JNCC Report
No: 579

A decision framework to attribute atmospheric nitrogen deposition as a threat to or cause of unfavourable habitat condition on protected sites

Laurence Jones[1], Jane Hall[1], Ian Strachan[2], Chris Field[3], Ed Rowe[1], Carly Stevens[4], Simon Caporn[3], Ruth Mitchell[5], Andrea Britton[5], Ron Smith[6], Bill Bealey[6], Dario Masante[1], Richard Hewison[5], Kevin Hicks[7], Clare Whitfield[8] & Ed Mountford[8].

April 2016

ISSN 0963-8901

Developing a decision framework to attribute atmospheric nitrogen deposition as a threat to or cause of unfavourable habitat condition on protected sites

Annex 3: Matrix design, testing and recommendations - Work Package 3 report

Laurence Jones, Ruth Mitchell, Richard Hewison, Dario Masante, Kevin Hicks, Bill Bealey

Contents

1 Introduction

This Annex is a report of work package (WP) 3 which developed the matrix which provides the overall assessment of whether N is likely to be a cause of unfavourable condition or a threat to condition. **As explained in the main report, the matrix was subsequently modified from the version presented in this Annex.**

2 Description of approach

The matrix combines the Factor 1 score (theoretical/national evidence, WP1) and the Factor 2 score (site-based evidence, WP2) to produce the overall assessment of whether N is likely to be a cause of unfavourable condition or threat to future condition. Crucial to this interpretation is how a combination of Exceedance Score and site-based evidence of N impact should be interpreted in the context of damage to conservation objectives (see Annex 1, section 5.2).

2.1 Basic design

A final assessment matrix (see Table 1) was created so that a series of final outcomes could be generated based on the combined strength of evidence from:

- national-theoretical evidence – as represented by the Exceedance Scores produced in WP1.3 (see Annex 1, Figure 10), which summarise the degree to which the N critical load for a habitat is likely to be exceeded – and shown in the left hand column in Table 1 below; and
- site-based evidence (where available) of N deposition impacts on habitat condition – as provided by a CSM assessment (see WP2.1, Annex 2 section 4) or additional evidence sources (see Annex 2 section 5) – and shown in the top row in Table 1 below.

The matrix contained a set of cells representing different combinations of Exceedance Scores and strengths of site-based evidence. An additional row was created to cater for those habitats that had no critical load assigned to them (and therefore no Exceedance Score) but which are potentially sensitive to N. Other habitat types which are not sensitive to N need no further consideration in this framework.

Table 1. The matrix recommended by the contractors (note the final matrix was modified from this version, please refer to the main report). This combines the strength of evidence from: (i) national-theoretical evidence as represented by a series of Exceedance Scores (left-hand column), which summarise the degree to which the N critical load for a habitat is likely to be exceeded (see Annex 1, Figure 10); and (ii) site-based evidence (where available) that N deposition is impacting on the condition of a habitat (top row), as provided by a CSM assessment (see Annex 2 section 4) or additional sources (see Annex 2 section 5). The bottom row is for habitats with no assigned N critical load but which are potentially sensitive to N deposition impacts and which have no Exceedance Score. The meaning of the coloured cells is explained in a series of boxes beneath.

Exceedance Score	**←Strength of site-based evidence that N deposition *is not* causing adverse impacts**		**No site-based evidence**	**Strength of site-based evidence that N deposition *is* causing adverse impacts →**				
	Moderate	Weak		Very weak	Weak	Moderate	Moderately strong	Strong
Very low								
Low								
Medium-low								
Medium								
Medium-high								
High								
Very high								
No critical load								
No Exceedance score		Not possible to assess	Not possible to assess	Not possible to assess	Not possible to assess			

Green outcome category (no threat)	**Description**
Most likely impacts on habitat condition	• Habitat condition is not being adversely impacted by N deposition, nor is it currently under threat
Site condition categorisation	• Condition and trend as assessed by CSM or other means is not altered
Action	• Does not require action to reduce N deposition impacts
Future prospects	• If current levels of N deposition continue, habitat expected to remain unaffected by N deposition.

Yellow outcome category (threat)	**Description**
Most likely impacts on habitat condition	• Habitat condition may not be adversely impacted by N deposition, but is currently under possible threat
Site condition categorisation	• Condition and trend as assessed by CSM or other means is not altered, but N deposition should be recorded as a threat
Action	• May require additional action to reduce N deposition impacts (remedies); would benefit from deposition reduction at national or site-level

	• Country Conservation Bodies may choose to investigate some sites further, for example where Exceedance Score is medium-high and where national and site based evidence appears in conflict.
Future prospects	• If current levels of N deposition continue, habitat condition will remain under threat unless effective remedies to reduce N deposition impacts are put in place • If such remedies are put in place, this will reduce current impact and potentially reduce or eliminate the level of threat

Orange outcome category (not recovering)	**Description**
Most likely impacts on habitat condition	• Habitat condition is either already adversely impacted by N deposition such that it is unable to recover/improve (i.e. not recovering/improving), or if currently favourable will become unfavourable in the foreseeable future
Site condition categorisation	• Condition can be favourable or unfavourable, as assessed by CSM or other means, but condition trend should be set as not recovering/improving
Action	• Requires action to reduce N deposition impacts at national or site-level (remedies); would benefit from deposition reduction at national or site-level • Country Conservation Bodies may choose to investigate some sites further
Future prospects	• If current levels of N deposition continue, habitat condition will not be able to recover or improve and will become unfavourable in the foreseeable future (unless effective remedies to reduce N deposition impacts are put in place)

Red outcome category (unfavourable-declining)	**Description**
Most likely impacts on habitat condition	• Habitat condition has already been and will continue to be adversely impacted by N deposition such that it is in unfavourable-declining condition
Site condition categorisation	• Condition should be set as unfavourable and condition trend should be set as declining
Action	• Requires action to reduce N deposition impacts at national or site-level (remedies); would benefit from deposition reduction at national or site-level • Country Conservation Bodies may choose to investigate some sites further
Future prospects	• If current levels of N deposition continue, habitat condition will remain unfavourable and not be able to recover (unless effective remedies to reduce N deposition impacts are put in place)

2.2 Final outcome categories

Four final outcome categories were identified. These were colour-coded from green, through yellow and orange, to red, to reflect the underlying strength of evidence that N deposition was likely to be adversely impacting and/or was posing a threat to current and future habitat condition. Each category is described below Table 1 in terms of:

- the most likely impacts on habitat condition;
- where it applies within the final assessment matrix;
- how it relates to the site condition categories used by the SNCBs;
- the need for action to reduce N deposition impacts (remedies) and for further investigation;
- future prospects if conditions remain the same, if effective remedies to reduce N deposition impacts were put in place, or if N deposition impacts increased or declined.

2.3 Rationale and approach to the categorisation of cells within matrix

The decision as to which final outcome category was assigned to each cell within the matrix depended on a number of factors.

1) The Exceedance Scores and site-based evidence were arranged in order of increasing strength of evidence of N deposition impacts – from top to bottom and left to right respectively. This meant that the overall strength of evidence increased within the matrix along an axis running from top left to bottom right. This axis provided a general guide as to where the final outcome categories should be positioned within the matrix.

2) The outcomes for each cell and the boundaries between classes of outcome were approached as follows.

   a. The column labelled **'no site-based evidence'** provided an initial benchmark, because the strength of evidence in this column was based solely on the Exceedance Scores. Three key transitions were identified as the Exceedance Scores increased, which were used to guide where the boundaries between the final outcome categories should be set, with reference to the description of impacts on conservation objectives (Annex 1, section 4.5) and the visual representation of Exceedance Scores (Annex 1, Figure 10):

      i. when the **Exceedance Score increased from *very low to low***
         - i.e. when the upper confidence interval for the N deposition range moved above the minimum critical load value, the N deposition and N critical load ranges started to overlap with each other;
         - this was identified as the point at which it was considered most likely that N deposition impacts should be seen as a threat to current and future habitat condition;
         - this transition was therefore used to set the boundary between the green and yellow outcome categories.

      ii. when the **Exceedance Score increased from *medium* to *medium-high***
         - i.e. when the specified deposition value lies below the maximum critical load, while the upper confidence interval lies above the maximum critical load, such that the majority of the N deposition range was in the upper half of the N critical load range, and may well exceed the maximum critical load;

- this was identified as the point at which it was considered most likely that N deposition impacts should be seen as preventing habitat condition from recovering or improving; the site may or may not currently be in unfavourable condition but will become unfavourable due to N in the foreseeable future;
- this transition was therefore used to set the boundary between the yellow and orange outcome categories.

iii. when the **Exceedance Score increased from *high to very-high***
- i.e. when the full range of N deposition moved above the full N critical load range;
- this was identified as the point at which it was considered most likely that N deposition impacts were resulting in unfavourable habitat condition and preventing it from recovering or improving both currently and in the foreseeable future*;*
- this was therefore used to set the boundary between the orange and red outcome categories.

b. To decide what effect site-based evidence should have on the choice of final outcome (compared to the categories in the 'No site-based evidence' column), the outcomes **which differ** from those described above are:

i. when the **strength of site-based evidence that N deposition *is causing adverse impacts was strong***
- i.e. where adverse impacts are clearly due to N deposition rather than confounding factors
- it was considered most likely that N deposition impacts were:
  - ***at very low, low and medium-low* Exceedance Scores**, preventing habitat condition from recovering or improving; the site may or may not currently be in unfavourable condition but will become unfavourable due to N in the foreseeable future – so the orange final outcome category was selected instead of the yellow category;
  - ***at medium, medium-high and high* Exceedance Scores**, resulting in unfavourable habitat condition and preventing it from recovering or improving both currently and in the foreseeable future – so the red final outcome category was selected rather than the yellow or orange categories.

ii. when the **strength of site-based evidence that N deposition *is causing adverse impacts was moderately strong***
- i.e. where there are some strong indicators of possible N deposition impacts, which are weakly confounded
- it was considered to be most likely that N deposition impacts were:
  - ***at very low* Exceedance Scores**, where N deposition impacts should be seen as a threat to current and future habitat condition – so the yellow final outcome category was selected instead of the green category;
  - ***at medium-low and medium* Exceedance Scores**, preventing habitat condition from recovering or improving; the site may or may not currently be in unfavourable condition but will become unfavourable due to N in the foreseeable future – so the orange final outcome category was selected instead of the yellow category;
  - ***at high* Exceedance Scores**, resulting unfavourable habitat condition and preventing it from recovering or improving both currently and in the foreseeable future – so the red final outcome category was selected instead of the orange category.

iii. when the strength of **site-based evidence that N deposition *is causing adverse impacts was moderate***
   - i.e. where there are some strong indicators of possible N deposition impacts that are strongly confounded
   - it was considered to be most likely that N deposition impacts were:
     - ***at medium* Exceedance Scores**, preventing habitat condition from recovering or improving; the site may or may not currently be in unfavourable condition but will become unfavourable due to N in the foreseeable future – so the orange final outcome category was selected instead of the yellow category.

iv. when the strength of **site-based evidence is that there is *moderate evidence for no N deposition impact***
   - i.e. where there are some strong indicators of possible N deposition impacts but these are not impacted
   - it was considered to be most likely that N deposition impacts were:
     - ***at low* Exceedance Scores**, not adversely affecting or posing a threat to habitat condition – so the green final outcome category was selected instead of the yellow category;
     - ***at very-high* Exceedance Scores**, only preventing habitat condition from recovering or improving; the site may or may not currently be in unfavourable condition but will become unfavourable due to N in the foreseeable future – so the orange final outcome category was selected instead of the red category.

c. For the row covering habitats that had no critical load assigned to them, the selection of final outcome was based solely on the strength of site-based evidence. Given that the N sensitivity of these three CSM habitats (Maritime grassland with rock crevices, Dunes with *Hippophae rhamnoides*, and Inland salt meadows) is not known, the outcomes for Medium exceedance were followed as a default. In this exceedance class, N deposition is considered a potential threat (yellow final outcome) up until the site-based evidence reached moderate strength, where the final outcome category increased by one level to orange final outcome and then to red final outcome where there was strong site-based evidence of N impact.

3 Conclusions

The framework provides a practical methodology for assessing the impacts of N deposition on protected sites in an objective way, which was previously lacking. It is based on a sound conceptual approach, and is relatively robust and flexible enough to cope with additional information. Any framework is only as good as the data that goes into it and there are some major limitations in the data currently used to populate the framework, discussed below. However, the framework has been designed with these limitations in mind, and achieves a workable methodology, despite those constraints. Subsequent improvements in the input data should not require major changes to the framework itself and will improve the rigour of the assessments conducted.

The framework has a number of strengths, listed as bullet points below.

- The decision framework provides a clear and logical basis on which to attribute atmospheric N deposition as a threat to or cause of unfavourable habitat condition on protected sites.

- The framework incorporates uncertainty in N deposition, in the empirical N critical loads, and in the cross-matching process required to allocate proxy critical loads for all relevant UK CSM habitats. It allows these input variables to be combined to assess critical load exceedance for the full suite of CSM habitats.
- This report has thoroughly evaluated the potential for the generic CSM targets to be used as indicators of N deposition impact, using a standardised and quality controlled methodology.
- For the first time, there is now a fully cross-matched set of proxy critical loads for each CSM habitat, together with a measure of the uncertainty in that cross-matching process. This provides a measure of the N sensitivity of each CSM habitat which can be used to assess both N sensitivity and empirical N critical load exceedance.
- An important advantage of the decision framework developed in this report is that its contents can be systematically updated as and when new evidence becomes available for specific habitats without any need to completely alter the conceptual approach.
- Furthermore, adaptation of site spreadsheets to include improved indicators or additional information on management would be relatively simple.
- Overall, the decision framework provides an excellent initial basis for attribution, but can also be seen as the starting point for a process of continual improvement and fine-tuning.

There are a number of limitations or deficiencies identified in the Factor 1 score – (National/theoretical evidence) component.

- The uncertainty in national N deposition models is poorly quantified, both how that uncertainty varies on a spatial basis across the UK, and how it varies at sub-grid scales.
- While the report has achieved a lot in allocating proxy critical loads for the vast majority of CSM habitats, it should be recognised that this is an expert judgement process, subject to some uncertainty. There is a basic requirement for greater knowledge about N impacts in many of these habitats which can only be achieved by experimental work or well-designed gradient studies in those habitats.

There are a number of limitations or deficiencies identified in the Factor 2 score (site-based evidence) component.

- The CSM assessment process was not designed for detecting N deposition impacts. Therefore the vast majority of the targets either do not describe those ecosystem components which might reflect impacts due to N deposition, or are worded such that any impacts cannot be reliably attributed to N should the target fail. Examples include: targets focusing on a wide range of species, only some of which might respond (positively or negatively) to N; targets which could fail at multiple end-points, some of which may be due to N, but others not (see Annex 2). As a result, there are very few useable Strong N indicators (i.e. targets which, where they fail, could reliably be used to infer an impact of N). Where there are Strong N indicators, the nature of the CSM targets means that they could also be failing due to some other confounding factor, which produces similar ecological responses to N. As a consequence we are only likely to get, at best, moderately strong evidence from CSM that there are or there are not N impacts.
- The number of useable Strong N indicators varies among habitats. Some habitats, such as a number of the grassland habitats, have one or more Strong N indicators. However, many more habitats have no useable N indicators at all. Woodlands are a particular problem in this regard, with none of the woodland habitats having any useable N indicators, due to the way the woodland CSM targets are structured. In total, eleven CSM habitats had no useable N indicators, these were two in the

Coastal, one in the Lowland Wetland, seven in the Upland, and the Woodland categories.
- This variability in the number of useable N indicators means that some habitats are better suited to application in the framework than others. Where there are no useable N indicators, the framework relies on other site-based evidence which is likely to be lacking for the majority of sites. In the absence of any site-based evidence, the assessment can only be conducted on the national/theoretical evidence alone. This risks arriving at the wrong outcome for some sites due to lack of site-based evidence.

The testing of the framework revealed some additional challenges to implementing the framework.
- There were considerable problems with non-standard use of the generic CSM targets. Many targets were re-worded at a country-level, or re-worded at the site level for CSM monitoring purposes. Whilst this may not affect the CSM process for monitoring habitat condition, it severely reduces its utility in detecting N deposition impacts in a consistent way.
- There were also difficulties where not all targets were assessed at a site. As a result, even for habitats which in theory had useable Strong N indicators or a number of Weak N indicators, it was not always possible to assess the site/feature for N impact, as those targets were not always assessed.
- CSM is implemented in very different ways across England, Scotland and Wales. These differences prevent a standardised application of the framework in the three countries, and make any automated assessment very difficult at present. There was not enough information about how CSM is applied in Northern Ireland to say whether the framework might be applied there or not.
- Evaluation of sites with known point-source issues clearly showed some limitations of the CSM process in detecting N impacts, even for sites such as Moninea Bog with clear ecological impact from N deposition. The main problem seems to be the lack of sensitivity of CSM targets to detect N impacts, because they were not designed for that purpose.

Based on these findings we make a number of **key recommendations**. More specific recommendations can be found within the three Annex reports.
- There is a need to improve quantitative estimates of the uncertainty in wet and dry oxidised and reduced deposition at the national scale, including any spatial variation in that uncertainty, and to quantify uncertainty in N deposition at sub 5x5 km level.
- Critical loads are not available for many CSM habitats, and the cross-matching process is a major component of the uncertainty in the Exceedance Score. Therefore, experimental or survey work is recommended to establish critical loads for some of these habitats, particularly those which are very different in character from the communities for which critical loads are already available.
- A major improvement in the ability of CSM to detect N deposition impacts at sites would be to design new N-focused targets, which would be applied across the UK without modification at the site level. Less than a third of the ~51 habitats/sub-habitats had one or more strong N indicators and eleven had no N indicators at all. It should be possible to design one or two N-focused targets, specifically designed to detect N impacts, for the majority of CSM habitats. The thresholds for these targets would be linked to observed impacts in experimental and gradient studies, further improving their rigour. By more than tripling the number of useable indicators, this would both increase the scope to use site-based evidence for a greater range of habitats, and would improve the ability of those indicators to detect impacts. We recognise that, on their own, they will not be able to rule out confounding factors (see next point), but would be a substantial improvement on the current indicators.

- Many of the confounding factors can be related to site-management, or to circumstances which would be known by a site manager (e.g. hydrological change). Yet, the assessment tool offers no flexibility to consider these factors at a site level. For example, one of the key effects of N deposition in grasslands is an increased cover of graminoid species and a reduction in the cover of forbs and bryophytes, yet this is also a consequence of lack of grazing. If more information about grazing management on the site is known, it should be possible to confirm or rule out this confounding factor. The spreadsheet tools could be adapted to incorporate the input of such information, to more robustly assess possible confounding factors and, as a consequence, increase confidence in the role that N deposition plays as a cause of unfavourable condition.
- Further consideration is needed on how to apply the framework given the different assessment approaches taken in England, Wales, Scotland and Northern Ireland. This should account for differences in how individual features are assessed in the four countries and the potential to automate the process with electronically stored data.

Appendix A - Testing the framework

Testing the framework

The aim of WP3.2 was to trial the draft framework using real data to see how the framework responded under a variety of conditions and habitats. The testing undertaken used an early prototype of the framework (December 2014). The final version of the framework is significantly different from the prototype used in the testing.

The testing was undertaken on 58 sites. The sites were selected to cover a wide range of habitat types and a large geographical spread. This included 41 from Scotland (19 SACs, 16 SSSIs and 6 'others'), 10 from England (9 SSSIs and 1 'other') and 6 from Wales (5 SACs, 1 SSSI and 1 'other') and 1 from N. Ireland (Table 2). The 'other' category was sites that had additional information about them, such as along an N deposition gradient study but were not SSSIs. Specifically we aimed to assess how the framework performed:

- over a variety of habitats;
- over a wide geographical spread;
- with only weak N indicators failing at the site level;
- with only strong N indicators failing at the site level;
- with a mixture of weak and strong indicators failing;
- with local point sources of N;
- with sites with no N indicators;
- with sites from national gradient studies;
- with sites with a variety of outcomes from the Factor 1 spreadsheet.

The results from the testing are not presented in this appendix: they were based on an early prototype and the purpose was to identify changes necessary to the framework and recommendations for future development, rather than examine the implications of the framework. Conclusions and recommendations are included below. Results from the testing are available on request from JNCC.

The modifications which were made to the framework in response to testing included:

- Providing greater resolution across the range of Factor 1 outcomes – creating seven Exceedance Score classes, rather than five, with a smaller range of deposition values across each;
- Constraining the exceedance score if unrealistically high deposition loads are entered – the revised approach means this produces the highest Exceedance Score class if the deposition + 95% Confidence Interval exceeds the critical load;
- Altering the Factor 2 score to base this on a target-by-target basis, with a new algorithm produced to derive an overall outcome for the Habitat Feature, based on the target-level scores;
- In addition, the outcome categories in the matrix were substantially revised in discussion with the steering group.

Conclusions from the testing

- The framework works over a variety of habitats – i.e. all the habitats covered by CSM;
- The framework works over a wide geographical spread (works on data from all the devolved countries in the UK);

- The framework suggests that even sites that are favourable according to CSM may be impacted by N deposition;
- The CSM guidance was not always successful in detecting the impact of N deposition. This was most apparent at sites close to large point sources of N where more work has been done to pick up N deposition impacts;
- Where there are no potential indicators in the CSM targets the framework relies solely on Factor 1, as there is no site based evidence - in particular woodlands, but also for a suite of upland habitats;
- High or low 1.2A and 1.2B scores did not influence the results in a consistent pattern.
- The results from the CSM data are not stored in a consistent fashion between sites and between countries making it difficult to use in the framework;
- CSM is not applied in a consistent way between sites and countries with the wording of the targets often altered making it impossible to match the targets to the framework;
- A lot of targets which were suitable indicators of N were either not assessed, or could not be matched to the targets used on the site;
- The framework does not take account of the number of N indicators that are not assessed or which cannot be assessed due to changes in wording or target. This may risk some sites being wrongly identified as not having any site based evidence of N deposition impacts.

Recommendations from the testing

The recommendations arising from the testing are split between modifications to the framework and changes required in CSM recording, with some specific recommendations of points to consider with regards to the development of CSM N indicators in woodlands.

The framework

- A clear caveat that many impacts of N are not detected by the CSM targets. This is most apparent where sites are impacted by point sources of pollution, and yet sites can clearly be impacted by these point sources;
- A warning flag if some N indicators are either not assessed or not matched – thus the overall outcome from the framework may be incorrect **Note:** Following the trialling of the framework has now been revised to include this recommendation;
- Reduce the need to have multiple excel spreadsheets open at one time;
- Clear advice on what to do with sites with no N indicators in the CSM targets – e.g. woodlands. For example, a statement that the outcome is based entirely on the Factor 1 score and no site evidence has been taken in to account.

CSM recording

- Rewording of targets by country SNCBs causes problems with implementation of a standardised approach. Modified targets will have to be matched with the original CSM target and an assessment made as to whether the changes influence the N indicator score;
- It would help if CSM results were recorded in a standard way such that it is easy to match targets across to the WP2.1 targets;
- Some CSM results are only held in paper format, making the framework harder to use. We recommend that all data is held in a consistent electronic format;
- Make sure that all targets that are strong N indicators in the CSM are assessed per feature. If this is not done then it reduces the utility of the CSM as a source of site-based evidence for N impacts;

- Make sure that all targets for a feature are assessed against one set of targets from one habitat, not from a mixture of CSM habitats;
- Further consideration is needed on how to deal with sites that are not assessed using standard CSM methods – e.g. sites in Wales;
- Consideration of the need to add specific N indicators as targets for each CSM habitat type. This would help detect impacts of N pollution and increase confidence that N is impacting the site;
- Further underpinning research to establish N indicators that could be included within CSM assessment for woodlands.

Woodlands

There are no generic CSM targets for woodland, only the overall CSM attributes are applied generically. The CSM targets for woodlands are therefore set at an individual site level using 5 generic attributes. As the targets are only guidance they are not specific enough to be indicators of N deposition (although the refined targets at any individual site may be). Thus CSM as it stands for woodlands is inadequate to assess whether changes within woodlands are due to N deposition.

If N indicators were to be developed for woodlands it is likely that such work would have to include the following steps/considerations:

- Identification of N indicators for different woodland types;
- Information on whether it is the presence or absence of an indicator or the proportion present that indicates N deposition, and what level of abundance would signify N impact;
- Information on whether N indicators can be developed solely from plants that might be included within the CSM or whether they would include species that are more difficult to identify such as lichens and bryophytes;
- Consideration of seasonal impacts on the use of indicators;
- Consideration of whether CSM is the most appropriate method to assess N impacts.

Given current knowledge, and the conflicting results so far on the impact of N deposition in woodland (see details in WP2.1 woodland spreadsheet) it is unlikely that these indicators can be developed from our existing knowledge and further underpinning research would be required. The above list is not exhaustive but provides a brief overview of some of the likely next steps.