meet the availability measure because, for example, of District Meter Area (DMA) or zone remodelling or capital works then it is to disclose this in its supporting statement.

For the purpose of this performance commitment, **Operability** means where leakage data derived from night flow monitoring and the application of legitimate night use data is within the company's accepted validity criteria for use in leakage targeting and internal reporting. Valid data must be available for at least 3 days of the week for the area to be considered operable.

A DMA or zone/tile might be "inoperable" but data from the DMA or zone/tile could still be "available". For example, data from a DMA or zone/tile that had negative results would be inoperable, but would still be available where installed meters and loggers are working correctly; the boundary is watertight and continuous data is provided. Data from an inoperable DMA or zone (including negative and zero results) should still be stored for future analysis or regulatory reporting.

An estimate of leakage in areas not covered by continuous monitoring can be extrapolated using leakage per property from the adjacent monitored area where a similar level of leakage management activity is applied in these areas; otherwise a separate assessment is needed. Leakage in monitored areas failing validity checks is expected to be infilled in accordance with the 'Data Infilling' section below.

Properties [1]

Household and non-household properties are used in the calculation of total night use in any DMA or zone. Properties are also used as a denominator in leakage comparisons and for data infilling where DMAs or zones are inoperable.

The company is expected to:

- map all properties to defined zones or DMAs using geo-location or similar methods available in the industry;
- check the consistency of property numbers contained within DMAs or zones against its billing system to minimise any under- or over- counting. Any differences shall be highlighted to external assurers who in turn shall allocate an appropriate ranking and confidence grade to that element and component;

[1] For the purposes of this performance commitment the definition of "households" (and any references to "household properties" or "household premises") is the same as the legal definition of "household premises" in section 17C of the Water Industry Act 1991. Non-household properties or premises are premises other than household premises (as defined in section 17C of the Water Industry Act 1991).

- exclude properties that are defined as void from night use allowances unless the company can evidence any use or losses from illegal occupation. The company shall justify the number of void properties each year and how this is derived. Reporting on void properties must be consistent throughout all regulatory reporting. If consumption is assigned to a proportion of void properties (illegal occupation) then the evidence base to support this must be considered during the assurance process;
- apply leakage allowance for properties not within DMAs or monitored zones consistent with other leakage estimates;
- update property data at least annually including void property data; and
- ensure its classification of properties as either household or non-household is consistent with our guidance on establishing the principal use of premises.[2]

1.2.2 Night Flow and Leakage

Night Flow Period

The UKWIR Report 'Managing Leakage 2011'[3] recommends using a fixed hour period. This approach allows average flows to be compared with average night use. This averaging approach may suggest exceptionally low or high values of leakage in particular zones or DMAs and at particular times of the year. However, the night use allowances should be representative of the true average across all DMAs/zone and shall be derived from a true representation of all customers. If the night use monitors are accurate, then any short term under/over reporting in zones/DMAs will cancel out in the annual average reported for all zones and for the whole year.

For current good practice, the only practical way is to use a fixed-hour statistic for both night flow and HH and NHH night use. This was confirmed in an UKWIR Report.[4] The company may extend this period to two hours. The company must justify its choice of fixed hour or fixed two hours, ensuring it aligns with the NU period, and demonstrate why this period is appropriate for its circumstances.

The company is expected to derive night flow data using the following criteria:

[2] See Eligibility guidance on whether business customers in England and Wales are eligible to switch their retailer, Ofwat, July 2022. To establish the principal use of premises served by the supply system of a company whose area is mainly in England, see Part A: Guidance for England, section 2.3; to establish the principal use of premises served by the supply system of a company whose area is mainly in Wales, see Part B: Guidance for Wales, section 3.4.
[3] UKWIR, Managing Leakage, 10/WM/08/42, published 21/09/2011.
[4] UKWIR, Improved Household Night Use Allowances, 14/WM/08/53, published 26/08/2014.

- night flow data frequency shall be at least every 15 minutes;
- leakage shall be derived from a fixed period during the night of at least a one hour period although up to two hours may be used; and
- the fixed period can be varied during the year for some or all DMAs or zones to address significant changes to night use patterns such as during Ramadan. Changes to the fixed period must be approved by company governance and verified by external assurance.

Night Flow Analysis

The analysis of night flow needs to be carried out using a consistent and valid statistical methodology. Both household and non-household night use are used to calculate daily leakage. The allowances for HHNU and NHHNU night use are based on average values over time and applied to night flows. Night flows therefore also need to be average values to derive statistically valid calculations of leakage. The use of any alternative percentile assumption is not statistically valid.

The company is expected to apply the following in its night flow analysis:

- the same time period (either 1 or 2 hours) shall be used to both measure minimum night flow and to determine average values of HHNU and NHHNU data for each DMA or zone;
- the value of HHNU shall be derived using methods set out in the 'Household Night Use' section below and the number of properties defined within the DMA or zone;
- the value of NHHNU shall be derived from a calculation of night use by group and the number of properties in each group defined as within the DMA or zone as set out in the 'Non-Household Night Use' section below; and
- account for properties not within DMAs or monitored zones both in terms of consumption in the water balance and leakage calculation which must be consistent with other components of the leakage calculation.

The analysis will derive values of leakage for each DMA or zone expressed as leakage per hour for every day of the year. Leakage is then expressed as leakage per day following the methodology set out in the 'Hour to Day Conversion' section below.

Data Infilling

Leakage in areas that are inoperable shall be infilled. Infilling of weekly values shall be limited to short periods of preferably no more than a month and certainly no greater than three months. While rules vary across companies, for consistency the company must do the following, or disclose where it has not been able to comply:

- Historical data specific to a single DMA or zone/tile shall not be used for more than three months before moving to area average;
- Data infilling taking the area average in which the DMA or zone/tile is located is valid if historical data is not available;
- When a DMA is restored to operability, for the purposes of annual average reporting, the subsequent leakage data shall be used to update retrospectively the data infilling interpolating between pre- and post- data. This is because a non-operable DMA is unlikely to be subject to detection processes and there is likely to be a natural rise in leakage over time; and
- Where properties are continuously monitored, the actual values of flow over the night flow period shall be used in place of estimates within the night flow analysis.

Seasonal Variation in Night Use

Fixed night use allowances are not appropriate for many companies who observe rising night flows during warm summer periods or spring planting. There is clear evidence that customer night use increases over these periods which may be due to households using overnight sprinklers or night time irrigation such as golf courses and plant nurseries.

The company is expected to make allowance for seasonal variance in night use:

- The night use allowance shall be adjusted regularly through summer months to allow for variable customer night use based on sample logging over the period or night use models; and
- Weekly leakage estimates shall be used for annual reporting with no exclusions for summer months.

The company must justify any seasonal adjustments they make to night allowances. Evidence based on data and or studies shall support this.

Negative Leakage Values

Average customer night use shall be applied equally to all DMAs although actual use can be higher or lower than across individual DMAs. The impact, particularly in small or low leakage DMAs, is that negative calculated leakage values may observed. While this may appear anomalous, combining leakage values at zone or company level will offset these negative values while maintaining the overall value of average household use. It is therefore appropriate to include negative leakage in collating leakage data to area or company level. Capping leakage to zero would artificially reduce the resulting average value of night use and is not appropriate.

The company is expected to make allowance for negative leakage values:

- where average night use values are applied across all DMAs, it is appropriate to include negative leakage values when compiling values of annual average leakage; and
- the reasons for any prolonged periods of negative leakage shall be investigated and any anomalies other than allowances (such as meter error) should be resolved quickly.

Household Night Use

An assessment of household night use shall be deducted from measured night flows in the calculation of leakage using the method described above in the 'Night Flow Analysis' section. The company can assess night use using either an Individual Household Monitor (IHM) or a Small Area Monitor (SAM) or a combination of both. The choice of method is likely to be related to the preferred method for assessing unmeasured household consumption.

The company shall use its own consumption data. Application of national default values is not valid. This is because these default values were derived from limited data over 25 years ago. In addition, techniques such as 'Socrates' loggers are no longer maintained or supported and hence are not best practice.

In the case of IHMs, these were originally designed to derive estimates of unmeasured per capita consumption and usually comprise about 1000 selected properties. We note this is a relatively small sample for night use assessments given the likely frequency and flow of intermittent and high-volume large night use customers. The company must ensure that the IHM has sufficient properties such that it is representative of the whole population and that it is continually monitored to ensure any failed meters or households leaving the monitor are replaced. Any periods of continuous night flow with respect to IHMs also need to be quickly identified and resolved to minimise any supply pipe leakage or plumbing losses being included in the assessed consumption.

SAMs normally provide a larger household sample size than IHMs and are appropriate for night use and unmeasured household consumption assessments. SAMS may be part or full DMAs; whatever size, they shall be selected and designed to give substantial coverage of households and minimise non-household properties. The company using SAMs for the assessment of HHNU shall apply the recommendations of the UKWIR

report on the application of a fast logging methodology for continuing monitoring and maintenance.[5]

The HHNU survey needs to have a sufficient number of samples, representative of the company's demographic factors, to identify both continuous and a significant number of intermittent flow events. The sample size of an IHM is unlikely to be sufficient to capture intermittent use with sufficient frequency. This is because intermittent use could be attributable to a small number of customers and the IHM inherently samples fewer customers.

The company is expected to derive weekly or monthly values of HHNU and shall retrospectively recalculate leakage each week or month as new data becomes available.

HHNU has a significant impact on reported leakage. There is a need to continually improve the coverage of properties with a focus on the factors having greatest impact on night use; for example, the impact of seasonal variations in use, increasing SAMs coverage and use of fast logging and low continuous flow capability to distinguish between usage and leakage.

The company is expected to derive an average (arithmetic mean) household night use applying the following criteria:

- the values of HHNU night flow shall be used with values of night flow and NHHNU for the same time period and on the same statistical basis to calculate leakage representative for the DMA or zone;
- it shall use its own data or shared data with proximate companies. National default values are not valid;
- plumbing losses shall be included and based on the company's own data;
- it shall satisfy itself and receive assurance from an external assessor that its survey is representative of the company as a whole; disaggregation of the sample by demographic factors, property type or similar represents good practice;
- it shall satisfy itself and receive assurance from an external assessor that the sample size is sufficient to capture continuous and intermittent night use with reasonable confidence;
- the application of IHMs, SAMS or a combination of both. It is unlikely that the IHM on its own will be of sufficient size to capture a valid sample of intermittent use;
- continual monitoring and maintenance of IHM and SAMs monitors; and

[5] UKWIR, Fast Logging for Improved Estimation of Household Night Use, 17/WM/08/66, published 28/03/2018

- HHNU shall be derived daily with regular, adjustment of values on a weekly or monthly frequency to reflect actual seasonal use. This may need to be done retrospectively.

Non-Household Night Use

Assessment for non-household night use shall be deducted from measured night flows in calculating leakage using the method described above in the 'Night Flow Analysis' section. Most companies use the 1999 UKWIR methodology[6] which sets out a methodology for deriving relationships between average night use and annual billed volume (ABV). The company may revise this where it has robust evidence that the change will improve the methodology.

The methodology stratifies non-household customers by groups of industry types and range of consumption. A representative sample of the variable characteristics of non-households by group and consumption shall be identified. Data logging of these sample customers shall be carried out for at least two weeks to derive model coefficients for each group.

The objective for leakage reporting is to take full account of water use in the night flow analysis where total flow is significant in relation to DMA night flows or the likely variation in flow has a significant impact on DMA analysis and presents a risk to deriving valid data. The target threshold for continuous monitoring is where average demand of an individual non-household is greater than a threshold normally between 24 to 48 m3 /day (or night flow >1,000 to 2,000 l/hr) or 25% of a DMA night flow. The company shall define its criteria, reflecting the impact of night use on the ability of a DMA to produce consistent and valid leakage calculation.

If the company is a water and sewerage company, it shall apply the 1999 UKWIR methodology to sewage treatment works and other company sites using significant water volumes.[7] The company shall apply the methodology for continuous monitoring of non-households to its own sites.

The company is expected to assess non-household night use applying the following criteria:

- the values of NHHNU night flow shall be used with values of night flow and HHNU for the same time period and on the same statistical basis to calculate leakage representative for the DMA or zone;

[6] UKWIR, Estimating Legitimate Non- Household Night Use Allowances, 99/WM/08/26, published 17/04/2002
[7] See Footnote 6, above

- it shall use its own data or shared data with proximate companies. National default values are not valid;
- the company shall apply the 1999 UKWIR methodology with the appropriate time window as used for the night flow and the published outcome of further methodology development;
- it shall demonstrate that the stratification of non-households to a number of groups and consumption bands is representative of the varying characteristics of commercial and industrial properties;
- it shall demonstrate that the sample size is sufficient to capture night use by stratification with reasonable confidence;
- it shall develop a reliable and representative average billed volume (ABV) model based on data logging of the representative sample sufficient to capture demand variations with further seasonal logging where relevant;
- direct linkage of the ABV model to the company's billing system or replacement database of billed volumes. It will update the average billed volumes at least annually;
- it shall continuously monitor selected non-households where average demand of an individual non-household has a material impact on the ability for a DMA or zone to provide valid and consistent data within operability limits; and
- if the company is a water and sewerage company, it shall apply the same ABV methodology as a separate group and continuously monitor sewage treatment works and other sites using the same criteria as for non-households.

Supply pipe leakage

The company shall have a robust methodology for calculating customer supply pipe leakage and this shall be confirmed by external assurance.

Hour to Day Conversion

An hour to day correction is required to take account of diurnal pressure variation in each DMA or zone. Leakage is monitored during the night when actual pressure is normally greater than other parts of the day. Daily leakage is calculated from night flow when actual pressure is likely to be greater than the average for a defined DMA unless pressure management is in place. Night leakage therefore needs a correction factor to convert it to the average daily leakage rate.

The company shall use the methodology in the UKWIR Report 'Assessment of Key parameters for Leakage Analysis' or explain its methodology and why it has chosen not

to follow this. [8] This report addresses average zone pressure, average zone night pressure (AZNP) and hour to day factor (HDF).

The company is expected to derive the hour-to-day conversion using the following criteria:

- the hour-to-day factor shall be derived separately for each DMA or zone using pressure logging within each DMA. The factors shall be updated at least annually or where there are any significant changes to pressure regimes;
- as an alternative, hydraulic models can be used provided they have been updated to reflect the latest network reconfiguration and any pressure changes, and provided it is dis-aggregated in sufficient detail at sub-zone level; and
- an N1 value of 1.0 to 1.2 in the leakage – pressure power law relationship unless the company can demonstrate a higher or lower value would be more appropriate using its own data.[9] The company shall set out its approach to deriving its N1 value.
- it should be noted that HTD factors are likely to be greater than 24 hours where the area is served by advanced pressure control.

Annual Distribution Leakage

Annual average distribution leakage expressed in Ml/d shall be derived from available DMAs or zones/tiles with minimal data infilling. Annual average distribution leakage ~~it~~ takes into account variable daily data, captures weekly trends and minimises the extent of statistical adjustments. The weekly leakage value is used as the base measure taking an average value of daily data in the week. The method captures the variance in weekly data through an average of the 52 weekly values.

Monthly reporting may be appropriate for internal reporting but must not be used in the calculation of annual average values.

1.2.3 Trunk Main and Service Reservoir Losses

Trunk Mains

For some companies who report leakage at zonal level, trunk mains losses are included in reported zonal or DMA leakage. If this applies to the company, the MNF calculation

[8] UKWIR, Assessment of Key parameters for Leakage Analysis, 17/WM/08/59, published 18/12/2017
[9] Leakage (L) is proportional to pressure PN1 where N1 can vary locally between 0.5 and 1.5, but at DMA level is typically between 1.0 and 1.2.

will include any trunk main losses and therefore a separate assessment of trunk main losses is not required.

If the company calculates leakage at DMA level it must calculate trunk mains leakage and service reservoir losses separately.

The company shall take a proportionate approach in calculating leakage. If the company has a relatively high proportion of trunk main losses to total leakage, it shall take a proactive leakage monitoring approach with a combination of field inspections, analytical techniques, and flow balancing methods. Otherwise, if the company has a relatively low proportion of trunk main leakage (<5% of total leakage), it may apply less intensive methods but shall use its own data and not rely on national default values.

Compilation of flow balances within sections of the trunk mains network is an important element to the proactive approach. Flow balances may identify either meter error or unknown connections, but in some instances, they may identify significant trunk mains leakage. The company should carry out flow balances between upstream and downstream meters or groups of meters

The company shall follow the advice given in UKWIR report 'Leakage Upstream of District Meters',[10] which describes two alternative methods for quantification of trunk main leakage:

1. A flow balance approach, as described above. This method is dependent on sufficient operational meters being installed. The method allows for a representative sample of meters to be used and for the findings to be extrapolated; or
2. A bursts and background estimate (BABE) component approach, using its own data on numbers of leakage with estimated flow rates and durations, together with an estimate of background leakage. The reported figures shall be subject to external assessment which shall provide assurance of both the methodology and calculation and publish the result alongside its APR.

Company-specific data shall be used to assess the value of trunk main leakage; national default values shall not be used.

The company is expected to derive values of trunk main leakage using the following criteria:

- Company-specific data shall be used to assess the value of trunk main leakage;

[10] UKWIR, Leakage Upstream of District Meters, 15/WM/08/55, published 25/02/2015

- A proactive leakage monitoring approach shall be applied where trunk main losses form a significant element (>5%) of total leakage or the MLE water balance gap is greater than +/-2%. This approach shall be a combination of field inspections, analytical techniques, and flow balance methods. The selection of methodology and level of leakage monitoring activities shall reflect the proportion of estimated losses in relation to total leakage and the characteristics of the network; and
- Companies with trunk main losses greater than 5% of total reported leakage shall review and refresh estimates annually.

Where the company does not employ physical survey or mass balance, it shall obtain assurance from its external assessors that its approach and stated uncertainty is appropriate.

Service Reservoir Losses

The ideal approach is a mass balance approach with inlet and outlets metered. However, circumstances can mean that other approaches to estimating losses are appropriate. Where this is the case, the company shall justify them. Leakage can occur through the structure and valves; overflows may be passing water. Losses are generally less than other areas of leakage, hence the lower frequency of leakage surveys. Drop tests have been used for many years and can be an acceptable and proportionate method for identifying any material leakage. Estimates are expected to be updated annually but this does not require, for example, a company to undertake annual drop tests of all service reservoirs. Where a new drop test has been done that year, the results shall be included in the overall estimate.

The company is expected to estimate service reservoir leakage using the following criteria:

- company-specific data shall be used to assess the value of service reservoir losses;
- reservoirs with known high leakage, structural deficiencies or those that are at risk of water quality failures shall be investigated on an individual basis;
- drop tests are an appropriate approach and normally carried out in parallel with ongoing routine reservoir inspection programmes. Drop tests shall be carried out not less frequently than every 10 years and for at least 12 hours depending on the size of the reservoir. All valves shall be checked to ensure they are closed tight; and
- the company shall consider investigating the extent of losses through reservoirs. Where reservoirs are shown to be at risk of overflowing, appropriate monitoring arrangements shall be put in place to control and minimise overflow events.

Annual Average Leakage

Annual average leakage is reported as the sum of distribution leakage from continuous DMA or zone monitoring, areas not covered by continuous monitoring, trunk main leakage and service reservoir leakage.

1.2.4 Water Balance Components

The information and assumptions made for leakage, per capita consumption and business demand PCs must be consistent and be based on the same water balance calculations. If any information is restated for one of the PCs, the others must also be restated if there is any impact on them.

Distribution Input

Distribution input (DI) is a measure of the volume of potable water input to the distribution network at treatment works, boreholes, and bulk supply locations. DI is reported as an annual average Ml/d.

The company is expected to report DI using the following criteria:

- The company shall meter DI to the system with at least daily readings at all defined locations;
- The meters that the company uses shall be an appropriate size for the flow to be measured and located at appropriate inputs to the network confirmed by record plans. The company shall exclude any treatment works take-off downstream of a meter from the DI calculations;
- The company shall carry out data validity checks at least monthly;
- The company shall infill any missing data using both pre- and post- data for the location over at least one month, extrapolated from pump hours or use of upstream or downstream meters;
- The company shall check and validate data transfer systems from meter output to central database on a risk-based frequency from one up to two years; and
- Meters can be verified or calibrated in situ in accordance with the guidance later in this document.

Measured and unmeasured consumption

There are separate performance commitments for per capita consumption (PCC) and business demand. The company methodology and assumptions must be consistent between all three performance commitments.

For the water balance it is not necessary to derive PCC. The company should use the total volume of unmeasured household consumption and measured household

consumption. This removes the need for assumptions regarding occupancy or population data and the uncertainty in the estimates do not need to be considered as part of MLE calculations.

Company Own Water Use

Many water and sewerage companies have significant water use at their sewage treatment works and other major assets. The driver for metering is not only accounting for water in the balance but to allow use as part of leakage monitoring and reporting. Many companies have water efficiency targets to meet and metering is an enabler to achieve these.

Distribution system operational use comprises water knowingly used by the company to meet its statutory obligations particularly those related to drinking water quality. This includes, amongst other things, mains flushing, air scouring, swabbing, service reservoir cleaning, discharge to control pH and other chemical parameters in distribution. Water taken for commissioning of assets or as part of other legitimate network use shall be included. The company shall take a proportionate approach and may apply an industry average. The company must justify and evidence the estimate it uses.

The company is expected to report using the following criteria:

- all sewage treatment sites and other key assets using greater than 10 m3 /d (0.01 Ml/d) shall be metered;
- an estimate of total company own use shall be included in the water balance, based on a clear methodology and actual data; and
- where an estimate of distribution operational use is greater than 0.6% of distribution input then this value needs to be clearly stated and justified. There should be no change to current assumptions unless clearly evidenced.

Other Water Use

This component comprises water delivered both legally and illegally.

Water taken legally unbilled shall include all water supplied for legitimate purposes but which is unbilled and not reported as water delivered to billed customers. It can include public supplies for which no charge is made such as some sewer flushing, uncharged church and other supplies, firefighting and training where not charged. The measure excludes leakage allowance rebates for measured customers. The company shall take a proportionate approach and may apply industry averages. Where use is

greater than 1.2% of distribution input the company will clearly evidence and justify that it is greater.

Water taken illegally unbilled is not permitted to be taken and so is unbilled. It shall only be reported here if it is based on actual occurrences using sound and auditable identification and recording procedures. This includes water use in void properties. The company shall take a proportionate approach and may apply industry averages. Where use is greater than 0.6% of distribution input this is to be clearly evidenced and justified.

The company is expected to report Other Water Use using the following criteria:

- other use components should be based on the company's own data;
- the company must justify and evidence the estimate it uses; and
- estimates should be updated when there is a material increase or decrease to volumes.

Meter under and over-registration (MUR)

Any measurement is subject to an element of error. Some meters may under-read (under registration) and some over-read (over registration).Within the calculation of leakage the company may use metered data taken from:

- Distribution Input (DI) meters;
- customer meters;
- night use monitor meters;
- PCC monitor meters; and
- night flow meters.

There is potential for both meter under and over registration to impact on estimates for distribution input, night flow, HHNU, NHHNU, unmeasured consumption, measured consumption and the water balance.

Dependant on technology and the flow through the meter, there may be no bias (to either under or over read). Any adjustment applied to any meter readings shall therefore be supported by sufficient evidence which shall be published to accompany the company's APR. Any such adjustment to meter readings shall be reviewed annually.

Meter accuracy can be checked either by in situ verification or calibration or by removing meters for off-site testing in an accredited test rig. In situ checks can either be:

- calibration – using the manufacturer's specific recommendations for checking that the meter functions in accordance with their specification; or
- verification against a second reference meter (transfer standard) – which will be installed for a short period in line with the meter to be checked

For all in-situ checks the company shall follow the Abstraction Metering Good Practice Manual 2016 published by the Environment Agency. [11]

In the case of revenue meters, checks are often undertaken on a representative sample of the meters removed as part of the company's routine meter replacement programme and the results from these checks extrapolated over the meters in service.

The company shall make any adjustment to the sum of meter readings used in the water balance calculation consistently each year. The company shall provide compelling evidence to support any calibration or verification of greater than +/-3%.

Any meter check which results in an adjustment greater than 5% shall prompt the company to further investigate and to install a more accurate metering solution as soon as is reasonably practicable.

The company shall set out its approach to stopped meters and demonstrate that there is no double counting between stopped meters in consumption from billing data and MUR.

1.2.5 MLE Adjustment

Concept

The basic assumption is that: Distribution Input shall equal the sum of water delivered to customers and used for other purposes and the leakage from the company's network.

As this is averaged over a year, any change in service reservoir storage will not be material.

[11] 'EA Abstraction Good Metering Guide', Environment Agency, version 3.4, February 2014

The company shall apply the methodology for estimating water balances set out in the Demand Forecasting Methodology report.[12] The company shall calculate an initial balance of all components to identify the extent of any water balance gap. The company will then distribute this gap to the components of the water balance by reference to the size and uncertainty surrounding each component of the water balance.

The water balance gap is defined as: 'the difference between distribution input and the sum of water delivered to customers, a company's own water use, water delivered unbilled, distribution system use and leakage. The water balance gap is positive where distribution input is more than the sum of components and negative where distribution input is less than the sum of components.'

We expect companies to achieve a water balance gap within ±2%. A gap greater than ±2% is non-compliant with reporting requirements; in such circumstances, the company is required to explain the reasons for the gap.

A water balance gap >+5% or < -5% indicates a significant inconsistency in one or more of the major components and is too wide for a valid MLE adjustment to be carried out. The company shall add any water balance gap in excess of the +5% gap, expressed as Ml/d, to the leakage component. In addition, for any water balance gap >+5% or < -5%, the company shall ensure a thorough review of all material components of the water balance is carried out and report this in its APR.

The company is expected to:

- set out its approach to MLE;
- apply the MLE methodology and identify any water balance gap;
- disclose and explain the reasons for any water balance gap exceeding 2% of distribution input;
- add any water balance gap in excess of +5% gap, expressed as Ml/d, to the leakage component; and
- revisit all material components of the water balance where the water balance gap is >5% or < -5% and report the results in the company's APR.

No elements of the water balance should be excluded from the MLE. The expected components of the MLE are as listed below:

For companies estimating leakage at DMA level:

- Measured household consumption (excl. SPL);

[12] Demand Forecasting Methodology, UKWIR

- Unmeasured household consumption (excl. SPL);
- Measured non-household consumption (excl. SPL);
- Unmeasured non-household consumption (excl. SPL);
- Distribution system operational use;
- Water taken legally unbilled consumption (excl. SPL);
- Water taken illegally unbilled;
- DMA leakage;
- Supply pipe leakage (SPL);
- Trunk mains leakage;
- Service reservoir leakage; and
- Distribution input.

For companies estimating leakage at zonal level:

- Measured household consumption (excl. SPL);
- Unmeasured household consumption (excl. SPL);
- Measured non-household consumption (excl. SPL);
- Unmeasured non-household consumption (excl. SPL);
- Distribution system operational use;
- Water taken legally unbilled consumption (excl. SPL);
- Water taken illegally unbilled;
- Distribution losses;
- Supply pipe leakage (SPL); and
- Distribution input.

Confidence Intervals

The MLE methodology requires the company to determine a confidence interval for each component of the water balance. This is to reflect the accuracy of each of the components. Best practice is to derive a statistical measure of accuracy for each component although this is difficult in practice. The confidence intervals can have a significant impact on the water balance, particularly for leakage and per capita consumption. There is therefore a need to be prescriptive in the approach to defining the range of confidence intervals

The uncertainty for the household unmeasured component of the water balance will in turn depend on the coverage and accuracy of the household monitor.

The company must have sufficient justification for the confidence intervals it uses and provide evidence of how these have been derived. In particular, the uncertainty for the household unmeasured component of the water balance will in turn depend on the coverage and accuracy of the household monitor. The company shall receive and publish external assurance that its confidence intervals for all components of the water balance are appropriate and in line with evidence. It is expected that companies' confidence intervals will fall within the following ranges:

- fully measured components such as distribution input should have a range from 2% to 4%;
- mainly measured with some estimated adjustments such as measured volumes with supply pipe losses and meter under-registration: from 2.5% to 5%;
- estimated using detailed and reliable methods such as distribution leakage and unmeasured household (including PCC): from 8% to 12%; and
- broad estimates not fully detailed or reliable such as trunk main leakage and water delivered unbilled components: from 20% to 50%.

The company shall have compelling evidence if it uses confidence intervals outside these ranges and bring it to the attention of Ofwat.

Reported Total Leakage

Total leakage is taken as the sum of the post MLE values for distribution leakage, including supply pipe leakage, and trunk main / service reservoir leakage. It is expressed as an annual average Ml/d value to one decimal place, consistent with the performance commitment measure.

The information and assumptions made for leakage, per capita consumption and business demand PCs must be consistent and be based on the same water balance calculations. If any information is restated for one of the PCs, the others must also be restated if there is any impact on them.

1.3 Specific exclusions

None.

1.4 Reporting and assurance

The company shall have a written methodology or procedure in place for reporting total leakage. The company shall review its methodology or procedure annually and update it as required.

The company shall also report leakage as a three-year average in Ml/d to one decimal place, corresponding to the percentage reduction reported.

The company shall ensure that its outcome delivery incentive payments only relate to real performance changes and not definitional, methodological or data changes in performance commitments.

Compliance checklist

The company shall complete the checklist below and report to Ofwat if any element is not green. Where an element is not green, we may intervene to protect customers and ensure that the company does not benefit from insufficient data quality. See Annex 1 for assessment rules for each element.

Table 1 – Compliance checklist for leakage

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
1	**Coverage**				
1a	At least 95% of all properties have continuous night flow monitoring throughout the year				
2	**Availability**				
2a	Above 90% of all properties within continuous night flow monitoring networks available for reporting night data throughout the year.				
3	**Properties**				
3a	All properties mapped to defined zones or DMAs (District Meter Area) using geo-location or similar methods				
3b	Consistency of property numbers contained within DMAs or zones within				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
	company billing system. Valid differences explained.				
3c	Properties that are defined as void excluded from night use allowances unless evidence for use of losses from illegal occupation is available.				
3d	Leakage allowance for properties not within DMAs or monitored zones consistent with other leakage estimates.				
3e	Property data updated at least annually.				
4	**Night flow period and analysis**				
4a	Night flow data frequency at least every 15 minutes				
4b	Leakage derived from a fixed period during the night of at least a one hour period and up to two hours.				
4c	If the fixed period is varied during the year for some or all DMAs or zones to address significant changes to night use patterns, such as during Ramadan, evidence for this is provided.				
4d	Leakage allowance applied for properties not within DMAs or monitored zones is consistent with other leakage estimates.				
4e	Data infilling for a single DMA or zone/tile does not use more than three months of historical data before moving to the area average.				
4f	Data infilling where historical data is not available uses the area average in which the DMA or zone/tile is located.				
4g	When a DMA or zone/tile is restored to operability, the subsequent leakage data is used to retrospectively update the data infilling interpolating between pre- and post- data over at least one month.				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
4h	Where properties are continuously monitored, the actual values of flow over the night flow period are used in place of estimates within the night flow analysis.				
4i	Weekly leakage estimates are used for annual reporting with no exclusions for summer months				
4j	Negative leakage values are used in compiling values of annual average leakage				
4k	The reasons for any prolonged periods of negative leakage are investigated and explained.				
5	**Household night use (HHNU)**				
5a	The night time period for HHNU is the same time period as used for night flow and NHHNU.				
5b	Own data or shared data with proximate companies is used for HHNU.				
5c	Plumbing losses are included and based on own data.				
5d	Evidence that survey is representative (based on demography, property type or other factors) of the company as a whole.				
5e	Sample size is sufficient to capture continuous and intermittent night use with reasonable confidence.				
5f	Continual monitoring and maintenance of IHM (individual household monitor) and SAMs (small area monitors) monitors.				
5g	HHNU is derived daily with regular adjustment of values on a weekly or monthly frequency to reflect actual				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
	seasonal use. This may be done retrospectively.				
6	**Non household night use (NHHNU)**				
6a	The time period for NHHNU is the same time period as used for night flow and HHNU.				
6b	Own data or shared data with proximate companies is used for NHHNU.				
6c	1999 UKWIR methodology with the appropriate time window as used for the night flow and the published outcome of further methodology development is applied.				
6d	Stratification of non-households to a number of groups and consumption bands is representative of the varying characteristics of commercial and industrial properties.				
6e	Sample size is sufficient to capture night use by stratification with reasonable confidence.				
6f	Reliable and representative average billed volume (ABV) model based on data logging of the representative sample sufficient to capture demand variations with further seasonal logging where relevant. Continuously logged properties not part of the sample.				
6g	ABV model linked to billing system or replacement database of billed volumes. Average billed volumes updated at least annually.				
6h	Continuous monitoring of selected NHH is carried out where average demand of an individual non-household has a material impact on the ability for a DMA				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
	or zones to provide valid and consistent data within operability limits.				
7	**Hour to day conversion**				
7a	The hour-to-day factor is derived separately for each DMA or zone using pressure logging within each DMA or zone. The factors are updated at least annually or where there are any significant changes to pressure regimes.				
7b	As an alternative, hydraulic models reflecting latest network configuration and pressure changes, are used if they disaggregate in sufficient detail at sub-zone level.				
7c	Evidence based N1 value used. Expected range is 1.0 to 1.20				
8	**Annual distribution leakage**				
8a	Average weekly data is derived from valid daily values of leakage using data points which are representative of the week. Backfilling using the methods described in night flow analysis – is done when valid data is not available for three or more data points.				
8b	The annual value of leakage expressed as Ml/d (Mega-litres per day) is to be derived from an average of the 52 week data.				
9	**Trunk main losses (only applicable if DMA level leakage assessment used).**				
9a	Company-specific data is used to assess the value of trunk main leakage, using either physical surveys and inspections or a mass balance approach.				
9b	Proactive leakage monitoring approach applied where trunk main losses form a				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
	significant element of total leakage, or the MLE (maximum likelihood estimation) water balance gap is greater than +/-2%.				
9c	If trunk main losses greater than 5% of total leakage estimates reviewed annually.				
10	**Service reservoir losses (only applicable if DMA level leakage assessment used).**				
10a	Company specific data is used to assess the value of service reservoir losses.				
10b	Reservoirs with known high leakage, structural deficiencies or at risk of water quality failures are investigated on an individual basis.				
10c	Drop tests (12 hour duration depending on size) carried out every five or ten years. All valves checked for tight close; and losses through overflows investigated. Appropriate monitoring arrangements in place to control and minimise overflow events.				
11	**Distribution input (DI)**				
11a	Distribution input to the system is metered with at least daily readings at all defined locations				
11b	Meters are appropriate size for the flow to be measured and located at appropriate inputs to the network confirmed by record plans. Any treatment works take-off downstream of a meter are excluded from the DI calculations.				
11c	Data validity checks are carried out at least monthly.				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
11d	Missing data is infilled using both pre- and post- data for the location over at least one month, extrapolated from pump hours or used of upstream or downstream meters.				
11e	The data transfer systems from meter output to central database are checked and validated on a risk-based frequency from one up to two years.				
11f	Flow checks are carried out on DI meters consistent with the principles of the document 'EA Abstraction Good Metering Guide' and in particular the frequency of flow checking defined in Table 6.2 of the Environment Agency guide.				
12	**MUR**				
12a	Meter under-registration (MUR) is applied consistent with own estimates. Evidence of MUR available and is compelling for MUR above 3%.				
13	**Company own water use**				
13a	All sewage treatment sites, and other sites and assets supplied downstream of the DI meters using greater than 10m3/d (0.01 Ml/d) are metered.				
13b	An estimate of total company own use is included in the water balance, based on a clear methodology and actual data.				
13c	Estimate of distribution operational use is evidence based and not greater than 0.6% of distribution input.				
14	**Other water use**				
14a	Other use components are based on own data.				
14b	Estimate of water delivered unbilled (legally and illegally) is evidence based				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
	and not greater than 1.8% of distribution input.				
14c	Estimates are updated when there is a material increase or decrease to volumes.				
15	**Water balance and MLE**				
15a	Fully measured components have a range within 2% to 4% or there is compelling evidence of an alternative range.				
15b	Mainly measured with some estimated adjustments have a range within 2.5% to 5% or there is compelling evidence of an alternative range.				
15c	Estimated using detailed and reliable methods have a range within 8% to 12% or there is compelling evidence of an alternative range.				
15d	Broad estimates not fully detailed or reliable have a range within 20% to 50% or there is compelling evidence of an alternative range.				
15e	Water balance discrepancy: <2% = G, >2% and <3% = A, >3% =R				
16	**The information and assumptions made for leakage, per capita consumption and business demand PCs is consistent and be based on the same water balance calculations.**				

Table 2 Definition parameters

Parameters	
Measurement unit and decimal places	Percentage reduction from 2019-20 baseline, reported to one decimal place. The volumetric levels resulting from the application of

Parameters	
	the percentage reduction in megalitres per day (Ml/d) reported to one decimal place.
Measurement timing	Reporting year
Incentive form	Revenue
Incentive type	Outperformance and underperformance payments
Timing of underperformance and outperformance payments	In-period
Price control allocation	100% water network plus
Frequency of reporting	Annual
Any other relevant information	Performance commitment levels are set as percentage reduction from 2019-20 baseline. Incentive payments relate to performance changes expressed in megalitres per day (Ml/d).
Links to relevant external documents	N/A

Annex 1 Compliance Checklist

This annex sets out the criteria on which to report checklists where specified in the performance commitment definition.

Compliance for elements is reported against:

R	Not compliant with the guidance and having a material impact on reporting
A	Not compliant with the guidance and having no material impact on reporting
G	Fully compliant with the guidance

An overall RAG to be assigned for each component based on the following rules: Compliance for overall components is reported against:

R	There are one or more red elements in the component, or the combined effect of amber elements is considered to produce a material impact.
A	Half or more of the elements in the component are amber and the combined effect of the amber elements is considered not to produce a material impact
G	More than half of the elements in the component are green

For each component on the checklist, and for the overall performance measure, the company will report a confidence grade. Confidence grades provide a reasoned basis for the company to qualify the reliability and accuracy of the data.

The company shall employ a quality assured approach in the methodology used to assign confidence grades, particularly if sampling techniques are in place. The confidence grade combines elements of reliability and accuracy, for example:

A2 – Data based on sound records etc. (A, highly reliable) and estimated to be within +/- 5% (accuracy band 2) Reliability and accuracy bands are shown in the tables below.

Reliability Band	Description
A	Sound textual records, procedures, investigations or analysis properly documented and recognised as the best method of assessment.
B	As A, but with minor shortcomings. Examples include old assessment, some missing documentation, some reliance on unconfirmed reports, some use of extrapolation.
C	Extrapolation from limited sample for which Grade A or B data is available.

D	Unconfirmed verbal reports, cursory inspections or analysis.

Accuracy band	Accuracy to or within +/-	But outside +/-
1	1%	-
2	5%	1%
3	10%	5%
4	25%	10%
5	50%	25%
6	100%	50%
X	Accuracy outside +/- 100 %, small numbers or otherwise incompatible (see table below)	

Certain reliability and accuracy band combinations are considered to be incompatible, and these are blocked out in the table below.

Compatible confidence grades				
Accuracy band	Reliability band			
	A	B	C	D
1	A1			
2	A2	B2	C2	
3	A3	B3	C3	D3
4	A4	B4	C4	D4
5			C5	D5
6				D6
X	AX	BX	CX	DX