

Notes on references used in expert judgement and position paper on the lower limit for project-specific calculations of nitrogen depositions

Professor Arthur Petersen, University College London

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This document highlights some ingredients from the underlying scientific literature and case law that I use in my [expert judgement](#) and [position paper](#) on the lower limit for project-specific calculations of nitrogen depositions.¹

I would also like to note that the update of my expert judgement in August 2024 (original text July 2023) took place as a follow-up to, and was informed by, my membership of the scientific sounding board of the study carried out by TNO and UvA (University of Amsterdam) on behalf of IPO into a calculation's lower limit (see below: TNO 2024). The position formulated by me in my documents is no more than an elaboration and substantiation of "track 3" (based on the measurement detection limit) for determining a calculation's lower limit, which was more widely shared within the sounding board, and which played an important role in a roundtable discussion with scientific experts about a lower limit in model calculations of nitrogen deposition in nature areas on 14 December 2023 in Utrecht (I was unable to attend).² TNO (2024) specifically follows "track 1" (based on a theoretically underpinned uncertainty analysis), ultimately leading to the conclusion that along that track and on purely model/atmospheric scientific grounds, no lower limit could be found. However, if track 3 is yet examined on the basis of the higher legal standard of proof required for permitting, then based on TNO (2022) – which in addition to track 3 also follows "track 2" (based on noise in the total deposition) – and TNO (2024) it can be argued that according to atmospheric science, 1 mol/ha/year is a safe choice for the calculation's lower limit. In the following I pay relatively extensive attention to the German legal situation (Bundesverwaltungsgericht 2019), because I only refer to it indirectly in the expert judgement and the position paper and because, according to me, the details of the German ruling are important and also relevant for the Netherlands.

Advisory Committee on Measuring and Calculating Nitrogen. 2020. *Meer Meten, Robuuster Rekenen* [Measure More, Calculate More Robustly]. [Members: L. Hordijk, J.W. Erisman, H. Eskes, J.C. Hanekamp, M.C. Krol, P.F. Levelt, M. Schaap and W. de Vries]. The Hague: Adviescollege Meten en Berekenen Stikstof [Advisory Committee on Measuring and Calculating Nitrogen]. 15 June 2020. <https://open.overheid.nl/repository/ronl-663f8b39-c4c3-4e21-a321-f14f8d103ba5/1/pdf/bijlage-adviescollege-meten-en-berekenen-stikstof.pdf> [In Dutch]

In this final report from the Hordijk Committee, the still relevant conclusion is drawn that AERIUS Calculator is not fit for the purpose of its use in permitting due to 'the imbalance between the detail required by policy and the degree of scientific uncertainty in calculating the deposition on a small surface area' (p. 2). According to the committee, 'the reliability of the prediction by using a very low assessment threshold [a calculation's lower limit of 0.005 mol/ha/year] is insufficient and this approach leads to false certainty' (p. 9). Setting a higher lower limit of 1 mol/ha/year does not solve all problems with respect to false certainty. Calculating at ha level continues to lead to the conclusion

¹ For the Dutch and English versions of the various documents written by me on this subject, see <https://www.ucl.ac.uk/steapp/news/2023/mar/professor-arthur-petersen-asked-dutch-government-advice-nitrogen-policy>.

² 'Opbrengst Rondetafelgesprek met wetenschappelijk experts over een rekenkundige ondergrens in modelberekeningen van stikstofdepositie op natuurgebieden, 14 december 2023, Utrecht (BIJ12)' ['Outputs Roundtable discussion with scientific experts about a lower limit in model calculations of nitrogen deposition in nature areas, 14 December 2023, Utrecht (BIJ12)'] (<https://www.tweedekamer.nl/downloads/document?id=2024D03194>) [In Dutch].

that AERIUS Calculator is not fit for its intended purpose (the Audit Committee RIVM Centre for Environmental Quality 2024 and TNO 2024 draw the same conclusion).

Audit Committee RIVM Centre for Environmental Quality. 2024. *Scientific Audit RIVM Centre for Environmental Quality*. [Members: A.C. Petersen, B.P. Loos, W. Halfman, A.A.M. Holtslag and A.P. van Wezel]. Bilthoven: RIVM National Institute for Public Health and the Environment, 21 June 2024. <https://www.rivm.nl/sites/default/files/2024-06/MIL%20Scientific%20Audit%202023%20Final%20Report.pdf>

This report from the audit committee of the RIVM MIL–Centre for Environmental Quality (site visit held in December 2023 and report completed in February 2024), which I chaired, notes and recommends:

‘For specific cases MIL is not sufficiently explicit and clear on the limits within which models, fed by input data, can still be used. Boundaries in spatial and temporal resolution and lowest boundaries with regard to depositions or concentrations should be more actively communicated. MIL should take responsibility to avoid the mis-use of models and data outside of these boundaries. . . . [D]ifferent policy and legal settings ask for different evidence standards. Be clear and consistent about which methods are “fit” for which “purpose”. E.g. refrain from using the AERIUS-tool for permitting. . . . Collaborate . . . with others, such as the PBL, on clarifying lowest boundaries with regard to the use of nitrogen-deposition modelling in permitting’ (pp. 5, 7, 19).

Balla, Stefan, Dirk Bernotat, Jakob Frommer, Annick Garniel, Markus Geupel, Heike Hebbinghaus, Helmut Lorentz, Angela Schlutow and Rudolf Uhl. 2014. ‘Stickstoffeinträge in der FFH-Verträglichkeitsprüfung: Critical Loads, Bagatellschwelle und Abschneidekriterium’. *Waldökologie, Landschaftsforschung und Naturschutz* 14: 43–56. https://www.afsv.de/images/download/literatur/waldoekologie-online/waldoekologie-online_heft-14-3.pdf

This German scientific article substantiates the calculation’s lower limit of 21 mol/ha/year applied in Germany:

‘Das vorhabenbezogene Abschneidekriterium soll für jedes zu genehmigende Vorhaben gelten. Für die Größenordnung von 0,3 kg N ha⁻¹a⁻¹ [21 mol/ha/jaar, acp] für den vorhabenbezogenen Stickstoffeintrag in ein FFH-Gebiet sprechen verschiedene Argumente: Einträge in dieser Größenordnung liegen deutlich unterhalb der messtechnischen Erfassbarkeit und deutlich unterhalb jeder bekannten Schwelle von Zusatzbelastungen, die negative Wirkungen für die Biodiversität auslösen können; unterhalb dieser Größenordnung ist eine Ermittlung von Belastungen und Beeinträchtigungen mit derzeit verfügbaren Modellen und Eingangsdaten auch aufgrund der Unsicherheiten und fehlenden statistischen Signifikanz nicht mehr sinnvoll möglich. Zusatzbelastungen eines Vorhabens in dieser Größenordnung stellen somit lediglich ein theoretisches Risiko dar und können keine erheblichen Beeinträchtigungen im Sinne der FFH-RL auslösen. Somit können auch nur diejenigen projektbezogenen Zusatzbelastungen, die oberhalb dieses Abschneidekriteriums liegen, für eine kumulative Prüfung mit weiteren Projekten und deren gemeinsamer Wirkung geprüft werden’ (p. 44).

The measurement detection limit for nitrogen concentrations (and depositions derived from those) is taken as the starting point for determining the calculation’s lower limit. The article assumes this detection limit to be 35 mol/ha/year. According to TNO (2022) and TNO (2024), the detection limit is currently in the order of 10 mol/ha/year. In my expert judgement I use the lower value of 10 mol/ha/year as the starting point for determining the calculation’s lower limit.

Bundesverwaltungsgericht. 2019. Einbeziehung weiterer Vorhaben in die FFH-Verträglichkeitsprüfung (Summationsprüfung) [Integration of new projects into the assessment of the implications for the site under the Habitats Directive (cumulative assessment)]. ECLI:DE:BVerwG:2019:150519U7C27.17.0. 15 May 2019.

<https://www.bverwg.de/150519U7C27.17.0> [English version:
<https://www.bverwg.de/en/150519U7C27.17.0>]

The highest administrative court in Germany states in this ruling of 15 May 2019:

(35) Der Abschneidewert von 0,3 kg N/(ha·a) [rekenkundige ondergrens van 21 mol/ha/jaar, acp] ist nach den Feststellungen des Oberverwaltungsgerichts an der Messunsicherheit orientiert (juris Rn. 593). Unterhalb dieser Grenze ist die zusätzliche von einem Vorhaben ausgehende Belastung nicht mehr mit vertretbarer Genauigkeit bestimmbar bzw. nicht mehr eindeutig von der Hintergrundbelastung abgrenzbar. Stickstoffeinträge unterhalb des Abschneidewerts können nicht mehr mit Messungen belegt und die modellierten Werte damit nicht validiert werden. . . . Unter Zugrundelegung der niedrigsten Nachweisgrenze liegt der Abschneidewert für Stickstoffeinträge umgerechnet bei einer Größenordnung von 0,5 kg N/(ha·a) (juris Rn. 563). Um auf der sicheren Seite zu sein, ist der Abschneidewert in der Größenordnung der (gerundet) halben Nachweisgrenze von 0,3 kg N/(ha·a) festgelegt worden (juris Rn. 563). (36) . . . Die Verträglichkeitsprüfung nach § 48d Abs. 3 LG NRW, § 34 Abs. 1 BNatSchG und Art. 6 Abs. 3 FFH-RL knüpft an die Eignung eines Projekts oder Planes an, das Natura-2000 Gebiet zu beeinträchtigen. Es bedarf insoweit nicht des Nachweises eines ursächlichen Zusammenhangs zwischen dem Projekt oder Plan und der erheblichen Beeinträchtigung der Erhaltungsziele. Eine gewisse Wahrscheinlichkeit einer solchen Störung muss aber gegeben („nachweisbar“) sein (EuGH, Urteile 14. Januar 2016 – C-141/14 [ECLI:EU:C:2016:8], Kommission/Bulgarien – Rn. 58 und vom 24. November 2011 – C-404/09 - Rn. 142; BVerwG, Urteil vom 23. April 2014 – 9 A 25.12 – BVerwGE 149, 289 Rn. 45). Rein theoretische Besorgnisse sind daher nicht zu berücksichtigen. Das unionsrechtliche Vorsorgeprinzip, das in Art. 6 Abs. 3 FFH-RL seinen Niederschlag gefunden hat (Art. 191 Abs. 2 Satz 2 AEUV, vgl. EuGH, Urteil vom 7. September 2004 - C-127/02 [ECLI:EU:C:2004:482], Raad van State/Niederlande – Rn. 58), verlangt auch nicht, die Verträglichkeitsprüfung auf ein Nullrisiko auszurichten, weil hierfür ein wissenschaftlicher Nachweis nie geführt werden könnte. Ein Projekt ist vielmehr dann zulässig, wenn nach Abschluss der Verträglichkeitsprüfung aus wissenschaftlicher Sicht kein vernünftiger Zweifel verbleibt, dass erhebliche Beeinträchtigungen vermieden werden. Um zu einer verlässlichen Beurteilung zu gelangen, muss die Verträglichkeitsprüfung die „besten einschlägigen wissenschaftlichen Erkenntnisse“ berücksichtigen und setzt somit die „Ausschöpfung aller wissenschaftlichen Mittel und Quellen“ voraus (BVerwG, Urteil vom 28. März 2013 – 9 A 22.11 – BVerwGE 146, 145 Rn. 41; EuGH, Urteil vom 26. Oktober 2006 – C-239/04 [ECLI:EU:C:2006:6653], Kommission/Portugal – Rn. 20). Hieran gemessen kann es für die Festlegung des Untersuchungsgebietes einer FFH-Verträglichkeitsprüfung und damit der in der Summationsprüfung zu berücksichtigenden Projekte nicht auf einen messtechnisch nicht erfassbaren Stickstoffeintrag ankommen. (37) Ein aufgrund von Rechenmodellen ermittelter, empirisch aber weder nachweisbarer noch wirkseitig zuordenbarer Eintragswert, stellt eine rein theoretische Besorgnis dar. Entgegen der Auffassung des Oberverwaltungsgerichts ist dieser dem BAST-Bericht zugrunde liegende Ansatz nicht nur plausibel, soweit er sich auf ein Vorhaben bezieht. Auch eine Vielzahl nicht mess- und validierbarer Besorgnisse führt nicht auf einen wirkseitig einem Projekt anzulastenden Betrag. Messunsicherheiten kumulierender Projekte lassen sich daher entgegen der Annahme des Oberverwaltungsgerichts nicht addieren. Eine Addition unterhalb der Nachweisgrenze liegender modellierter und damit hypothetischer Einträge änderte an dem mangelnden Wirknachweis in Bezug auf ein Projekt nichts. Solange sich nicht klären lässt, ob, und wenn ja, in welcher Höhe, Einträge überhaupt existieren und welchen Quellen sie entstammen, lässt sich auch keine hinreichende Wahrscheinlichkeit einer erheblichen Beeinträchtigung feststellen. Solche "Einträge" wirken vielmehr diffus und sind allenfalls als Teil der Hintergrundbelastung abbildbar (vgl. Balla, Bernotat, Frommer, Garniel, Geupel, Hebbinghaus, Lorentz, Schlutow, Uhl, Stickstoffeinträge in der FFH-Verträglichkeitsprüfung: Critical Loads, Bagatellschwelle und Abschneidekriterium, Waldökologie, Landschaftsforschung und Naturschutz, 2014 S. 43 <51>). Es ist aber nicht Gegenstand der Verträglichkeitsprüfung, vorhabenbezogenen Maßnahmen zur Verbesserung der Hintergrundbelastung durch Stickstoff zu prüfen und festzusetzen. Dies ist vielmehr Aufgabe des Gebietsmanagements (vgl. auch Weuthen, ZUR 2017, 215).'

English version:

(35) According to the findings of the Higher Administrative Court, the cut-off value of 0.3 kg N/(ha·a) [rekenkundige ondergrens van 21 mol/ha/jaar, acp] is oriented at measurement uncertainties (...). Below this threshold, the additional load from a project can no longer be determined with reasonable accuracy or cannot be clearly distinguished from the background level (*Hintergrundbelastung*). Nitrogen inputs below the cut-off value can no longer be measured and thus the modelled values cannot be validated. . . . On the basis of the lowest detection limit, the cut-off value for nitrogen inputs converts into the order of 0.5 kg N/(ha·a) (...). To be on the safe side, the cut-off value has been set in the order of half the (rounded) detection limit at 0.3 kg N/(ha·a) (...). (36) . . . The assessment of the implications for the site according to section 48d (3) LG NRW, section 34 (1) BNatSchG and article 6 (3) of the Habitats Directive is linked to a project or plan likely to affect the Natura 2000 site. In this respect it is not necessary to prove a causal link between the project or plan and the significant effect on the conservation objectives. However, a certain probability of such a disturbance must exist (“be possible to establish”) (CJEU, judgments of 14 January 2016 – C-141/14 [ECLI:EU:C:2016:8], Commission/Bulgaria – para. 58 and of 24 November 2011 – C-404/09 – para. 142; BVerwG, judgment of 23 April 2014 – 9 A 25.12 – BVerwGE 149, 289 para. 45). Purely theoretical concerns are therefore not to be taken into account. The precautionary principle under EU law, which is reflected in article 6 (3) of the Habitats Directive (article 191 (2) second sentence of the Treaty on the Functioning of the European Union (TFEU), see CJEU, judgment of 7 September 2004 – C-127/02 [ECLI:EU:C:2004:482], Raad van State/Netherlands – para. 58), also does not require the assessment of the implications for the site to be based on zero risk, because scientific evidence could never be provided for this. Rather, a project is permissible if, after completion of the assessment of the implications for the site, there is no reasonable doubt from a scientific point of view that significant effects will be avoided. In order to arrive at a reliable evaluation, the assessment of the implications for the site must take into account the “best relevant scientific knowledge” and thus presupposes the “exhaustion of all scientific means and sources” (BVerwG, judgment of 28 March 2013 – 9 A 22.11 – BVerwGE 146, 145 para. 41; CJEU, judgment of 26 October 2006 – C-239/04 [ECLI:EU:C:2006:665], Commission/Portugal – para. 20). Measured against this standard, the determination of the site to be examined in an assessment of the implications for the site under the Habitats Directive and thus the projects to be considered in the cumulative assessment cannot depend on nitrogen input that cannot be measured. (37) An input value determined on the basis of calculation models which is neither empirically verifiable nor attributable with regard to its impact, represents a purely theoretical concern. Contrary to the opinion of the Higher Administrative Court, this approach underlying the BAST Report 2013 is not only plausible insofar as it relates to one project. A large number of concerns that cannot be measured and validated do not lead to an actual amount to be charged to a project with regard to impact either. Measurement uncertainties of cumulative projects can therefore not be added up, contrary to the assumption of the Higher Administrative Court. An addition of modelled and thus hypothetical inputs lying below the detection limit would not change the lack of proof of impact with regard to a project. As long as it is not possible to clarify whether, and if so to what extent, inputs exist at all and which sources they originate from, no sufficient likelihood of significant effect can be determined. Rather, such “inputs” have a diffuse impact and can at best be represented as part of the background level (...). However, it is not part of the assessment of the implications for the site to consider and establish measures to improve the background nitrogen level on a project basis. This rather is the task of site management (...).’

The highest German administrative court hereby confirms that the calculation’s lower limit must be oriented to the measurement detection limit and that depositions below such a lower limit, determined on the basis of empirics, are ‘theoretical’ and therefore provide false certainty (cf. Advisory Committee on Measuring and Calculating Nitrogen. 2020) and must be disregarded – and they may not be included in summations in the assessment of individual projects.

Council of State (Raad van State). 2023. Tussenuitspraak over rekenafstand 25 km [Interim ruling on calculation distance of 25 km.]. ECLI:NL:RVS:2023:1299. 5 April 2023.

<https://www.raadvanstate.nl/uitspraken/@136592/201702813-17-r3/> [In Dutch]

Just like the German highest administrative court (*Bundesverwaltungsgericht*), the Dutch Council of State (*Raad van State*) makes it clear in this ruling that when calculations are falsely certain – in the context of this ruling this concerns project-specific calculations of deposition beyond the distance of 25 km – they must be disregarded (and may not be included in summations in the assessment of individual projects). Managing the risk of accumulation is a task for the government with generic policy. In the ruling (under 1.5), the Council of State writes, for example: ‘The question whether the competent administrative bodies implement the obligation to take conservation measures and appropriate measures in relation to the total deposition contribution to a Natura 2000 area in a timely manner and with the correct measures [arts 6.1 and 6.2 HD, acp] is, in the opinion of the Administrative Jurisdiction Division, not relevant in a decision granting a permit for a plan or project [art 6.3 HD, acp].’

Don, Henk. 2007. ‘Foreword’. In *Dealing with Uncertainty in Policymaking*, edited by Judith Mathijssen, Arthur Petersen, Paul Besseling, Adnan Rahman and Henk Don, 5. The Hague: CPB Netherlands Bureau for Economic Policy Analysis, Bilthoven: MNP Netherlands Environmental Assessment Agency and Leiden: Rand Europe.

<https://www.pbl.nl/sites/default/files/downloads/550032011.pdf>

CPB director Henk Don, together with several others (including me), was the initiator of the conference ‘Dealing with uncertainty in policymaking’ in May 2006. He concludes in this foreword to the conference report that dealing with uncertainty in various policy domains is quite complex and mutually different. I think this is confirmed when one tries to answer the present question about dealing with uncertainty in nitrogen deposition calculations in the context of permitting.

European Commission. 2019. *Scientific Advice to European Policy in a Complex World*. Brussels: Group of Chief Scientific Advisors, Scientific Advice Mechanism, European Commission.

<https://op.europa.eu/en-GB/publication-detail/-/publication/5cb9ca21-0500-11ea-8c1f-01aa75ed71a1/language-en>

In this scientific opinion from the Group of Chief Scientific Advisors of the Scientific Advice Mechanism of the European Commission, the Guidance for Uncertainty Assessment and Communication (Petersen et al. 2013, see below) is recommended as an example of how to deal with uncertainty in scientific advice to policy.

Hordijk, Leen. [2007] 2008. ‘Case V: Air quality’. In *Dealing with Uncertainty in Policymaking*, edited by Judith Mathijssen, Arthur Petersen, Paul Besseling, Adnan Rahman, and Henk Don, 51–55. The Hague: CPB Netherlands Bureau for Economic Policy Analysis, Bilthoven: MNP Netherlands Environmental Assessment Agency and Leiden: Rand Europe.

<https://www.pbl.nl/sites/default/files/downloads/550032011.pdf>

Leen Hordijk (then director of the International Institute of Applied Systems Analysis) discussed the case of large-scale air quality at the conference ‘Dealing with uncertainty in policymaking’ in May 2006. He emphasises: ‘When building the model, it is important when selecting model components to take into account the policy-related requirements and the circumstances of the specific policy problem’ (p. 54). It follows from this that how a model is built and used (e.g. with regard to the choice of a calculation’s lower limit in model calculations of nitrogen deposition in the context of permitting) should not be left to the model builders alone.

Hordijk, Leen. 2024. ‘Twee alternatieven voor het Nederlandse stikstofbeleid’ [‘Two alternatives for Dutch nitrogen policy’]. *ESB* 109 (4837): 410–412. <https://esb.nu/twee-alternatieven-voor-het-nederlandse-stikstofbeleid/> [In Dutch]

In this article, Leen Hordijk explains, among other things, that the conclusions of the Hordijk Committee (the Advisory Committee on Measuring and Calculating Nitrogen) from 2020 still apply. He

refers to TNO (2024) as follows: 'A recent study shows that [the imbalance between the detail required by policy (deposition calculations at ha level) and the degree of scientific uncertainty in calculating the deposition at that small surface] leads to large uncertainties in the calculation of the deposition contribution from a single source' (p. 411).

Janssen, Peter, Arthur Petersen, Jeroen van der Sluijs, James Risbey and Jerome Ravetz. 2003. *RIVM/MNP Guidance for Uncertainty Assessment and Communication: Quickscan Hints & Actions List*. Bilthoven: National Institute for Public Health and the Environment/Netherlands Environmental Assessment Agency.
https://www.rivm.nl/bibliotheek/digitaaldepot/Guidance_QS-HA.pdf

This is the 1st edition of (part of) Petersen et al. (2013, see below).

Mathijssen, Judith, Arthur Petersen, Paul Besseling, Adnan Rahman and Henk Don, eds. [2007] 2008. *Dealing with Uncertainty in Policymaking*. The Hague: CPB Netherlands Bureau for Economic Policy Analysis, Bilthoven: MNP Netherlands Environmental Assessment Agency and Leiden: Rand Europe.
<https://www.pbl.nl/sites/default/files/downloads/550032011.pdf>

This is the full report of the conference 'Dealing with uncertainty in policymaking' held in May 2006. This conference still represents the state-of-the-art in the field of dealing with uncertainties in policy.

Natura 2000 Support Centre. 2010. *Leidraad bepaling significantie: Nadere uitleg van het begrip 'significante gevolgen' uit de Natuurbeschermingswet [Guidelines for Determining Significance: Further Explanation of the concept of 'significant effects' from the Nature Conservation Act]*. Ede: Ministry of Agriculture, Nature and Food Quality.
https://www.commissiemer.nl/docs/mer/diversen/leidraad_bepaling_significantie27052010.pdf [In Dutch]

This guidance proposes a risk approach for determining whether an effect has the potential to lead to ecologically significant effects:

'the *extent* of an effect and the *chance* with which the effect can occur must be clearly distinguished. Attention is often concentrated on the first, while the second is just as relevant. This point needs to be further developed, where lessons can be learned from the (legal) practice of environmental protection. In particular, the question arises: when is a probability unacceptably high? And how does that relate to the effect? For example, can both be multiplied so that a 100% chance of a small effect (building a house in the edge of a forest) is just as significant as a small chance of a large effect (the complete disappearance of river seepage in a wetland forest as a result of limited dike reinforcement) (p. 25).

Petersen, Arthur. 2006. *Simulating Nature: A Philosophical Study of Computer-Model Uncertainties and Their Role in Climate Science and Policy Advice*. Apeldoorn/Antwerp: Het Spinhuis Publishers. DPA thesis VU University, Amsterdam.
<https://research.vu.nl/ws/portalfiles/portal/42175122/complete+dissertation.pdf>

This is the 1st edition of Petersen (2012, see below).

Petersen, Arthur. [2007] 2008. 'Dealing with uncertainty in policymaking'. In *Dealing with Uncertainty in Policymaking*, edited by Judith Mathijssen, Arthur Petersen, Paul Besseling, Adnan Rahman, and Henk Don, 15–18. The Hague: CPB Netherlands Bureau for Economic Policy Analysis, Bilthoven: MNP Netherlands Environmental Assessment Agency and Leiden: Rand Europe. <https://www.pbl.nl/sites/default/files/downloads/550032011.pdf>

This piece contains the uncertainty matrix from Janssen et al. (2003) (2nd edition Petersen et al. 2013).

Petersen, Arthur. 2012. *Simulating Nature: A Philosophical Study of Computer-Model Uncertainties and Their Role in Climate Science and Policy Advice*. 2nd edition [of Petersen (2006)]. Boca Raton, FL: CRC Press.

This book offers a philosophy of science exploration of the uncertainty matrix, value-ladenness and methodological reliability.

Petersen, Arthur. 2022. 'Expert judgement on the underpinning of the maximum calculation distance in project-specific calculations of nitrogen depositions'. Written on behalf of the Ministry of Infrastructure and Water Management. 9 November 2022.
https://www.ucl.ac.uk/steapp/sites/steapp/files/expert_judgement_arthur_petersen_11-11-202235.pdf

The reasoning in this expert judgement is analogous to the reasoning in the expert judgement about a calculation's lower limit.

Petersen, Arthur, and Marjolein van Asselt. [2007] 2008. 'Conclusions and recommendations'. In *Dealing with Uncertainty in Policymaking*, edited by Judith Mathijssen, Arthur Petersen, Paul Besseling, Adnan Rahman, and Henk Don, 59–69. The Hague: CPB Netherlands Bureau for Economic Policy Analysis, Bilthoven: MNP Netherlands Environmental Assessment Agency and Leiden: Rand Europe.
<https://www.pbl.nl/sites/default/files/downloads/550032011.pdf>

This piece contains the conclusions and recommendations of the conference 'Dealing with uncertainty in policymaking' held in May 2006.

Petersen, Arthur, Peter Janssen, Jeroen van der Sluijs, James Risbey and Jerome Ravetz. 2003. *RIVM/MNP Guidance for Uncertainty Assessment and Communication: Mini-Checklist & Quickscan Questionnaire*. Bilthoven: National Institute for Public Health and the Environment/Netherlands Environmental Assessment Agency.
https://www.rivm.nl/bibliotheek/digitaaldepot/Guidance_MC_QS-Q.pdf

This is the 1st edition of (part of) Petersen et al. (2013, see below).

Petersen, Arthur, Peter Janssen, Jeroen van der Sluijs, James Risbey, Jerome Ravetz, Arjan Wardekker and Hannah Martinson Hughes. 2013. *Guidance for Uncertainty Assessment and Communication*. 2nd edition [of Petersen et al. (2003) and Janssen et al. (2003)]. The Hague: PBL Netherlands Environmental Assessment Agency.
https://www.pbl.nl/sites/default/files/downloads/pbl_2014_guidance_for_uncertainty_assessment_and_communication_712_0.pdf

This guidance represents the state-of-the-art in the field of dealing with uncertainties in policy (see European Commission 2019).

Smith, Leonard, and Arthur Petersen. 2014. 'Variations on reliability: Connecting climate predictions to climate policy'. In *Error and Uncertainty in Scientific Practice*, edited by Marcel Boumans, Giora Hon and Arthur Petersen, 137–56. London: Pickering & Chatto.
<https://www.lse.ac.uk/CATS/Assets/PDFs/Publications/Papers/2014/Smith-Petersen-Variations-on-reliability-2014.pdf>

This philosophy of science chapter distinguishes between three types of reliability: (1) statistical reliability ('confidence intervals'), (2) methodological reliability and (3) public reliability.

TNO. 2022. *Afbakening in de modellering van depositiebijdragen van individuele projectbijdragen (Fase 2) Versie 3 [Delineation in the Modelling of Deposition Contributions from Individual Project Contributions (Phase 2) Version 3]*. Reference 100342643. [Authors: J. Duyzer and H. Erbrink]. Utrecht: TNO. 26 April 2022.
<https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2022/04/26/afbakening-in-de-modellering-van-de-depositiebijdragen-van-individuele->

[projectbijdragen/afbakening-in-de-modellering-van-de-depositiebijdragen-van-individuele-projectbijdragen.pdf](#) [In Dutch]

According to me, this report provides – with today’s legal knowledge – all the necessary information to arrive at a scientifically substantiated calculation’s lower limit, either on the basis of track 2 (based on noise in the total deposition) or on the basis of track 3 (based on the measurement detection limit). It forms the basis of my expert judgement (see the explicit references).

TNO. 2024. *Een ondergrens in de berekening van stikstofdepositiebijdragen voor vergunningverlening: Onderzoek naar een wetenschappelijk onderbouwde ondergrens [A Lower Limit in the Calculation of Nitrogen-Deposition Contributions for Permitting: Study into a Scientifically Substantiated Lower Limit]*. Referentie R11334. [Authors: E. Meijer and E. van Loon]. Den Haag: TNO. 15 August 2024. <https://www.ipo.nl/5541> [In Dutch]

The insights gained in this study have been incorporated (also with explicit references) into my expert judgement. In the discussion chapter (pp. 21–24), the report discusses the options of following tracks 2 or 3 as ‘possible other lines of thought’ for determining a scientifically substantiated calculation’s lower limit.

van der Sluijs, Jeroen. [2007] 2008. ‘Uncertainty communication’. In *Dealing with Uncertainty in Policymaking*, edited by Judith Mathijssen, Arthur Petersen, Paul Besseling, Adnan Rahman, and Henk Don, 23–27. The Hague: CPB Netherlands Bureau for Economic Policy Analysis, Bilthoven: MNP Netherlands Environmental Assessment Agency and Leiden: Rand Europe. <https://www.pbl.nl/sites/default/files/downloads/550032011.pdf>

This piece contains an explanation of pedigree analysis to qualify the strength of knowledge.