UK Technical Advisory Group on the Water Framework Directive

Paper 11b(ii) : Groundwater Quantitative Classification for the purposes of the Water Framework Directive.

This Guidance Paper is a working draft defined by the UKTAG. It documents the principles to be adopted by agencies responsible for implementing the Water Framework Directive (WFD) in the UK. This method will evolve as it is tested, with this draft being amended accordingly.

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WFD Requirement:	Classification schemes, environmental standards, groundwater	**UKTAG Review:**	Feb 2007

1 Purpose

1.1 The UKTAG Groundwater Task Team has produced two papers describing the classification process for quantitative and chemical status of groundwater bodies.

1.2 Paper 11b(i) details the procedures for translating the definitions of good groundwater chemical status into an operational classification system. The classification system is divided into 5 tests using the criteria for good chemical status as set out in the Water Framework Directive (WFD) and the Groundwater Daughter Directive (GWDD).

1.3 This paper provides the detailed procedures for the translation of the definitions of good groundwater quantitative status outlined in Annex V of the WFD into an operational classification system. The classification system is divided into 4 tests using the criteria for good quantitative status as set out in the WFD.

1.4 The criteria that define good groundwater quantitative status are fixed within the WFD and cannot be altered. These detailed classification papers use, and build upon, the principles outlined in UKTAG Paper 11b (Outline classification under the WFD) to describe how these criteria have been taken and developed into a classification system.

1.5 Environmental standards[1] to be used in regulation and in the derivation of Programmes of Measures (PoM) will be developed from these detailed procedures. The links between classification and regulation are the subject of UKTAG paper 11b(iii)[2].

2 Overview of Classification Process

2.1 Achieving ‘good status’ for groundwater involves meeting a series of conditions that are defined in Annex V of the WFD and applied to the whole of the groundwater body.

2.2 Groundwater status objectives set by the WFD rely <u>in part</u> on the protection of, or objectives for, other associated waters and dependant ecosystems. ***The objectives for these must be known before groundwater classification can be fully completed.*** These associated waters and dependant ecosystems may have different sensitivities to water level and/or pollutants. As a result it is possible that different standards may apply within a single groundwater body to reflect these varying sensitivities.

2.3 The definition of Quantitative status is set out in WFD Annex V 2.1.2. but some elements of the wording are problematic. It is necessary to further interpret the text in order to derive a viable classification system that adheres to the spirit of the Directive and protects the groundwater resource.

2.4 In order to assess whether a groundwater body is meeting all the varying criteria for achieving good status, a series of classification tests have been developed for both quantitative and chemical elements. These are outlined in Table 1 and detailed in later sections.

[1] For groundwater, the term “environmental standards” includes standards or conditions for water quantity, water quality standards, and the threshold values that are discussed in UKTAG Paper 11b(i).
[2] UKTAG Paper 11b(iii) – Application of groundwater standards to regulation.

2.5 There are five chemical and four quantitative status tests, some elements of which are common to both.

2.6 The variety of classification elements in Table 1, the volume and precision of groundwater monitoring data and the inherent uncertainties in our understanding of groundwater flow and quality, all contribute to uncertainty in the classification process. Whilst the WFD emphasises the use of monitoring data during classification, in practice a **weight of evidence** approach, with monitoring data complemented by conceptual understanding and risk assessment data, is essential to ensure reliable classification of groundwater bodies and subsequent proper targeting of measures in the River Basin Planning process.

2.7 For each groundwater body, the worst case classification from the five chemical tests is reported as the overall chemical status of the groundwater body, and the worst case classification from the four quantitative tests is reported as the overall quantitative status. This is the one-out all-out system, as required by the WFD. Thus, if any one of the tests results in poor status, then the overall classification of the body will be poor. The confidence associated with the worst case test result is also reported.

2.8 The results of the tests for both quantitative and chemical status are then combined to give an overall classification of good/poor for each groundwater body (see Figure 1 below). If either the chemical or the quantitative assessment is poor, then the overall classification will be poor.

Table 1 - Classification Elements

Classification Element	Classification Test
Common to both quantitative and chemical:	
“No saline or other intrusion” Element And alterations to flow direction resulting from level changes may occur temporarily, or continuously in spatially limited area, but such reversals do not cause salt water or other intrusion, and do not indicate a sustained and clearly identified anthropogenically induced trend in flow direction likely to result in such intrusions. (WFD Annex V 2.1.2) Changes in conductivity are not indicative of saline or other intrusion into the groundwater body (WFD Annex V 2.3.2)	Entry into the groundwater body of either: a) saline water of higher conductivity/salinity from connate or sea water; or b) water of different chemical composition from other groundwater bodies or surface waters and which is liable to cause pollution.
Surface water element No “Failure to achieve the environmental objectives specified under Article 4 for associated surface waters Any significant diminution in the status of such waters”	No significant diminution of surface water chemistry and ecology.
GWDTE element No “significant damage to terrestrial ecosystems which depend directly on the groundwater body”	No significant damage to GWDTE
Quantitative only:	
Water Balance element “Available Groundwater Resource” means the long term annual average rate of overall recharge of a body of groundwater less the long term annual average rate of flow required to achieve the ecological quality for the associated surface waters specified under Article 4, to avoid any significant diminution in the ecological status of such waters and to avoid any significant damage to associated terrestrial ecosystems. (WFD Art. 2 Definitions 27)	Abstraction < (recharge-ecological needs of river bodies)
Chemical only:	
No deterioration in quality of waters for human consumption (GWDD Article 4.2 b (iii)) and paragraph 4, Annex III)	Meet the requirements of WFD Article 7(3) – Drinking Water Protected Areas
No significant impairment of human uses (GWDD Article 4.2 b (iv))	General assessment of quality of the groundwater body as a whole.
No significant environmental risk from pollutants across a groundwater body. (GWDD Article 4.2 b (i) and paragraph 3, Annex III).	

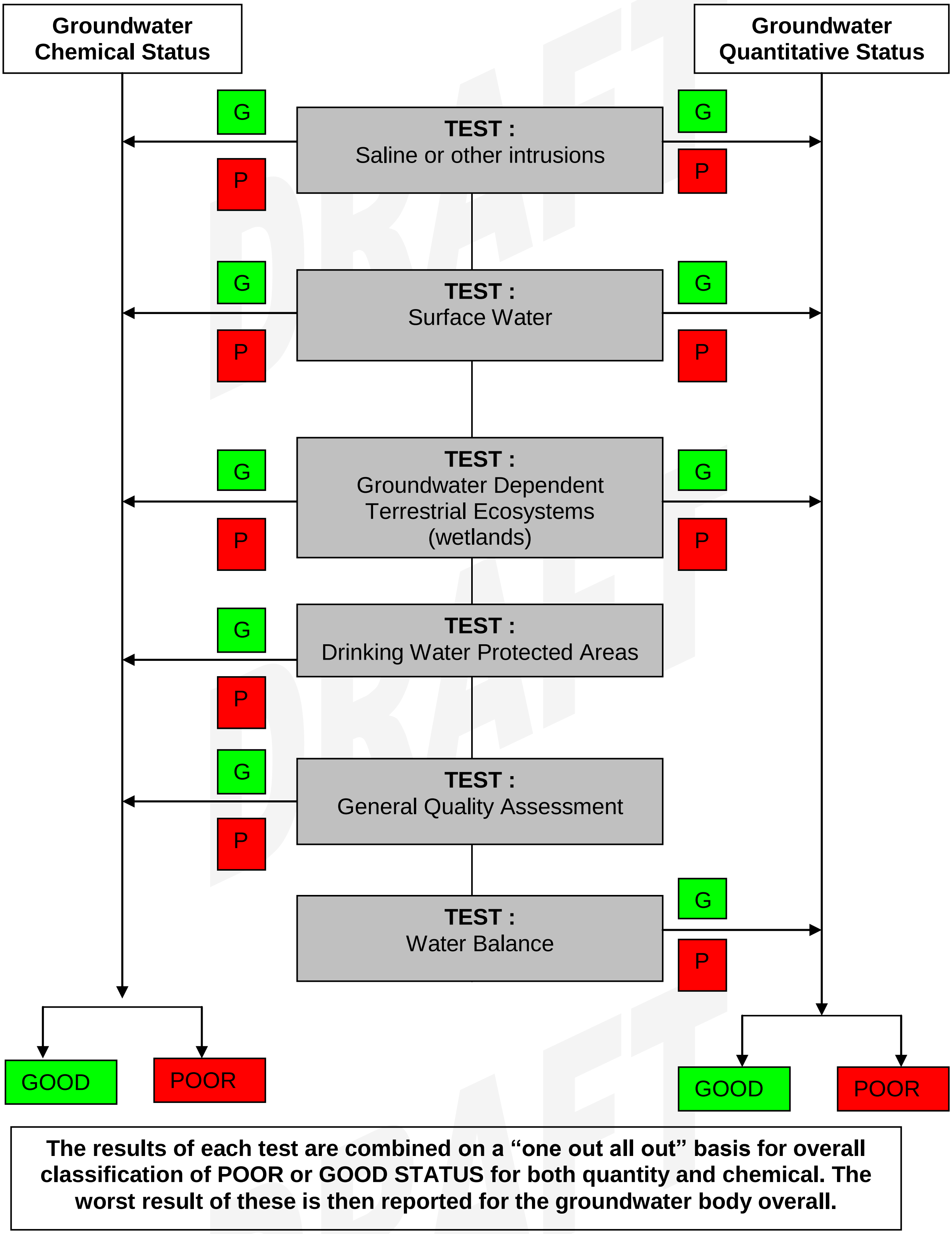

Figure 1. Overview of the Classification Process.

3 Definition of Quantitative status

3.1 The definition of Quantitative status is set out in WFD Annex 5 2.1.2.

3.2 As noted in this Annex, Good groundwater quantitative status is achieved when:

"The level of groundwater in the groundwater body is such that the available groundwater resource is not exceeded by the long term annual average rate of abstraction.

Accordingly, the level of groundwater is not subject to anthropogenic alterations such as would result in:

- *failure to achieve the environmental objectives specified under Article 4 for associated surface waters;*
- *any significant diminution in the status of such waters; and*
- *any significant damage to terrestrial ecosystems which depend directly on the groundwater body.*

and alterations to flow direction resulting from level changes may occur temporarily, or continuously in a spatially limited area, but such reversals do not cause salt water or other intrusion, and do not indicate a sustained and clearly identified anthropogenically induced trend in flow direction likely to result in such intrusions."

3.3 The Quantitative Status definition is framed in terms of the relationship of a range of factors to groundwater level. The use of groundwater level alone does not lead to reliable classification. Groundwater flows are equally important but these cannot be measured directly, but only estimated on the basis of hydrological and meteorological measurements. For this reason it is considered that groundwater levels alone should not be determinative of quantitative status. Annex 1 suggests how they might be used in practice.

3.4 In order to derive a viable classification system, it is necessary to break down the different elements of this definition and interpret this text into elements that are capable of assessment, whilst retaining a meaning that adheres to the spirit of the Directive.

3.5 The above definition of Quantitative Groundwater Status is divided into two parts. The initial section defines an overall measure of the water balance of the groundwater body that can be used as a general indication as to whether current levels of abstraction are satisfactory. The second part of the definition sets out more detailed aims that must be satisfied for the groundwater body to be at good status

3.6 Based upon the definition, this paper sets out a framework of four tests designed to lead to the determination of groundwater quantitative status. A failure to achieve the requirements of any one of these tests will give rise to an overall quantitative status classification of "poor".

3.7 The tests to determine Significant Damage to Groundwater Dependent Terrestrial Ecosystems (GWDTE) and to determine the presence of adverse Saline or Other Intrusions are needed for both the quantitative and chemical status assessments. These tests are intimately connected and therefore have been combined. The GWDTEs test is presented in this paper, as physical relationships and impacts need to be assessed prior to chemical impacts. The Saline/Other Intrusions test is presented in the Chemical Status Classification paper.

4 Water Balance

4.1 For this test we must assess annual average abstraction against the available groundwater resource in the groundwater body. This test is applied at the groundwater body scale, in contrast to the Surface Water Test (in Section 5), which is applied at the surface water body scale. This test and the Surface Water Test are complementary tests as they are carried out at different scales. Given the difference in scale it is entirely possible and acceptable to pass this test and fail the Surface Water test. (Note: groundwater bodies are normally large and often have several surface water bodies crossing them.)

4.2 The available groundwater resource is calculated from the difference between recharge[3] and the flow required to support the ecology in surface water bodies that are dependent on the groundwater body.

4.3 The annual average recharge should be estimated for the whole of the groundwater body including any recharge water deemed to enter the groundwater body from outside (e.g. run off from adjacent impermeable strata). If there are significant flows between groundwater bodies these should be taken into account in the recharge assessment. However, as most groundwater bodies are likely to have been delineated as hydraulically distinct units (in accordance with UKTAG guidance on the delineation of water bodies), there should not normally be significant flows between them.

4.4 The annual average abstraction rate should include all abstractions from the groundwater body, including any connected confined sections of the aquifer. Abstracted groundwater that has been locally returned to the aquifer or to a river should be discounted (for example, this may occur at a water cress farm or at a quarry / mine dewatering operation).

4.5 We must determine both the surface water ecological flow requirements, and the impacts of groundwater abstraction on these flows. The method used can depend on the degree to which abstraction pressures affect the groundwater body. Ecological flow needs can be estimated on the basis of:

- local specialist technical knowledge or simple tools such as SNIFFER research project WFD53[4]
- the aggregated flow requirements of individual river water bodies. This could be done using the results of SNIFFER research project WFD48[5].
- more sophisticated modelling tools.

4.6 Notably, this comparison of the Available Groundwater Resource with groundwater abstraction **ignores other influences on surface water body flows** – i.e. surface water abstractions or discharges. These influences may result in a failure to achieve Good

[3] Recharge is calculated over a sufficiently long period of time to differentiate between short term perturbations in recharge (e.g. droughts) and the long term average annual recharge
[4] SNIFFER Report WFD53 - Criteria For WFD Groundwater Good 'Quantitative Status' And A Framework For The Assessment Of Groundwater Abstractions
[5] SNIFFER Report WFD48 – Development of Environmental Standards (Water Resources) Stage 3: Environmental Standards

Ecological Status, and they are considered separately as part of the Surface Water Test, as described in Section 5.

4.7 Wherever possible, the abstraction rate pressure estimates and the discharge rate estimates that are used in the following tests should be based on our best estimate of what is actually being abstracted or discharged at the time of classification (i.e. 2008/9 during the first River Basin Management Plan).

Classification Test

For a groundwater body:

1. **Calculate the annual average recharge to groundwater.**
2. **Calculate the annual average abstraction from groundwater.**
3. **Estimate the groundwater contribution as an annual average needed to support all river ecosystems across the groundwater body.**
4. **Calculate the available groundwater resource. This is the result of step 1 minus the result of step 3.**
5. **For good status, the available groundwater resource must exceed the annual average abstraction.**

Evidence of sustained trends in groundwater levels over at least one river basin planning cycle will inform our confidence in the status assessment for this test.

5 Surface Water Element for Groundwater Quantitative Status

5.1 Surface water and groundwater bodies are intimately connected and pressures on one may impact on the other. This test addresses whether, at a local scale, the pressures from groundwater are having a significant effect on an individual surface water body, taking into account all the pressures on that surface water body. The impacts from groundwater are usually difficult to measure, and in practice they will be determined on the basis of models of the systems or on expert judgement. Where the effects are believed to require remediation, such expert judgement should be tested, usually by some form of modelling or monitoring.

5.2 As part of the surface water characterisation, flow standards for the associated surface water bodies will be set on the basis of recommended flow criteria (SNIFFER Report WFD 48 : Development of Environmental Standards (Water Resources)), or using expert judgement.

5.3 It is rarely possible to make precise or timely measurements of the reduction in flow caused by groundwater pressures, as these increase slowly over extended periods after a new groundwater pressure is applied. The component of the surface water failure due to groundwater will therefore need to be estimated as suggested in the 'significance test' box below.

Classification Test

1. **Associate each groundwater body with a related surface water body or bodies.**
2. **Are any of these related surface water bodies failing their WFD flow standards (e.g. WFD48)?**
3. **If the flow standards are not being met for a surface water body, determine whether groundwater abstraction impacts on this surface water body are a significant component of the failure to achieve flow standards.**
4. **If groundwater abstractions are considered to be significant in any related surface water body that is failing to meet its flow standards, then the groundwater body is at poor status for this test.**
5. **If the flow standards are being met or groundwater abstractions are not considered to be causing a significant diminution of flow, then the groundwater body is at good status for this test.**

Significance test

A failure to meet the required flow standard in any surface water body may be due to either groundwater or surface water abstractions. This significance test assesses the proportion of the problem that can be attributed to groundwater abstraction within the total upstream catchment. If greater than 50% of the allowable abstraction (based on the flow standards from WFD48) can be attributed to groundwater then the groundwater body fails to meet good status for this test

6 Groundwater-Dependent Terrestrial Ecosystems (GWDTE)

Introduction

6.1 This section describes the GWDTE[6] test for both chemical and quantitative status, as the information needed for these assessments is closely linked. To complete the assessment for both quantitative and chemical status it must first be established that there is a physical linkage between the ecosystem and the groundwater body. Only terrestrial ecosystems that are directly dependent on a groundwater body can contribute to the assessment of good status for that body. The screening procedure (which is essentially an element of further characterisation) and step 5 of the test below aim to establish this link. The overall assessment procedure is outlined in Figure 2.

Screening

6.2 A screening exercise must be applied to all wetlands to identify sites that are damaged or likely to be damaged due to groundwater-related pressures. This assessment will be made based on criteria such as ecological indicator communities, likely connection to a groundwater body, proximity to anthropogenic pressures etc, backed up with site condition reports and local knowledge of the site and hydrogeological situation.

6.3 Sites identified by screening as being at risk (damaged or at high risk of being damaged through groundwater-related pressures) will be considered in the classification test. The classification test is run for the pressure identified as causing the risk to the GWDTE. If the risk screening only identifies a risk from quantitative pressures, the classification test is only run for quantitative pressures. If the risk screening only identifies a risk from chemical groundwater pressure, the test is only run for chemical pressures. If a risk is identified from both quantitative and chemical pressures the classification test should be run for both of these elements.

Classification

6.4 For quantitative status environmental supporting conditions (e.g. flow or level) must be defined which are required to maintain dependent (plant) communities in a favourable state. If these conditions are met in the GWDTE, then the groundwater body is at good status for this test. If these conditions are not being met as a result of significant impacts from groundwater pressures, then the groundwater body will be at poor status for this test.

6.5 To comply with the Groundwater Daughter Directive's requirements for chemical status, if a risk has been identified threshold values must be derived to use as triggers for further investigation to determine whether good status has been met. These thresholds are applied at monitoring points in the surveillance and operational monitoring network (see Paper 11b(i) for further details). If all threshold values are met at these monitoring points then the groundwater body is at good status.

6.6 The linkage between conditions at monitoring points and conditions within a specific GWDTE identified as being at risk will often be uncertain, particularly if the monitoring points are some distance from the GWDTE. Therefore, for this test in particular, threshold values may need to

[6] A GWDTE is a wetland ecosystem on the land surface that is directly dependent on a groundwater body and which is not part of a surface water body.

be precautionary, with a strong emphasis on drawing on site-specific data from the GWDTE as part of any investigation that follows the exceedence of a threshold value.

6.7 The threshold used to trigger further investigation will be the higher of either:

- the upper limit of natural background for the groundwater body; or
- a relevant surface water quality standard.

1.1 For many sites, it will not be possible to quantify supporting conditions required within the GWDTE (step 2 below) with a high degree of confidence. This is because sufficiently detailed site-specific information will not be available for all sites. Under these circumstances the groundwater body will be at good status for this test and the results of initial risk screening and any other available evidence should be used to decide if sites are considered 'at risk'. These 'at risk' sites should be prioritised for further investigation.

Classification test

Following the screening procedure, conduct the assessment for the pressure identified; either quantitative or chemical or both (starting with quantitative).

1. **For chemical status only, determine if the mean of the past six years of data at an appropriate point in the groundwater monitoring network indicate that a chemical threshold is exceeded in the groundwater body. If so, proceed to (2). If not the groundwater body is at good chemical status for this test.**

2. **Define relevant environmental supporting conditions (e.g. flow, level or chemistry) required within the GWDTE to maintain dependent (plant) communities in a favourable state. This can be done using a combination of published sources, relevant monitoring data, and/or expert judgement.**

3. **If the required environmental supporting conditions are in place, the groundwater body is considered to be at good status for this test.**

4. **If there is high confidence that the required environmental supporting conditions are not in place, determine the magnitude of the departure from required conditions within the GWDTE.**

5. **Determine whether departure from the required environmental supporting conditions has been caused by anthropogenic pressures in the associated groundwater body. If so, determine the proportion of the departure due to these anthropogenic pressures compared to other pressures.**

6. **If this proportion is significant (see below), and a dependent community is damaged, the groundwater body is at poor status for this test.**

7. **If this proportion is significant, and a dependent community is not damaged, the groundwater body is at good status for this test, but is at risk of failing good status requirements in the future.**

Significance test to be used in steps 6 & 7

The test of significance will be determined on a case by case basis, taking into account the functioning of the wetland. The assessment of significance should use similar principles to and be comparable with the related surface water significance tests.

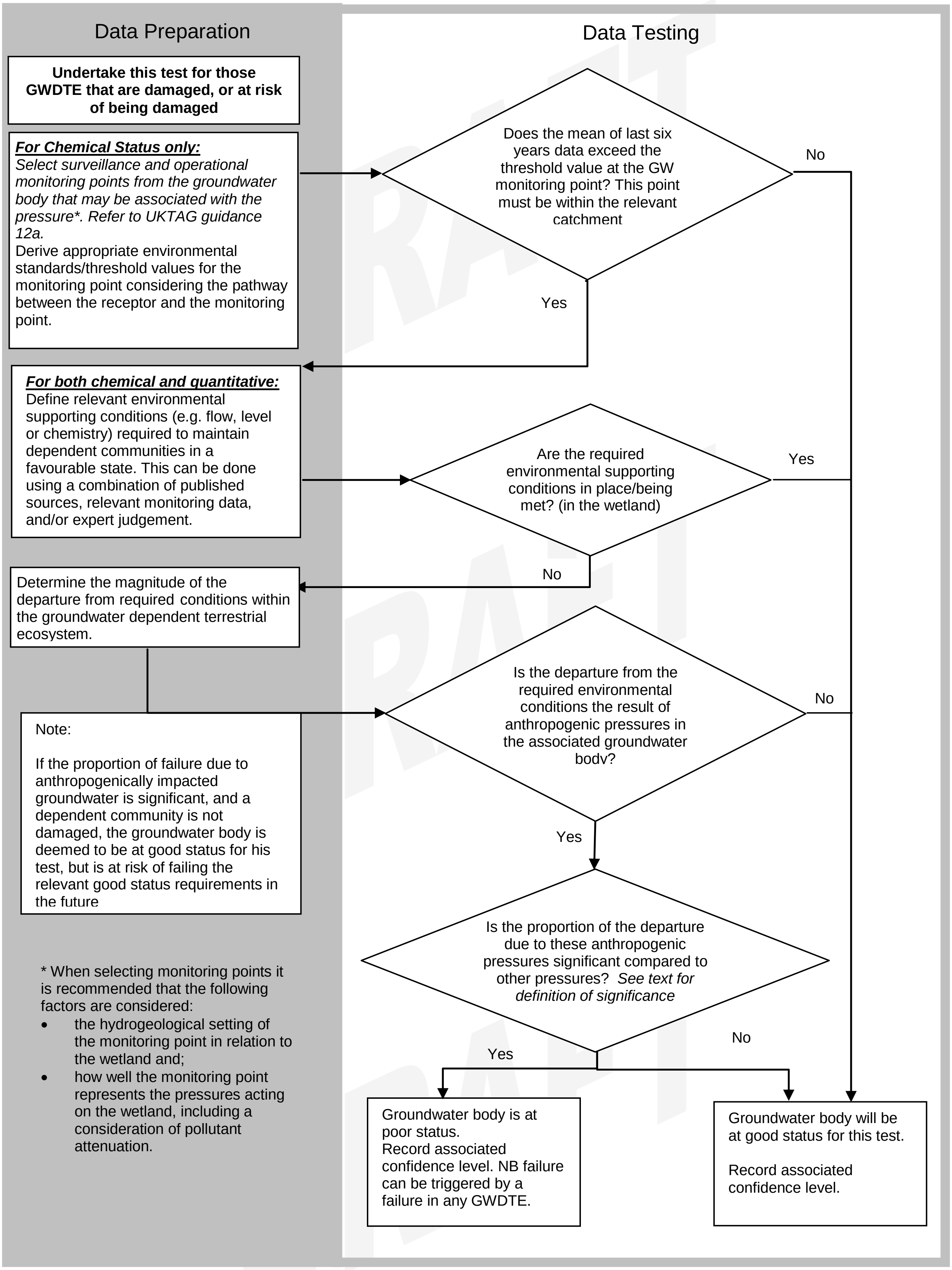

Figure 2 : Outline of procedure and data preparation for status test for significant damage to groundwater dependent terrestrial ecosystems

7 No saline or other intrusions

6.1 The test to determine the presence of adverse Saline or Other Intrusions is needed for both the quantitative and chemical status assessments. It is presented in the Chemical Status Classification paper.

Annex 1 : Discussion on the Use of Level Monitoring

A1.1 **Water balance element.** If groundwater levels are falling in a sustained long-term manner, this will confirm that more water is being abstracted than is recharged during the period of the record, thereby indicating poor status from this element. However, long-term, sustained water levels do not necessarily indicate good status, since the water required to maintain this constant level could be drawn from surface water, potentially causing ecological damage.

A1.2 **Surface Water Element.** If there is 100% surface water / groundwater connection, the rivers tend to anchor the groundwater level to the river level so that variation is minimal. In these circumstances groundwater level is not useful in indicating surface water / groundwater interaction. If there is no surface water / groundwater connection, the level in the aquifer can be above, at or below the river level and by itself does not indicate anything about the effects of groundwater on the river.

A1.3 **GWDTE element.** The groundwater level at or around terrestrial ecosystems is fundamental for improving the conceptual model of how a GWDTE functions. It is an essential tool to confirm groundwater connection but there is no single signal from the level monitoring which implies or confirms this. Rather, it is a combination of absolute level measurements, of accounting for variations in the aquifer properties and flow conditions, wetland strata and the open water area. It will almost certainly involve some sort of model developed to confirm the conceptual understanding. This model will include surface water, groundwater or both.

A1.4 **Intrusion Element.** The determination of Intrusion is to be based upon quality rather than level measurement.

A1.5 In low permeability aquifers and karst aquifers, monitoring boreholes may not give a true reflection of the piezometric surface and in some areas, the concept of a piezometric surface will have no relevance. In these circumstances, it may be better to use other indicators of quantitative (and qualitative) status such as river flows and spring flows.

A1.6 It is proposed that the best use of level data is to confirm the functioning of the groundwater body and then use the knowledge to inform the determination of status.