Environment Agency

Evidence

ROMANSE: (Risk Of Misclassification And Number of Samples Estimator) USER GUIDE

Report: SC080051/R2

Integrated catchment science programme

Evidence Directorate

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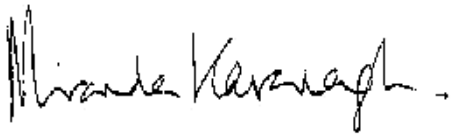

Miranda Kavanagh

Director of Evidence

Executive summary

The Water Framework Directive (WFD) requires that all European surface waters (rivers, lakes, estuaries and coastal waters) achieve environmental objectives set on a water body basis. In addition to producing a face value classification result, the Environment Agency is required to report the level of confidence and precision associated with water body classifications. In practice, uncertainty is reported as a risk of misclassification – i.e. the probability that the face value result places the water body in an incorrect status class.

In July 2009, WRc developed a spreadsheet tool called ROMANSE (Risk Of Misclassification And Number of Samples Estimator) to support the Environment Agency's WFD biological monitoring programme. ROMANSE allows users to explore the relationship between the number of samples taken per water body and the precision and confidence in the classification results, and can be used to plan and optimise biological monitoring activities. ROMANSE was designed to apply to rivers, and the examples used relate to biological measurements taken in rivers. The tool can be applied to biological quality elements in lakes, estuaries and coastal waters, however, so long as replicate samples taken from a water body each yield a separate Ecological Quality Ratio (EQR) value.

ROMANSE can be used to answer two main questions:

- How many samples are required to achieve a given level of confidence or risk of misclassification?
- What level of confidence or risk of misclassification can be expected for a given number of samples?

This User Guide documents the development of ROMANSE and helps first-time users to run ROMANSE and interpret its output. Specifically, it:

- Gives an overview of the WFD water body classification process;
- Introduces some key concepts concerning the reliability of the classification results;
- Explains the provenance of ROMANSE and its links to Variability In Spatial Component Objectively Unified Statistically (VISCOUS);
- Summarises its approach to classification;
- Lists the assumptions that it makes;
- Provides step-by-step instructions on how to set and run ROMANSE and how to interpret the output; and
- Provides two brief worked examples to illustrate the application of ROMANSE to real-life monitoring situations.

Contents

1 Introduction

In July 2009, WRc developed a spreadsheet tool called ROMANSE to support the Environment Agency's Water Framework Directive (WFD) biological monitoring programme. ROMANSE stands for 'Risk Of Misclassification And Number of Samples Estimator'. ROMANSE (v1.2) allows users to explore the relationship between the number of samples taken per water body and the precision and confidence in the classification results, and can be used to plan and optimise biological monitoring activities. ROMANSE was designed to apply to rivers, and the examples used relate to biological measurements taken in rivers. The tool can be applied to biological quality elements in lakes, estuaries and coastal waters, however, so long as replicate samples taken from a water body each yield a separate EQR value.

This User Guide documents the development of ROMANSE and helps first-time users to run ROMANSE and interpret its output. The guide is split into three main sections.

Section 2 gives an overview of the WFD water body classification process, introduces some key concepts concerning the reliability of the classification results, explains the provenance of ROMANSE and its links to VISCOUS, summarises its approach to classification, and lists the assumptions that it makes.

Section 3 describes what ROMANSE can and cannot do, and provides step-by-step instructions on how to set and run ROMANSE and how to interpret the output.

Finally, Section 4 provides two brief worked examples to illustrate the application of ROMANSE to real-life monitoring situations.

2 Background

2.1 The WFD classification process

The WFD requires that all European surface waters (rivers, lakes, estuaries and coastal waters) achieve environmental objectives set on a water body basis. The default objective is to achieve 'Good' status by 2015. Good status represents a composition of good chemical and good ecological status. The ecological status is an expression of the quality of the structure and functioning of biological elements associated with surface waters, classified in accordance with Annex V. Ecological status should be assessed via a deviation from reference condition approach using bio-assessment tools of selected quality elements (QEs) such as phytoplankton, macrophytes and phytobenthos, benthic invertebrate fauna and fish.

For each biological QE, the Environment Agency is required to classify surface water bodies into one of five status classes: High, Good, Moderate, Poor or Bad. Status is measured by an EQR between 0 and 1, where 0 corresponds to very low status and 1 correspond to very high status. The EQR result for each water body is based on one or more individual samples, which are assumed to be representative of conditions throughout the water body over a relevant reporting period. For the purposes of this user guide, a sample is defined as an individual measurement that yields an EQR value. For example, benthic invertebrate sample might be a 5-minute sweep of a site, or a single sediment core sample; a macrophyte sample might be a survey of plants along a 100 m length of river.

Boundaries have been set for each QE to translate the EQR result into a status class. For example, Table 2.1 shows how EQR scores map to status classes for the DARLEQ tool which assesses the status of diatom communities in rivers. This direct conversion of the EQR result is known as the face value class because it interprets the results at face value without reference to the uncertainty in the data.

Table 2.1 EQR class boundaries for diatoms in rivers.

Status Class Boundary	EQR
High/Good	0.93
Good/Moderate	0.78
Moderate/Poor	0.52
Poor/Bad	0.26

In addition to producing a face value classification result, the Environment Agency is required to report the level of confidence and precision associated with water body classifications. There will always be some uncertainty in the classification result because the true EQR of the water body cannot be estimated without error; samples can be taken only in certain locations at certain times and so we do not know what the biological conditions were like in unsampled locations and at unsampled times. In addition, there will always be some measurement error associated with each sample.

In practice, uncertainty is reported as a risk of misclassification (RoM) – i.e. the probability that the face value EQR result places the water body in an incorrect status class. Although we can never know the true status class of a water body, we can use the observed data and some basic statistical principles to estimate the probability of the water body truly being in each of the five status classes; this is known as a confidence

of class (CofC) assessment. For example, Table 2.2 shows a hypothetical confidence of class assessment for a water body with an EQR of 0.55. The result is close to the Poor/Moderate boundary but puts the water body in Moderate class. The confidence of class assessment gives 40 per cent that the true status truly is Moderate, 50 per cent confidence that the true status is worse than Moderate and 10 per cent confidence that the true status is better than Moderate. Overall, the risk of misclassification is 50 per cent + 10 per cent = 60 per cent and the confidence that the water body is worse than Good is 20 per cent + 30 per cent + 40 per cent = 90 per cent.

Table 2.2 Hypothetical confidence of class results for a water body with an EQR of 0.55.

EQR Range	Status class	Confidence of class
0.00 – <0.26	Bad	20%
0.26 – <0.52	Poor	30%
0.52 – <0.78	Moderate	40%
0.78 – <0.93	Good	10%
0.93 – 1.00	High	0%

The risk of misclassification must be stated in the River Basin Management Plans and will guide the development of cost-effective programmes of measures. Of particular interest is the confidence with which a water body can be classified as Good or better, or as Moderate or worse. If there is convincing evidence (i.e. high confidence) that a water body is failing to meet Good status, then a programme of measures must be put in place.

The level of confidence, or conversely the risk of misclassification, depends upon three main factors:

- the true status of the water body;
- the amount of variability in the biological quality element; and
- the number of samples taken.

The first two factors are fixed parameters, but the third can be altered. Specifically, the more samples that are collected, the greater will be the confidence in the classification result and the lower the risk of misclassification. The purpose of ROMANSE is to provide a simple and user-friendly way to understand this relationship between sampling effort and reliability of the classification result.

2.2 Provenance and relationship to VISCOUS

ROMANSE was developed to complement another spreadsheet tool called VISCOUS (Variability In Spatial Component Objectively Unified Statistically).

VISCOUS uses real monitoring data to estimate the status of a water body and perform a confidence of class assessment. The key feature of VISCOUS is that is it performs these calculations in a spatially explicit way. Specifically, VISCOUS recognises that ecological conditions within a water body can vary from place to place and adopts a flexible approach that can accommodate both homogeneous bodies (i.e. those that have no impacted areas and can be represented as a single spatial unit) and heterogeneous water bodies (i.e. those that have marked spatial discontinuities in conditions).

VISCOUS is a data analysis tool – it relies on the input of real monitoring data and produces a classification result. By contrast, ROMANSE is a planning tool – it does not require input of monitoring data and instead performs theoretical calculations to predict how the confidence of class results vary with the number of samples collected from a water body. The two tools are therefore complementary: ROMANSE predicts the type of results that VISCOUS would produce using a particular monitoring programme.

2.3 Approach to classification

The calculations in ROMANSE are based on those in VISCOUS and it is beyond the scope of this User Guide to give full details of the underlying conceptual model and statistical methodology. The following section therefore gives only brief details and interested readers are referred to Davey (2009), which gives full details of the development and application of VISCOUS.

ROMANSE is designed to deal with just one biological QE at a time. (The process by which multiple QEs are combined to give an overall assessment of ecological status is beyond the scope of this tool.) ROMANSE can be applied to any QE that yields an EQR for each individual, replicate sample. For example, a river water body might be sampled at six sites, and each sample yields its own EQR result between 0 and 1. Conversely ROMANSE cannot be applied to QEs where the results from replicate samples are pooled together to yield a single, overall EQR result for the water body as a whole, as happens for some lake, estuary and coastal water classification tools.

As ROMANSE is based on VISCOUS, it makes the same assumptions, the main ones being:

- That sampled sites are representative of the water body within which they are located, and also representative of conditions throughout the WFD reporting period; (ROMANSE deals with spatial variability but not temporal variability);
- That the EQR for each site provides a full, integrated measure of the conditions at that site throughout the reporting period; and
- That the EQR measurements of replicate sites within a water body follow a Normal distribution.

In essence this means that ROMANSE considers only the spatial variability from site to site within a water body and not the temporal variability in biological conditions at a site over time.

Unlike the VISCOUS default setting, however, ROMANSE assumes that each water body is homogeneous (i.e. it has a single stratum within which there is no marked discontinuity in ecological conditions); this has the benefit of simplifying the calculations whilst making little difference to the results.

ROMANSE considers three alternative measures of water body status (Figure 2.1):

- The mean EQR of the water body (MeanEQR), calculated as the average of the individual EQR results;
- The percentage of the water body that is worse than Good status (%NG); and
- The area (or length) of the water body that is worse than Good status (AreaNG), calculated as the product of %NG and the total area (or length) of the water body.

Mean EQR provides a measure of the average conditions within a water body, whereas %NG provides a more stringent test of the WFD's requirement for Good ecological status and helps to avoid missing local 'hotspots' of poor ecological quality. AreaNG works in a similar way to %NG, except that it is based on an absolute rather than a relative scale.

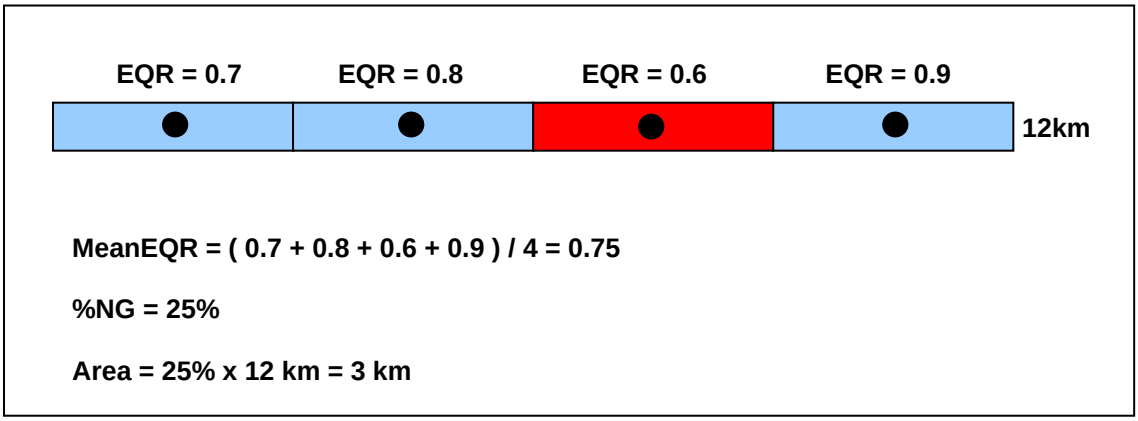

Figure 2.1 Three alternative measures of water body status.

To predict the confidence of class and risk of misclassification, ROMANSE requires an estimate of the expected amount of variability in ecological conditions (i.e. EQR scores) from site to site within a typical water body. Generic estimates of spatial variability have been pre-loaded into ROMANSE for four riverine biological metrics (see Section 3.4 and List of abbreviations for details):

- NTAXA (RICT)
- ASPT (RICT)
- TDI (DARLEQ)
- EQR (LEAFPACS)

Similar estimates can be entered manually for other biological metrics in lakes, estuaries etc, if required.

ROMANSE assumes that these generic estimates of spatial variability are constant, irrespective of water body typology and water body status. As discussed in Davey (2009, pp 25-26), these assumptions are unlikely to be true but for most biological classification tools there is currently insufficient data to derive estimates of spatial variability that are typology-specific or that vary as a function of the mean EQR of the water body.

3 Using ROMANSE

3.1 What ROMANSE does and does not do

ROMANSE is a planning tool; it can be used to help design a programme of monitoring within a particular water body but cannot be used to analyse the actual monitoring data generated by a monitoring programme.

ROMANSE can be used to answer two main questions:

- How many samples are required to achieve a given level of confidence or risk of misclassification? and
- What level of confidence or risk of misclassification can be expected for a given number of samples?

3.2 Worksheets

ROMANSE comprises 10 linked worksheets:

- The Settings and InputParameters worksheets allow you to control the information that is input into ROMANSE, and hence to run different scenarios;
- The Calcs worksheet contains all the intermediate calculations performed by ROMANSE; and
- The remaining seven worksheets display a series of graphs to help you interpret the results of the calculations.

Each of the worksheets is explained in more detail below.

3.3 Settings worksheet

The Settings worksheet (Figure 3.1) is the front page of ROMANSE. It gives some brief details of what ROMANSE does and what assumptions it makes, and lists the subsequent worksheets.

The most important part is the six cells in the middle of the worksheet. The bright yellow colour indicates that you can change these cells.

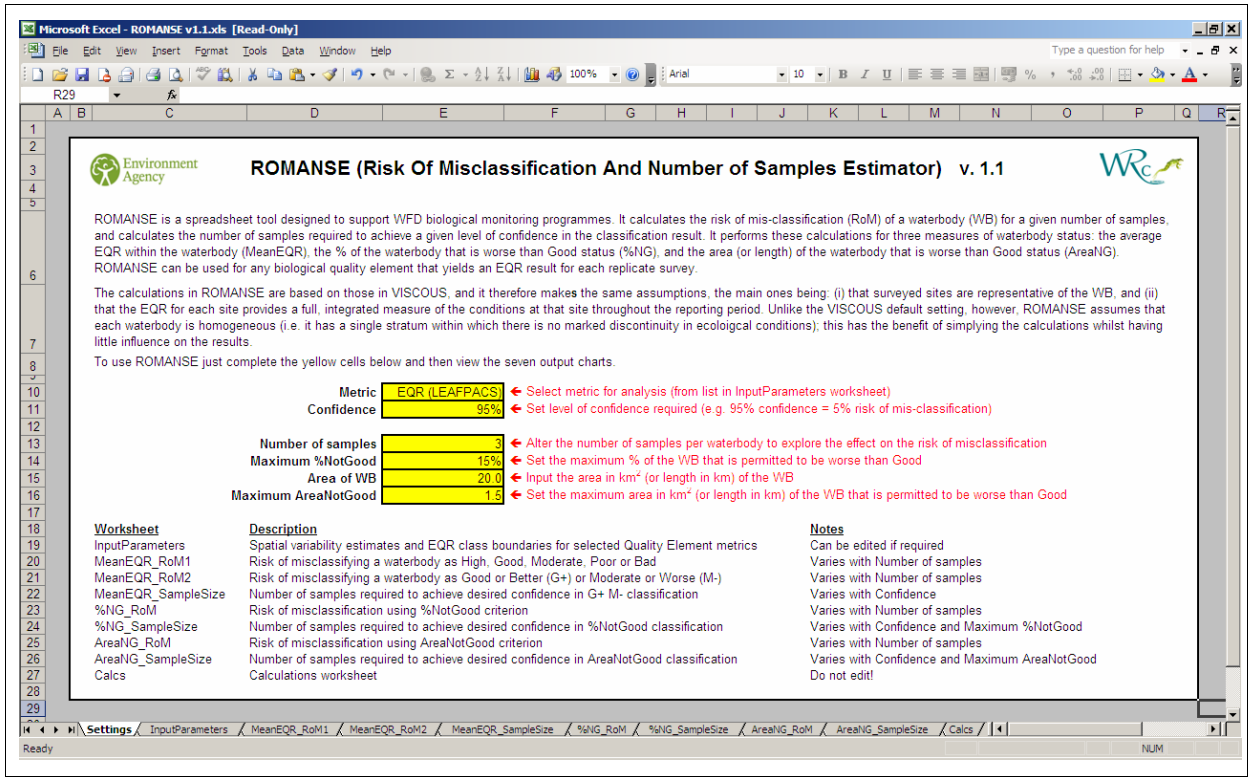

Figure 3.1 Settings worksheet.

The **Metric** cell allows you to select from a drop-down list the biological metric you are interested in. The drop-down list is propagated from the InputParameters worksheet. By default, ROMANSE comes pre-loaded with a choice of four riverine biological metrics: NTAXA and ASPT for the macroinvertebrate tool RICT, TDI for the diatom tool DARLEQ, and EQR for the macrophyte tool LEAFPACS. (Note that although the metrics all have different names, they all measure ecological status on an EQR scale running from 0 to 1.) The chosen metric is then automatically displayed on the horizontal axis of the graphs on the output worksheets.

Additional metrics can be added via the InputParameters worksheet. These metrics can be for rivers, lakes, estuaries or coastal waters.

The **Confidence** cell allows you to specify what level of confidence you require in the classification result. For example, a confidence of 95 per cent would mean that the target risk of misclassification is 5 per cent. The target risk of misclassification is shown as a horizontal dashed line in worksheets MeanEQR_RoM1, MeanEQR_RoM2, %NG_RoM and AreaNG_RoM.

The **Number of samples** cell allows you to enter how many sites you expect to be sampled in the water body. You can alter the number of samples to see how it affects the risk of misclassification in worksheets MeanEQR_RoM1, MeanEQR_RoM2, %NG_RoM and AreaNG_RoM. Section 4.1 provides a worked example.

The **Maximum %NotGood** cell allows you to specify what percentage of the water body is permitted to be worse than Good status before it is declared to be non-compliant. The default value is 15 per cent, which is based on a UK Technical Advisory Group (UKTAG 2007) recommendation that non-compliance should be defined as >15 per cent of the length or area of the water body being worse than Good status.

The **Area of WB** cell allows you to specify the area in km^2 (or length in km) of the water body that you are interested in. You only need to do this if you want to use AreaNG as a measure of water body status.

The **Maximum AreaNotGood** cell allows you to specify what area (or length) of the water body is permitted to be worse than Good status before it is declared to be non-compliant. Note that it does not have to be the product of 'Maximum %NotGood' and 'Area of WB'. The default value is 1.5 km^2 (or 1.5 km), which is again based on UKTAG (2007) recommendations.

3.4 InputParameters worksheet

The InputParameters worksheet (Figure 3.2) contains important details about each biological metric.

Each metric is listed on a separate row. ROMANSE comes pre-loaded with four riverine biological metrics. Additional metrics for rivers, lakes, estuaries or coastal waters can be added by inserting a new row below NTAXA.

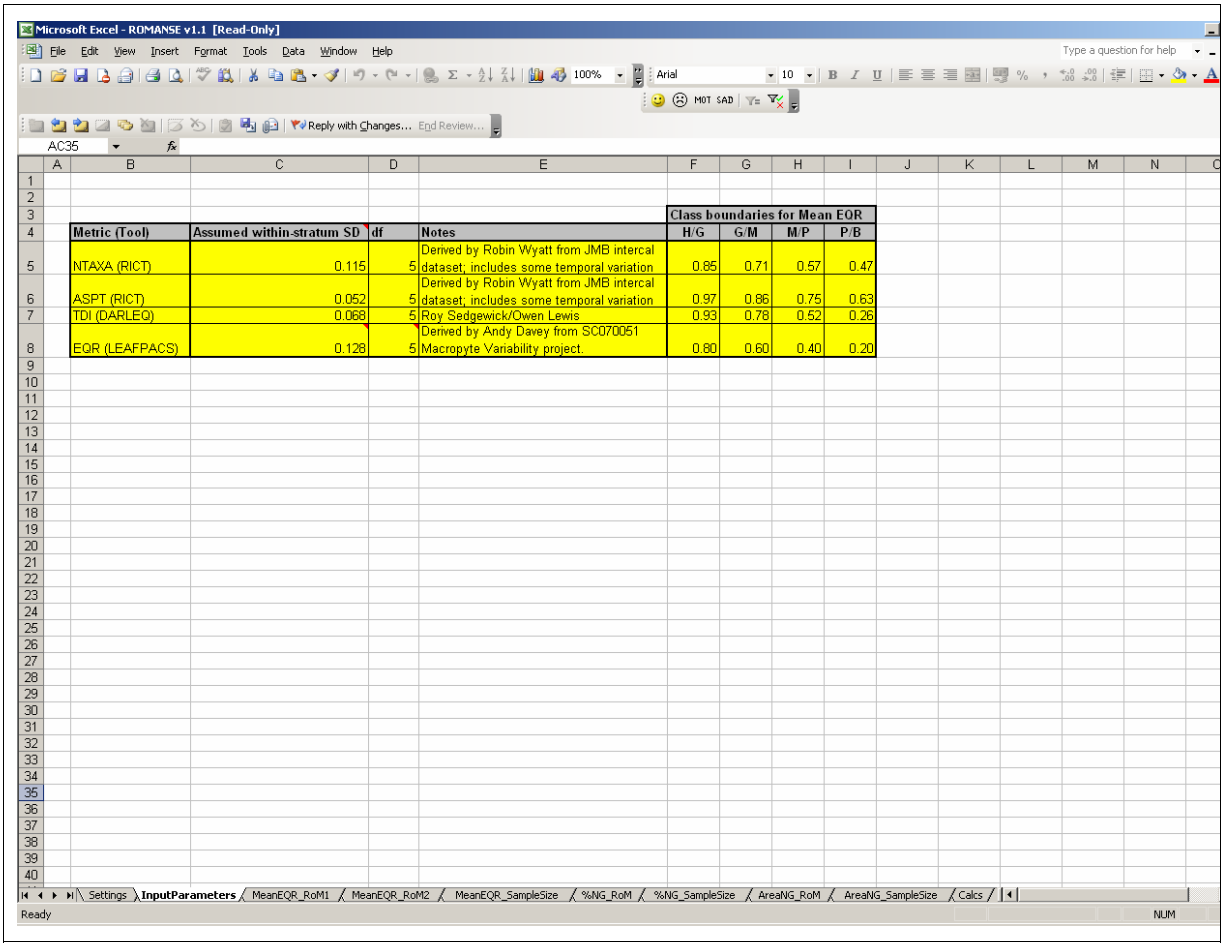

Figure 3.2 InputParameters worksheet.

Column C gives an estimate of the expected variability in EQR results from site to site in a typical water body (see Section 2.3 for how these are used). These are generic estimates that have been estimated in previous studies (Column E gives details of the derivation of these variability estimates). The pre-loaded variability estimates comprise spatial variability among sites plus measurement error, and therefore provide an estimate of how much variability one would typically expect to see between sites within a water body. In reality, these figures may include some temporal variation because it is often not possible to partition the total variation in the data into its components parts.

Column D gives the degrees of freedom associated with each estimate; this tells ROMANSE how much 'weight' to give to the generic estimates in the analysis. The default is 5. These values should not be changed unless there is a specific reason for changing the weights of the generic estimates.

Columns F to I give the EQR boundaries that delimit the five status classes. These are unique to each biological metric and have been set to reliably translate the mean EQR result into a face value class. For this reason they should not be altered.

3.5 MeanEQR_RoM1 worksheet

The MeanEQR_RoM1 worksheet (Figure 3.3) displays the risk of misclassifying a water body (vertical axis) as a function of the true mean EQR of the water body (horizontal axis). The horizontal axis is split into five status classes from Bad to High. The risk of misclassification is calculated based on metric and number of samples entered in the Settings worksheet. The horizontal dashed line shows the level of misclassification that we deem to be acceptable (i.e. if the confidence is set at 95 per cent in the Settings worksheet, then we are looking to get the misclassification risk down to 5 per cent).

There are three important features to note:

- For water bodies with a true EQR very close to zero or very close to 1, the RoM is extremely low. This reflects the fact that it is usually obvious when a water body is of Poor or High status;
- For water bodies with a true EQR right on the boundary between two status classes, the RoM will always be at least 50 per cent, irrespective of the number of samples. When spatial variability is low relative to the width of the status classes, there will be a 50:50 chance of accidentally over-estimating the EQR (and therefore placing the water body in the higher class), or of under-estimating the EQR (and therefore placing the water body in the lower class);
- When spatial variability is high relative to the width of the status classes, the risk of misclassification can actually exceed 50 per cent because the data suggest that the mean EQR might be in any of three or more status classes; and
- Between class boundaries, the risk of misclassification is less than 50 per cent and is lowest at the mid-point between two status class boundaries where over- or under-estimation of the true EQR is less likely to result in a misclassification.

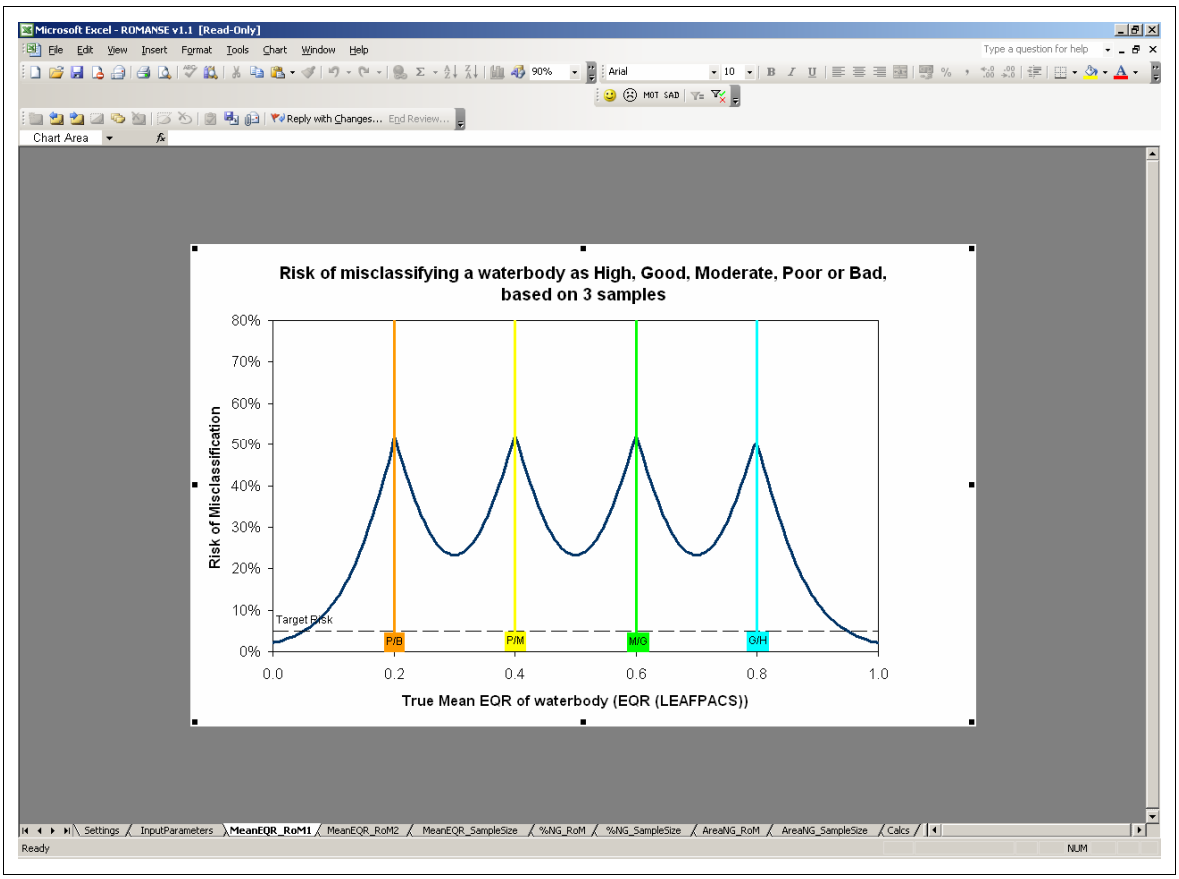

Figure 3.3 MeanEQR_RoM1 worksheet showing the risk of misclassifying a water body as High, Good, Moderate, Poor or Bad.

3.6 MeanEQR_RoM2 worksheet

The MeanEQR_RoM2 worksheet (Figure 3.4) displays the risk of misclassifying a water body (vertical axis) as a function of the true mean EQR of the water body (horizontal axis). The only difference between this worksheet and MeanEQR_RoM1 worksheet is that the horizontal EQR axis is split into just two classes: Good or better and Moderate or worse.

As with MeanEQR_RoM1, the risk of misclassification is highest (50 per cent) at the boundary of the two classes and lowest when the true EQR is near 0 or 1.

When the risk of misclassification falls below the dashed horizontal line, we can be confident that the risk of misclassification is acceptably small. In Figure 3.4, for example, we can be 95 per cent confident of correctly classifying a water body if its mean EQR is truly less than 0.45 or greater than 0.75 (highlighted with red arrows). Conversely, those water bodies that are closer to the Good/Moderate boundary (i.e. that have a mean EQR between 0.45 and 0.75) are inherently harder to classify correctly, and the confidence in the classification result for these water bodies is expected to be worse than 95 per cent.

A worked example showing how this worksheet might be used can be found in Section 4.1.

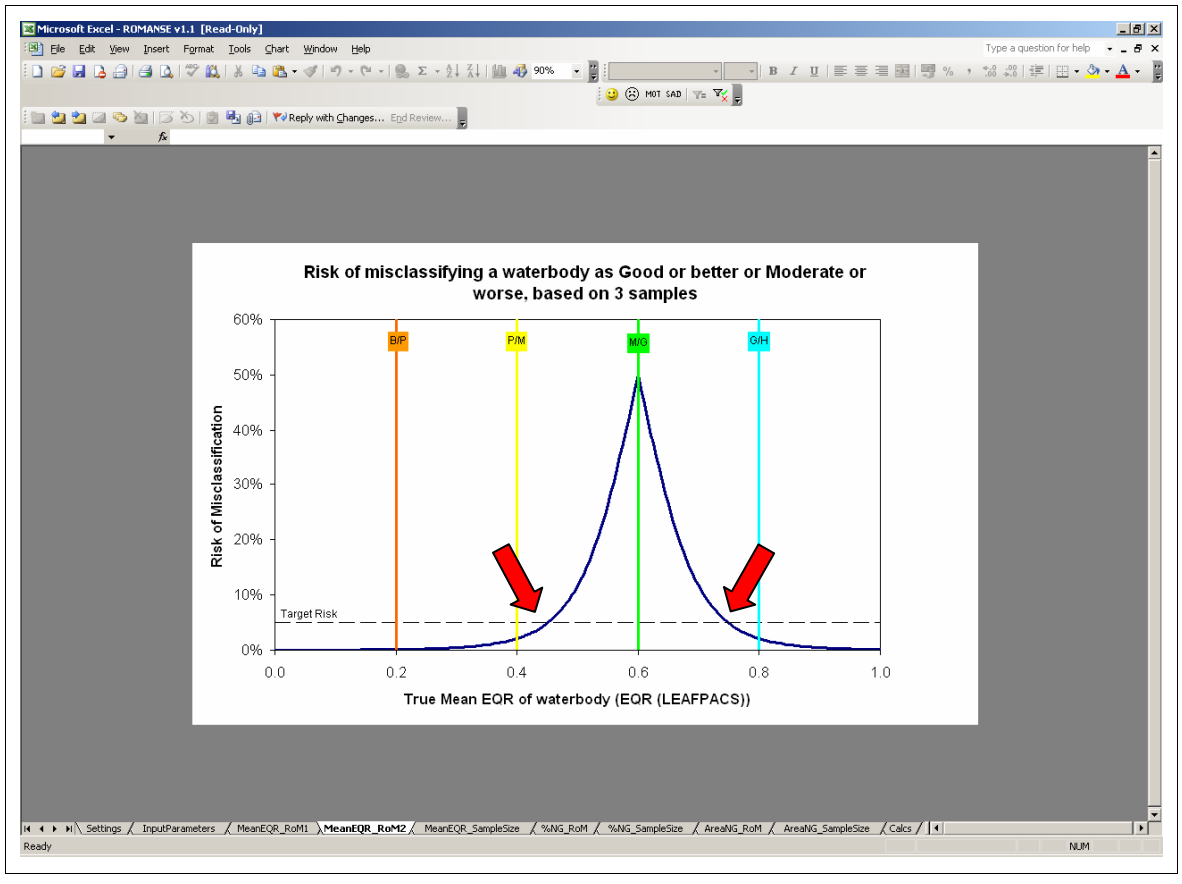

Figure 3.4 MeanEQR_RoM2 worksheet showing the risk of misclassifying a water body as Good or better or Moderate or worse.

3.7 MeanEQR_SampleSize worksheet

The MeanEQR_SampleSize worksheet (Figure 3.5) takes the confidence level entered in the Settings worksheet and uses it to compute how many samples would be required to be confident that the water body is either Good or better or Moderate or worse. The number of samples is plotted on the vertical axis and the true mean EQR is plotted on the horizontal axis.

There are two important features to note:

- When mean EQR is near 0 or 1, the number of samples required to meet the confidence criteria is theoretically less than one. The status of the water body should be obvious and therefore in practice only one sample would be needed to get a reliable measure of the true mean EQR; and
- When mean EQR is equal to the class boundary, the number of samples required to meet the confidence criteria is infinite as the RoM is always exactly 50 per cent. There is always a 50:50 chance of either over- or under-estimating the EQR and placing the water body in the wrong class, even with a very large number of samples.

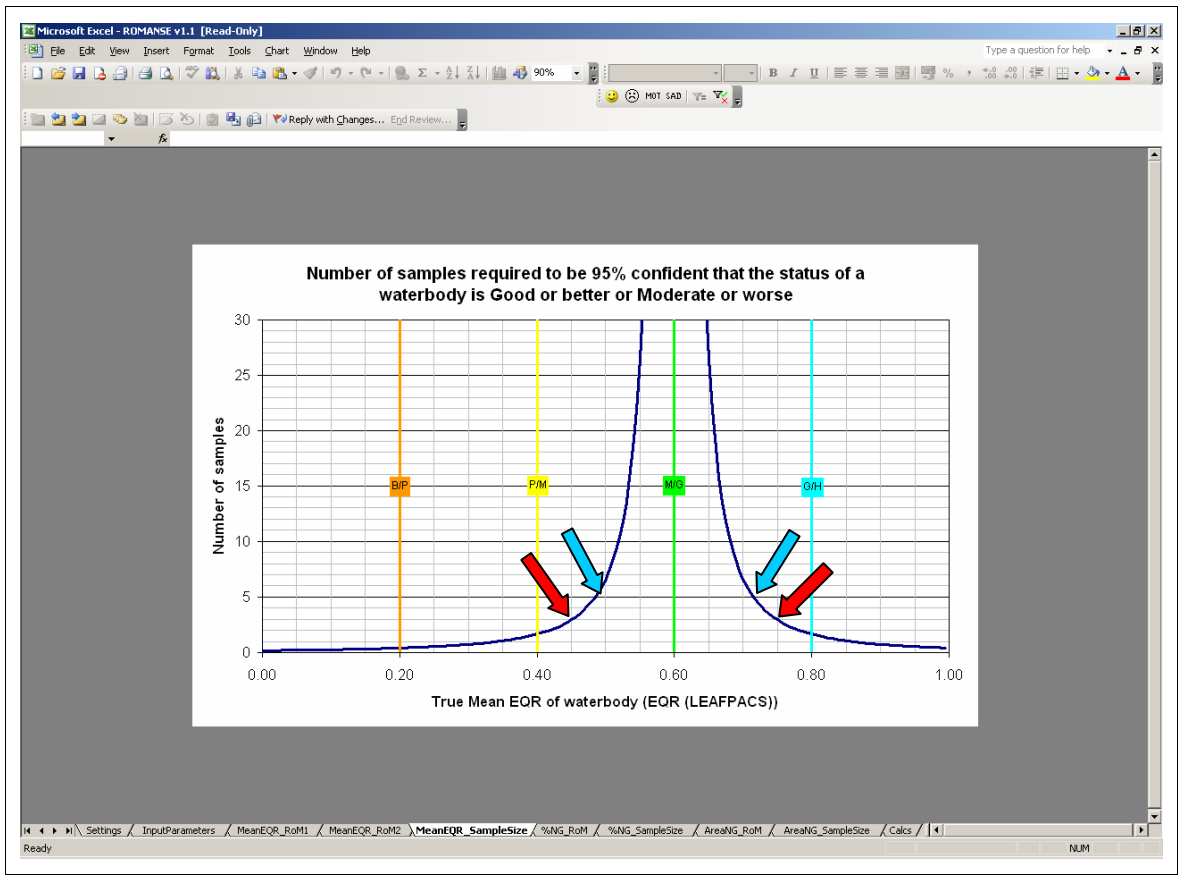

Figure 3.5 MeanEQR_SampleSize worksheet showing the number of samples required to be confident that the status of a water body is Good or better or Moderate or worse.

Using fewer samples means that the prescribed level of confidence is achieved only for water bodies where the true mean EQR is either quite low or very high. Increasing the number of samples means that the prescribed level confidence is achieved for a greater proportion of water bodies. For example, Figure 3.5 shows that if three samples are taken, 95 per cent confidence can only be achieved in the classification of water bodies with true mean EQRs of 0.45 or lower, or 0.75 or higher (highlighted by the red arrows). (Note that this corresponds with the results shown in Figure 3.4). However, taking five samples instead of three changes these limits to 0.49 and 0.72 respectively (shown by the blue arrows), meaning that those water bodies with EQRs of 0.45-0.49 or 0.72-0.75 are also now expected to be classified with 95 per cent confidence.

A worked example showing how this worksheet might be used can be found in Section 4.2.

3.8 %NG_RoM worksheet

The %NG_RoM worksheet (Figure 3.6) is similar to the MeanEQR_RoM2 worksheet (Section 3.6) except that the horizontal axis represents the true status of the water body in terms of the percentage area of the water body that is less than Good (%NG), rather than the mean EQR (Section 2.3). The horizontal dashed line shows the level of misclassification that we deem to be acceptable (i.e. if the confidence is set at 95 per cent in the Settings worksheet, then we are looking to get the misclassification risk down to 5 per cent). The vertical line shows the threshold of the maximum area of the water body that is permitted to be worse than Good, as entered in the Settings worksheet.

There are two important features to note:

- For water bodies where the true %NG is either very close to 0 per cent or close to 100 per cent, the RoM is extremely low. This reflects the fact that it is usually obvious when a water body is of very Poor or very High status; and
- For water bodies where the %NG falls right on the boundary between two status classes, the RoM is always 50 per cent, irrespective of the number of samples. This is because there is a 50:50 chance of accidentally over-estimating the %NG (and therefore accidentally failing the water body), or of under-estimating the %NG (and therefore accidentally passing the water body).

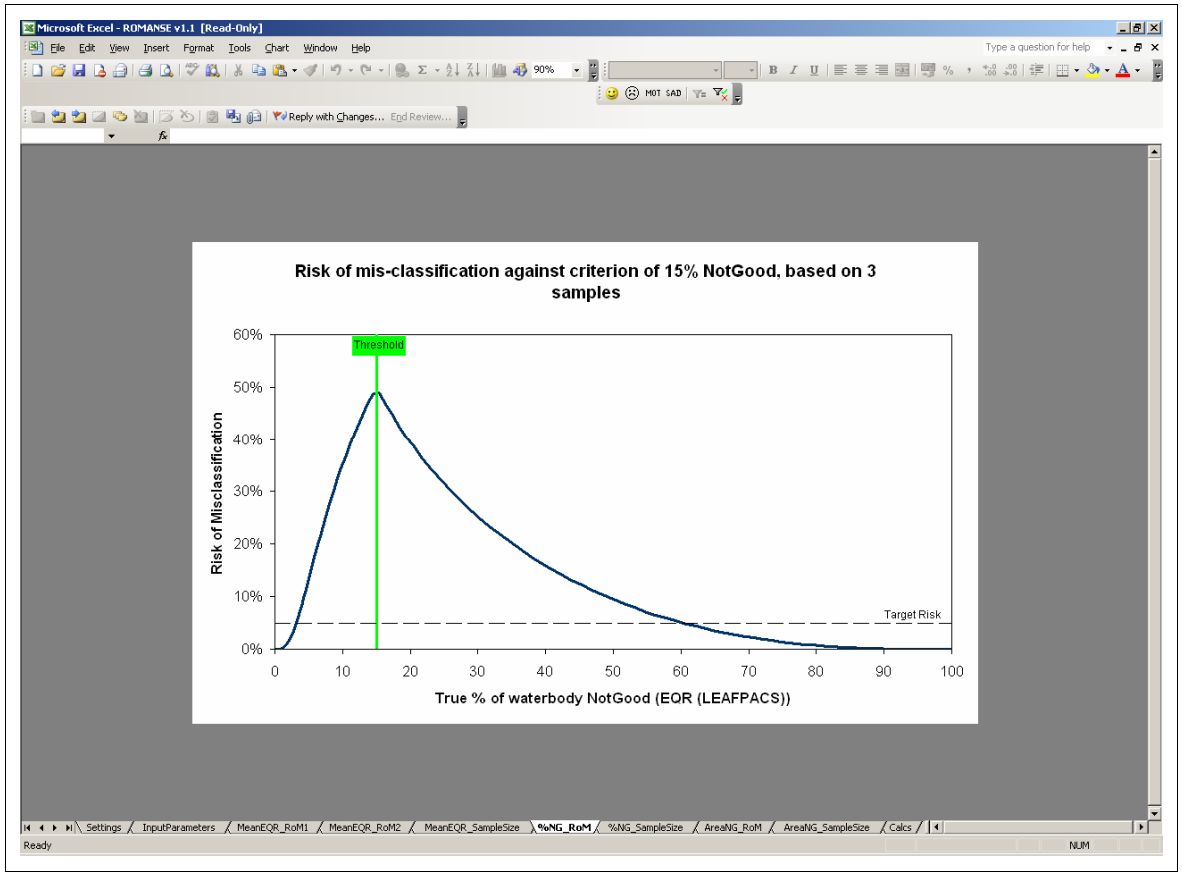

Figure 3.6 %NG_RoM worksheet showing the risk of mis-classifying a water body using the %NotGood criterion.

3.9 %NG_SampleSize worksheet

The %NG_SampleSize worksheet (Figure 3.7) is similar to the MeanEQR_SampleSize worksheet (Section 3.7) and represents the true status of the water body in terms of the area of the water body that is less than Good (%NG), rather than the mean EQR (Section 2.3). The vertical green line shows the maximum percentage area of the water body permitted to be Not Good, as entered in the Settings Worksheet.

This worksheet uses the confidence level from the Settings worksheet to calculate how many samples would be required to achieve that level of confidence in the classification result.

There are two important features to note:

- When the true %NG is very close to 0 per cent or close to 100 per cent, the number of samples required for the classification to achieve the confidence criterion is very low. The status of the water body should be obvious and therefore just one sample will usually be enough to get a reliable measure of the %NG; and
- At the threshold of the area permitted to be Not Good, the number of samples is infinite. There is always a 50:50 chance of either over- or under-estimating the %NG and thereby wrongly classifying whether the water body is below or above the threshold, even with a very large number of samples.

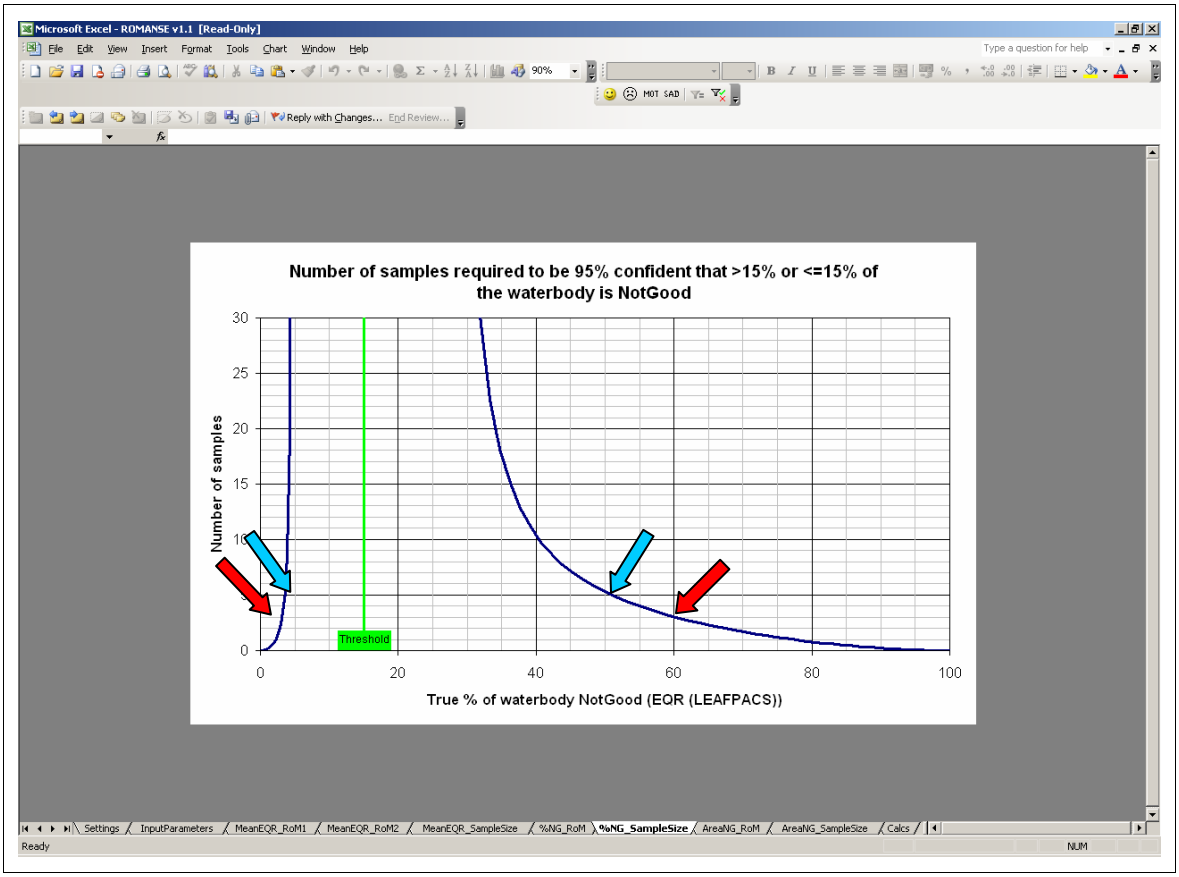

Figure 3.7 %NG_SampleSize worksheet showing the number of samples required to be confident that a given percentage of the water body is NotGood.

For example, Figure 3.7 shows that with three samples, 95 per cent confidence can only be achieved in the classification of water bodies with true %NG of 2.4 per cent or less, or 60 per cent or more (highlighted by the red arrows). Taking five samples instead of three changes these limits to 3.3 per cent and 50 per cent respectively (shown by the blue arrows), meaning that 95 per cent confidence would now also be achieved for water bodies with true %NG of 2.4-3.3 per cent or 50-60 per cent.

3.10 AreaNG_RoM and AreaNG_SampleSize worksheets

These worksheets (Figure 3.8 and Figure 3.9) work in exactly the same way as the %NG_RoM and %NG_SampleSize worksheets (Figure 3.6 and Figure 3.7), except that that the horizontal axis represents the true status of the water body in terms of the actual area of the water body that is worse than Good status (AreaNG), rather than the percentage area that is worse than Good (%NG; Section 2.3).

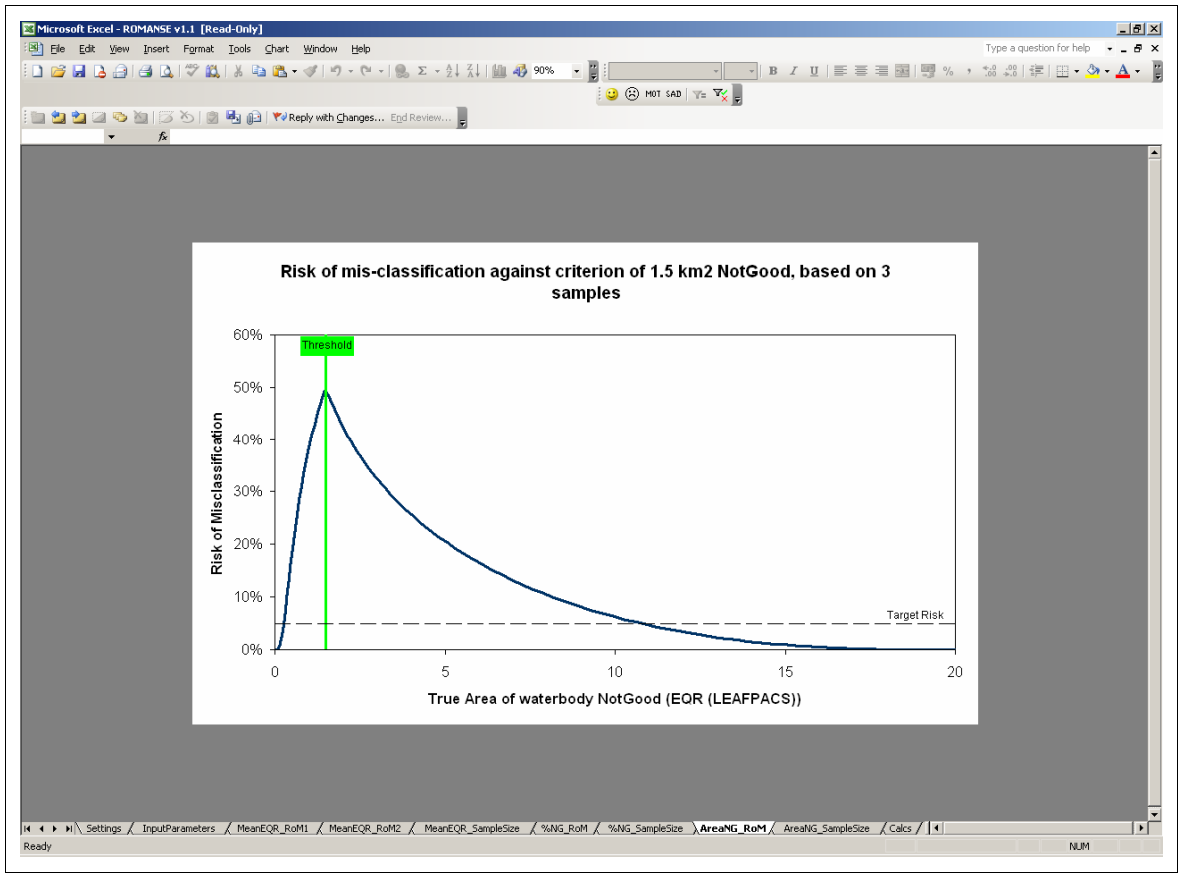

Figure 3.8 AreaNG_RoM worksheet showing the risk of misclassifying a water body using the % NotGood criterion.

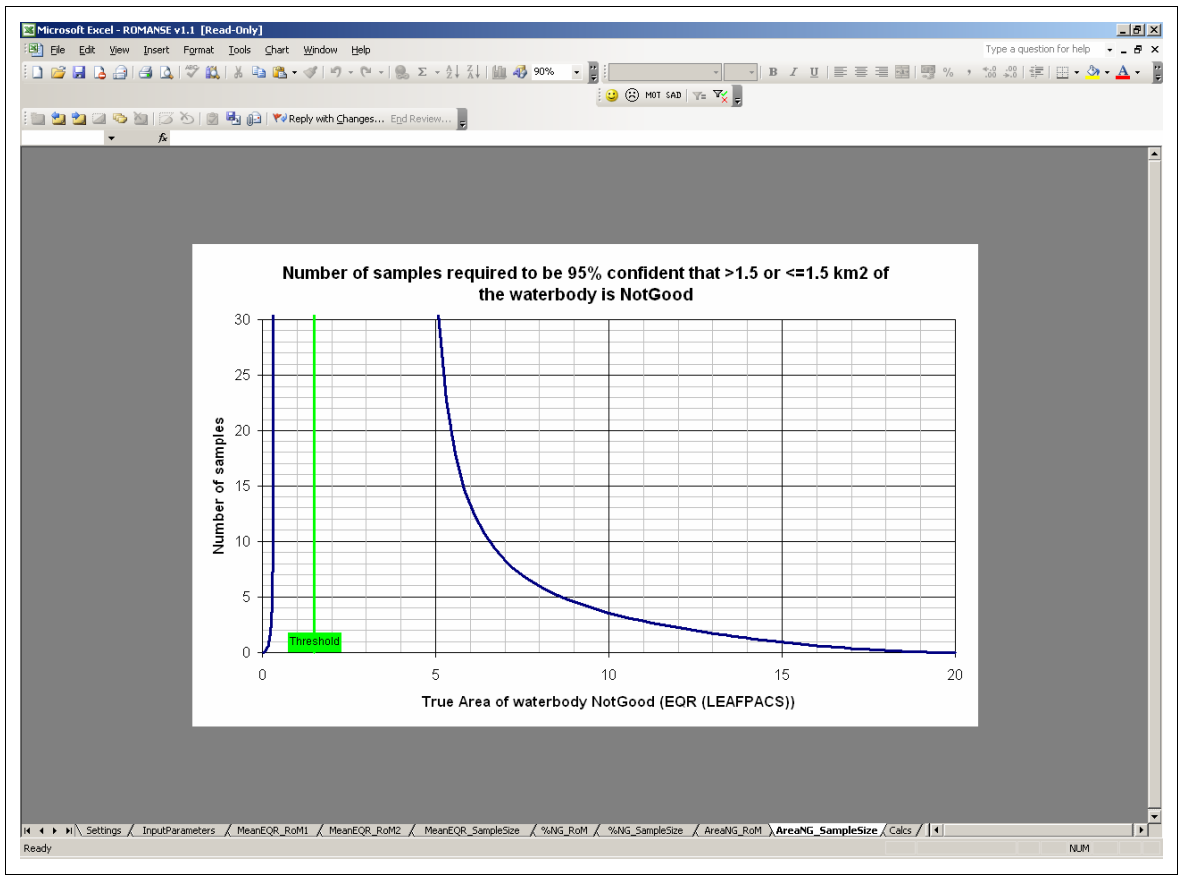

Figure 3.9 AreaNG_SampleSize worksheet showing the number of samples required to be confident that a given area of the water body is NotGood.

3.11 Calcs worksheet

The Calcs worksheet (Figure 3.10) contains all the intermediate calculations performed by ROMANSE. It should not be edited.

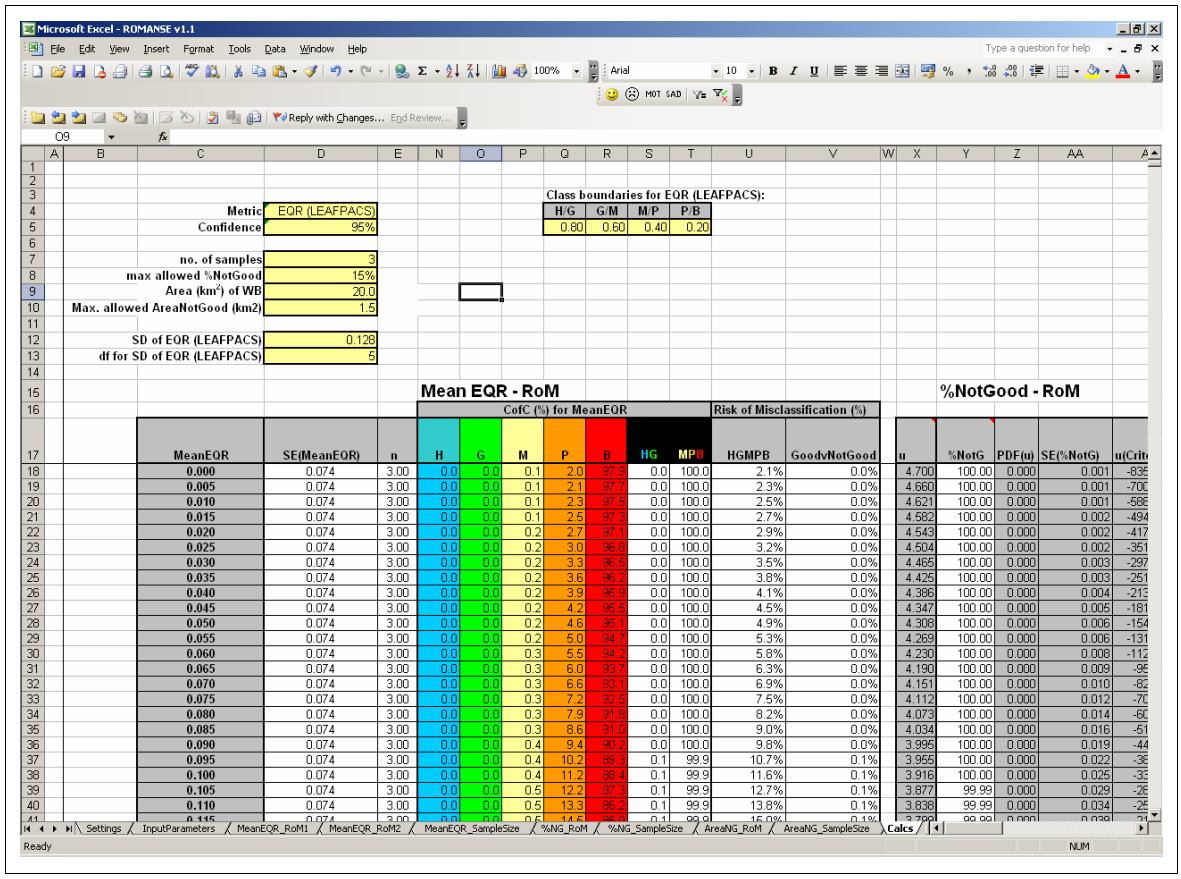

Figure 3.10 Part of the Calcs worksheet showing details of the intermediate calculations performed by ROMANSE.

4 Worked Examples

4.1 Example 1: Calculating the number of samples required

This first example shows how ROMANSE can be used to determine the number of samples required to achieve a given level of confidence in the classification.

To assess macrophytes in rivers (using the LEAFPACS tool) and classify water bodies using the mean EQR, the first step is to decide what risk of misclassification is acceptable; if this was 5 per cent, then Confidence would be set at 95 per cent on the Settings worksheet. The next step is to decide which water bodies you want to achieve this level of confidence. As per Section 3.6, the risk of misclassification will always be 50 per cent for any water body whose true mean EQR is right on the Good/Moderate boundary, so an appropriate statement would be: “the risk of misclassification should be less than 5 per cent for all water bodies with a true mean EQR within ±0.1 of the Good/Moderate boundary (i.e. between 0.5 and 0.7)”.

Figure 4.1 shows worksheet MeanEQR_RoM2, which illustrates the risk of misclassification for LEAFPACS based on three samples per water body. Note that the dashed horizontal line represents the target 5 per cent risk of misclassification.

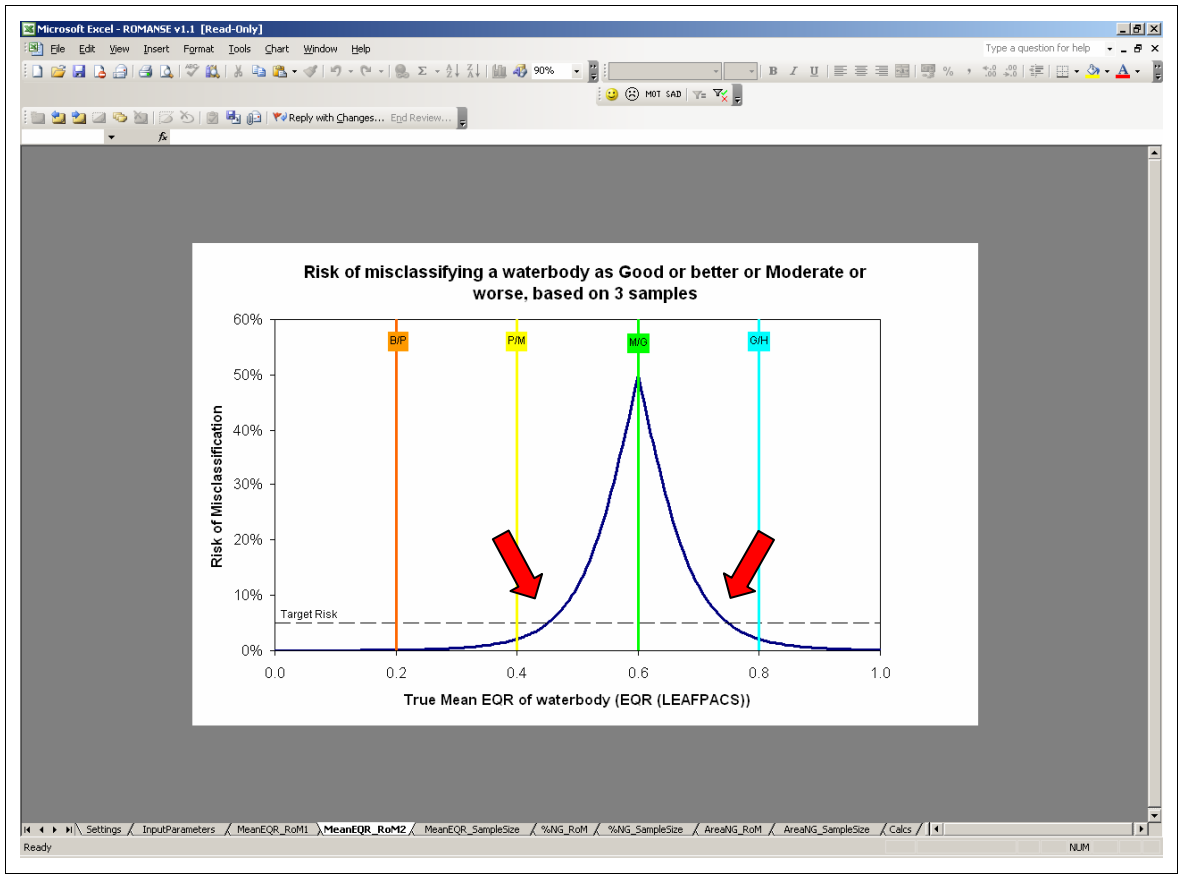

Figure 4.1 MeanEQR_RoM2 worksheet – three samples.

The aim now is to tune the number of samples (on the Settings worksheet), so that the range of conditions over which the risk of misclassification is unacceptably large becomes suitably narrow. Increasing the number of samples means that a greater range of water bodies will have a risk of misclassification of less than 5 per cent. Using four or five samples is not sufficient to meet the criterion of ±0.1 from the Good/Moderate boundary, but with six samples, the risk of misclassification is less than 5 per cent for water bodies with a true EQR of 0.5 or less or 0.7 or above (Figure 4.2).

Tip: hover the mouse over the dark blue line to see the mean EQR and risk of misclassification at any given point.

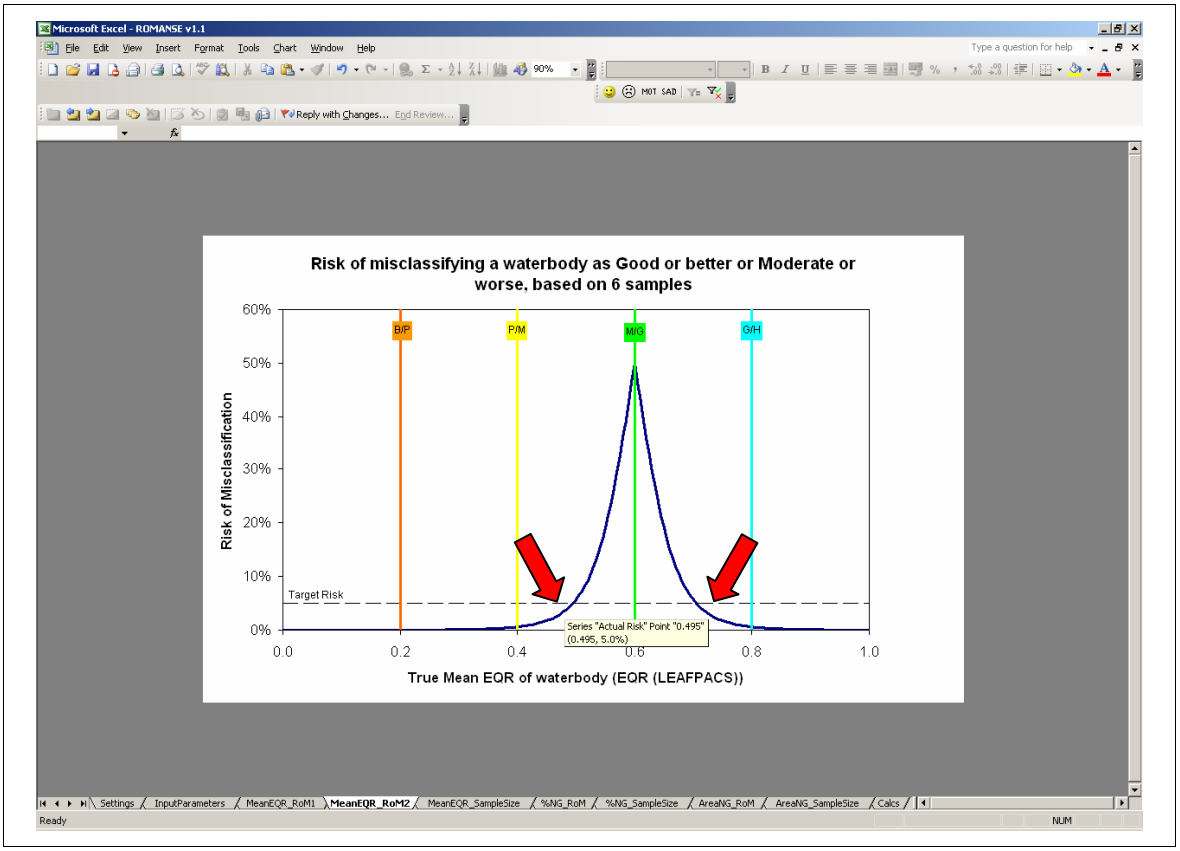

Figure 4.2 MeanEQR_RoM2 worksheet – six samples.

4.2 Example 2: Predicting the level of confidence in the classification result

We will now see how ROMANSE can be used to determine the level of confidence or risk of misclassification that can be expected for a given number of samples.

Suppose that the classification of water bodies is based on three samples, and that this sample size is fixed and cannot be changed. ROMANSE can be used to answer the following questions:

- What is the range of water bodies for which you can achieve, for example, 90 per cent, 95 per cent and 99 per cent confidence in the classification result? and
- What level of confidence can be achieved for water bodies with a true mean EQR within, for example, ±0.05 of the Good/Moderate boundary?

Figure 4.3 shows worksheet MeanEQR_SampleSize, which illustrates the number of samples required to have a given level of confidence that the status of a water body is Good or better, or Moderate or worse. The dashed red line represents three samples. In this case, it is possible to be 95 per cent confident that water bodies with a true mean EQR of 0.45 or lower, or 0.75 or higher, will be classified correctly. These values can be found by hovering the mouse over the dark blue line at the relevant point.

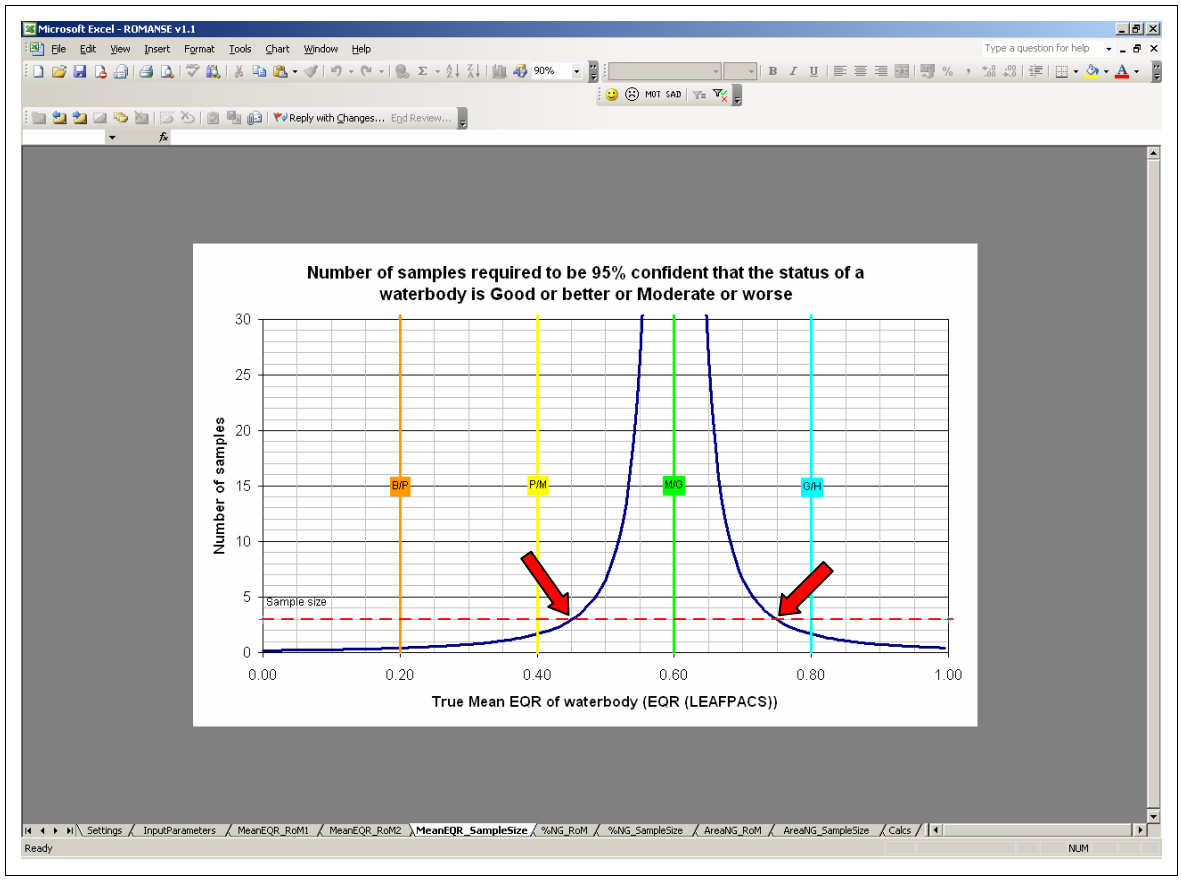

Figure 4.3 MeanEQR_SampleSize worksheet – 95% confidence.

However, it may be necessary to be only 90 per cent confident in the classification. By changing the confidence level in the Settings worksheet to 90 per cent, Figure 4.4 demonstrates the gap between the red arrows is narrower than in Figure 4.3; i.e., it is possible to be 90 per cent confident in the classification of water bodies with a true EQR of 0.49 or lower, and 0.71 or higher, which therefore includes a greater proportion of water bodies than if the confidence level were 95 per cent.

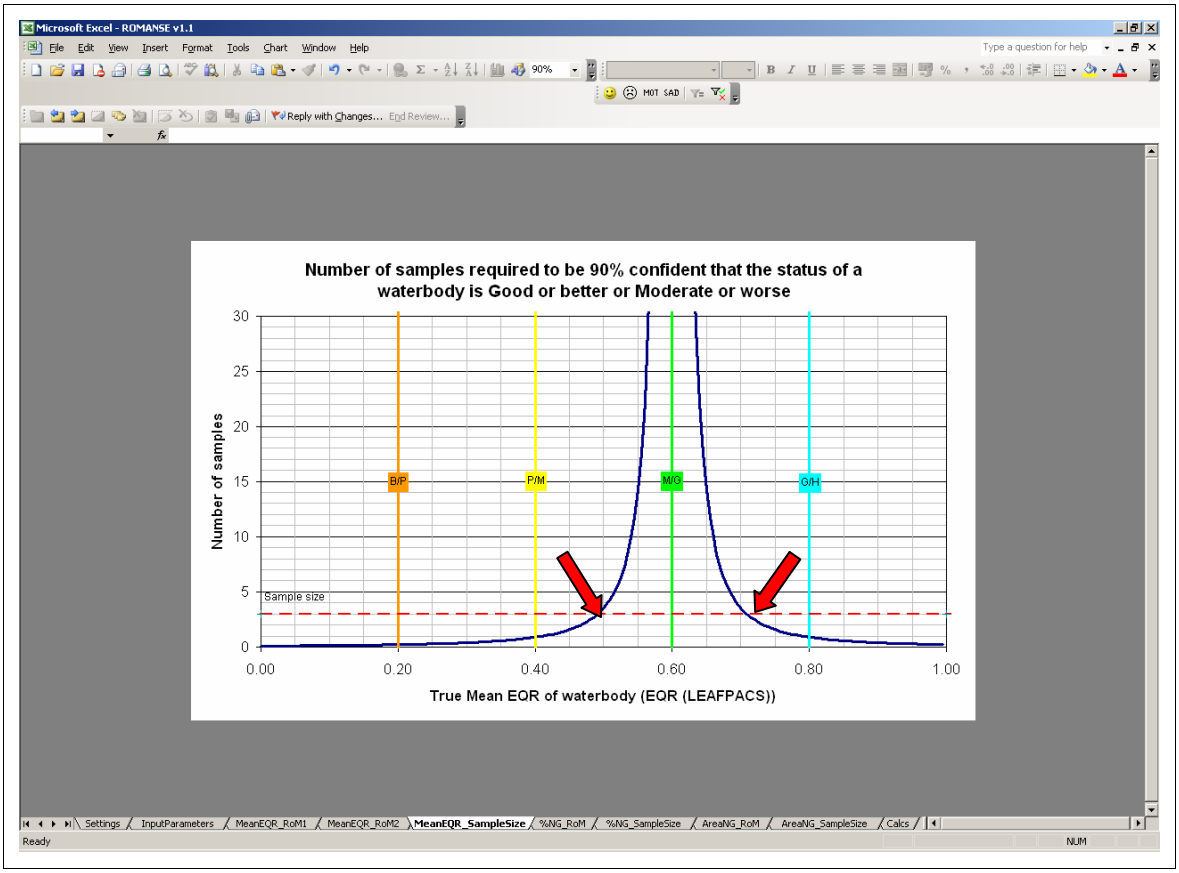

Figure 4.4 MeanEQR_SampleSize worksheet – 90% confidence.

Alternatively, it may be necessary to know the range of water bodies for which we can achieve 99 per cent confidence in the classification. Figure 4.5 shows that 99 per cent confidence will be achieved by only those water bodies with a true mean EQR of 0.35 or lower, or 0.85 or higher. This is a more exacting requirement, so fewer water bodies will achieve it.

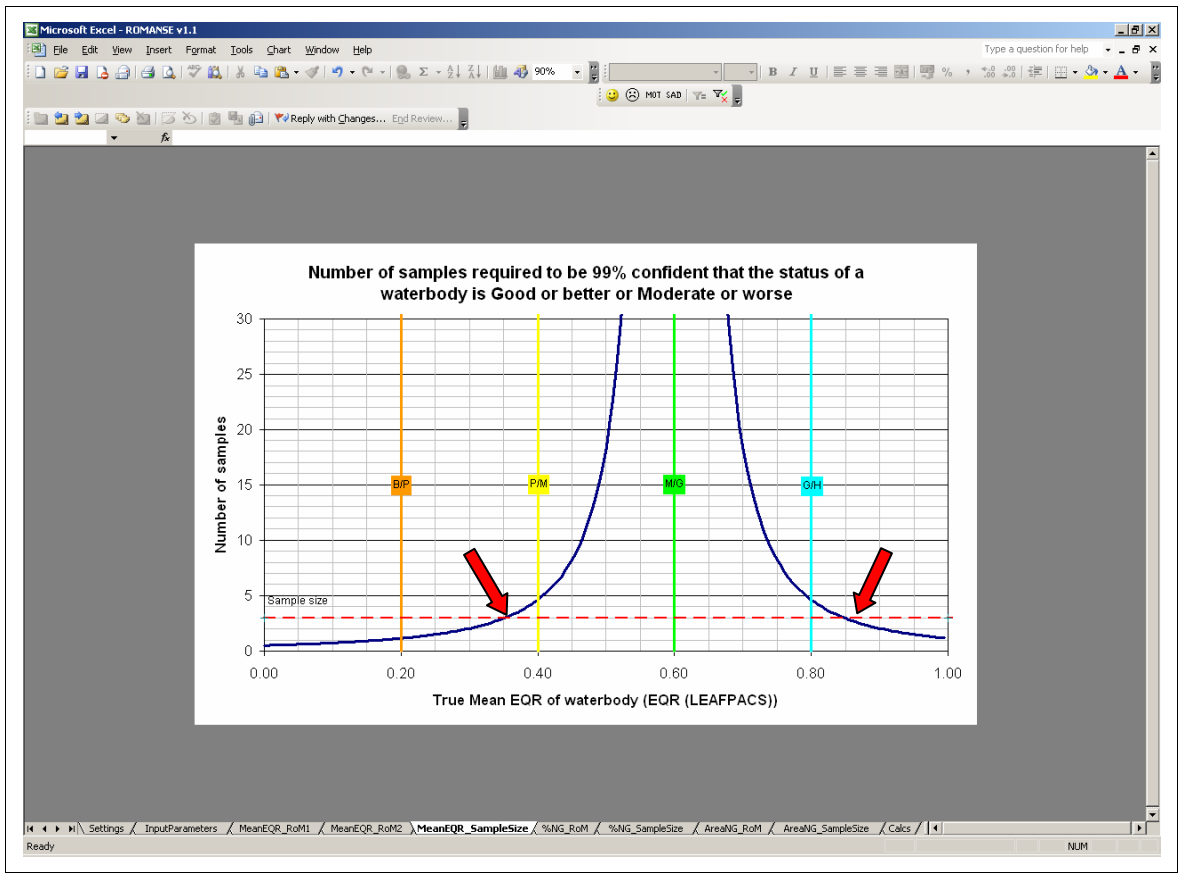

Figure 4.5 MeanEQR_SampleSize worksheet – 99% confidence.

This worksheet can also be used to establish the level of confidence that can be achieved by water bodies over a given range of status conditions. Suppose you want to predict the level of confidence for water bodies with a true mean EQR within ±0.05 of the Good/Moderate boundary, still with a sample size of three. The goal now is to tune the confidence level (on the Settings worksheet), so that the range of conditions over which the risk of misclassification is unacceptably large is matching the ±0.05 criterion. In this example, this is achieved at 75 per cent confidence (Figure 4.6).

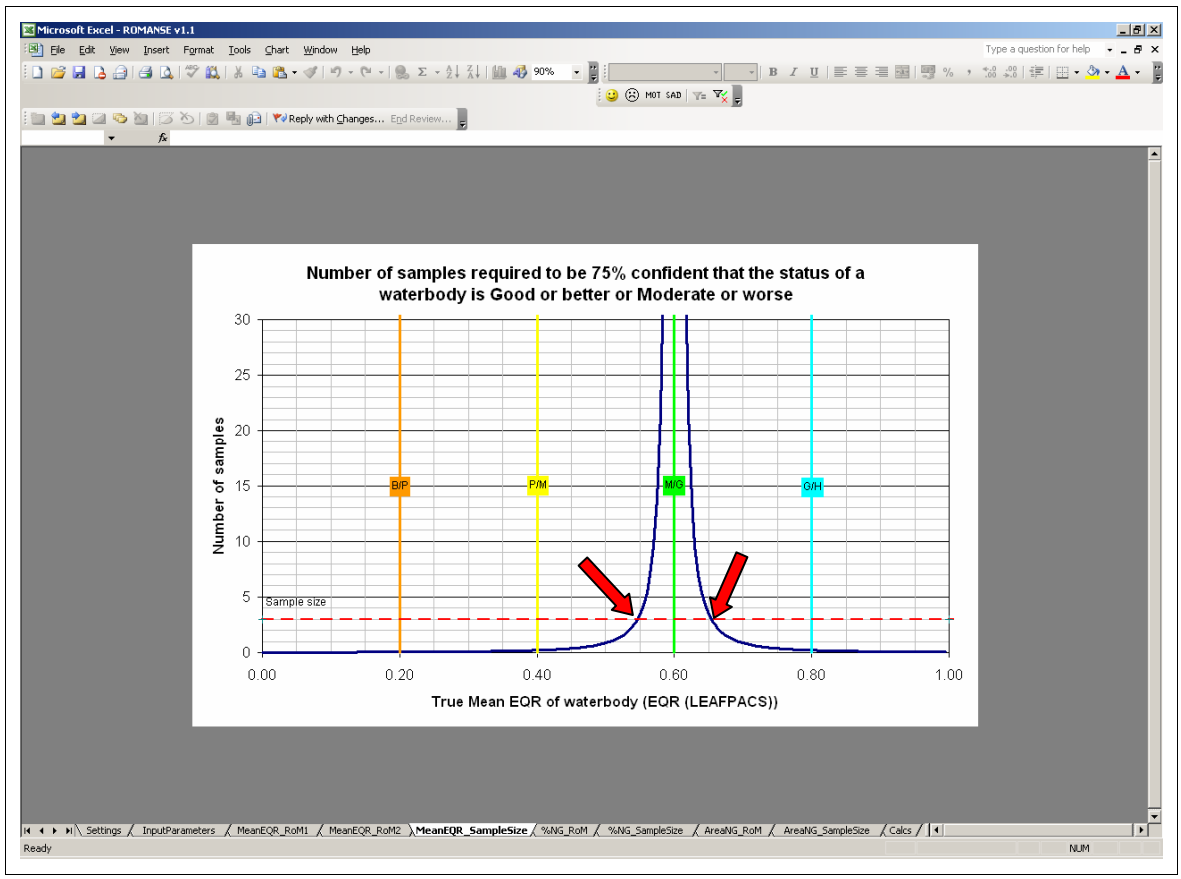

Figure 4.6 MeanEQR_SampleSize worksheet – 75% confidence.

References

DAVEY, A.J.H., 2009. VISCOUS: Taking account of spatial variability in water body classification. Environment Agency Science Report SC080051/SR1.

UKTAG, 2007. Recommendations on Surface Water Classification Schemes for the purposes of the Water Framework Directive. Available at: http://www.wfduk.org/UKCLASSPUB/LibraryPublicDocs/class%20v9 [Accessed 13 November 2009]

List of abbreviations

%NG	Percentage not of Good status
AreaNG	Area not of Good status
ASPT	Average Score Per Taxon
CofC	Confidence of Class
DARLEQ	Diatoms for Assessing River and Lake Ecological Quality
EQR	Ecological Quality Ratio
LEAFPACS	Aquatic Macrophyte Prediction And Classification System
NTAXA	Number of Taxa
QE	Quality Element
RICT	River Invertebrate Classification Tool
ROMANSE	Risk Of Misclassification And Number Of Samples Estimator
RoM	Risk of Misclassification
TDI	Trophic Diatom Index
VISCOUS	Variability In Spatial Component Objectively Unified Statistically
WFD	Water Framework Directive

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