Norwegian methods used to set TP boundaries and how they have worked in practice

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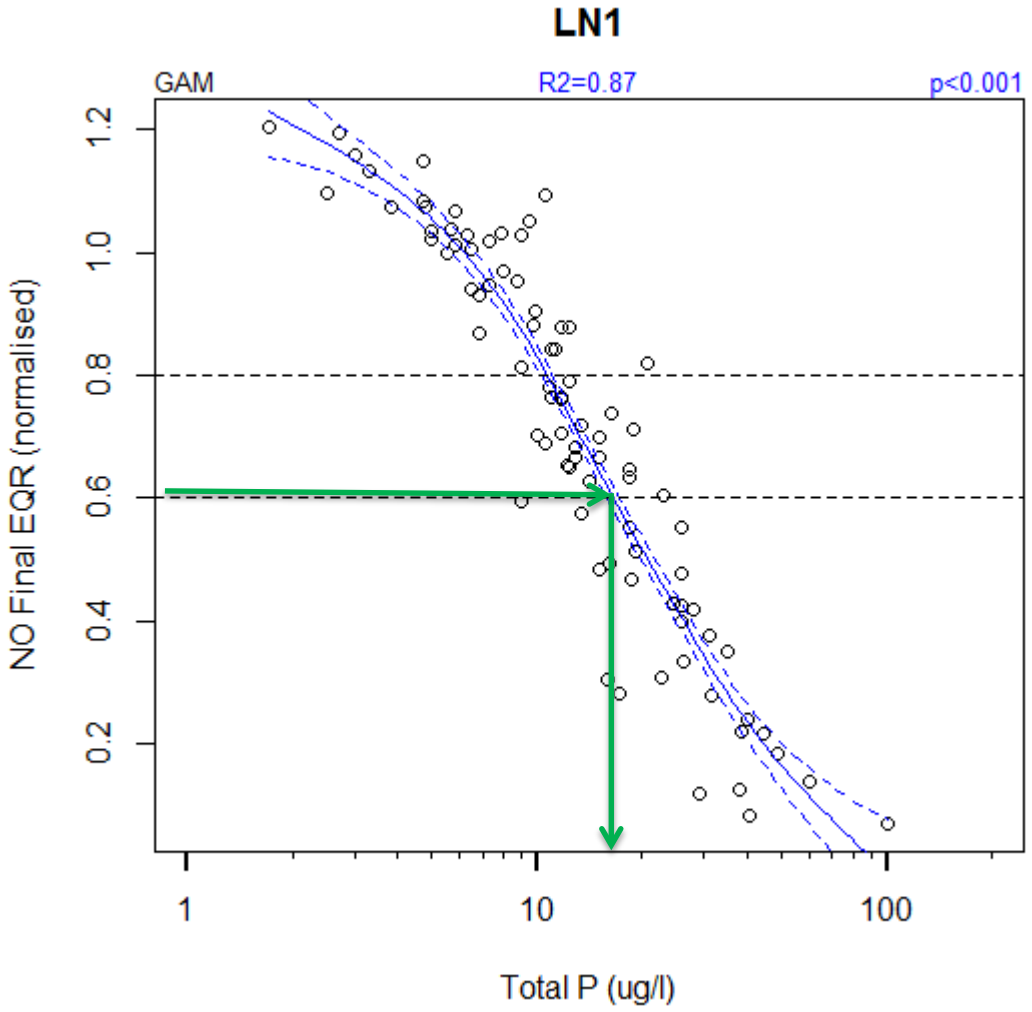
Methods used for deriving nutrient standards in Norway

Phosphorus:

Regressions with intercalibrated BQE metrics:

- The intercalibrated GM boundary for the BQEs are used to set the GM boundary for Total-P in both lakes and rivers

Norwegian lakes:
Total P vs Phytoplankton nEQR or chlorophylla



Face value used to set GM boundary

(low variability)

Example shown for lowland, moderate alkalinity, clear, stratified lakes (graph by G. Phillips, data by Brettum and Skjelbred, NIVA)

For many other types, the intercalibrated chlorophyll a GM boundary was used instead of the nEQR value, due to lower variability in the regressions

Norwegian Total-P classification system for for different lake types

			Total Phosphorus (µg/L) in lakes					
Type description	***National lake type no.***	***NGIG type***	**Ref value**	**high**	**good**	**moderate**	**poor**	**bad**
Lowland, low alk, clear, shallow	1,2,4,**5**,18	L-N2a	4	1 - 7	7 - 11	11 - 20	20 - 40	>40
Lowland, low alk, clear, deep	6	L-N2b	3	1 - 4	4 - 9	9 - 16	16 - 38	>38
Lowland, low alk, humic	3,**7**,19	L-N3a	6	1 - 11	11 - 16	16 - 30	30 - 55	>55
Lowland, mod alk, clear	**8**,10,	L-N1	6	1 - 10	10 - 17	17 - 26	26 - 42	>42
Lowland, mod alk, humic	**9**,11,	L-N8a	7	1 - 13	13 - 20	20 - 39	39 - 65	>65
Mid-altitude, low alk, clear	12,13,15,**16**	L-N5a	3	1 - 5	5 - 10	10 - 17	17 - 36	>36
Mid-altitude, low alk, humic	14,**17**,22,25	L-N6a	5	1 - 9	9 - 13	13 - 24	24 - 45	>45
Highland, low alk, clear	20,21,23,**24**	L-N7	2	1 - 3	3 - 5	5 - 11	11 - 20	>20

*** Types in bold font are most similar to the NGIG type**

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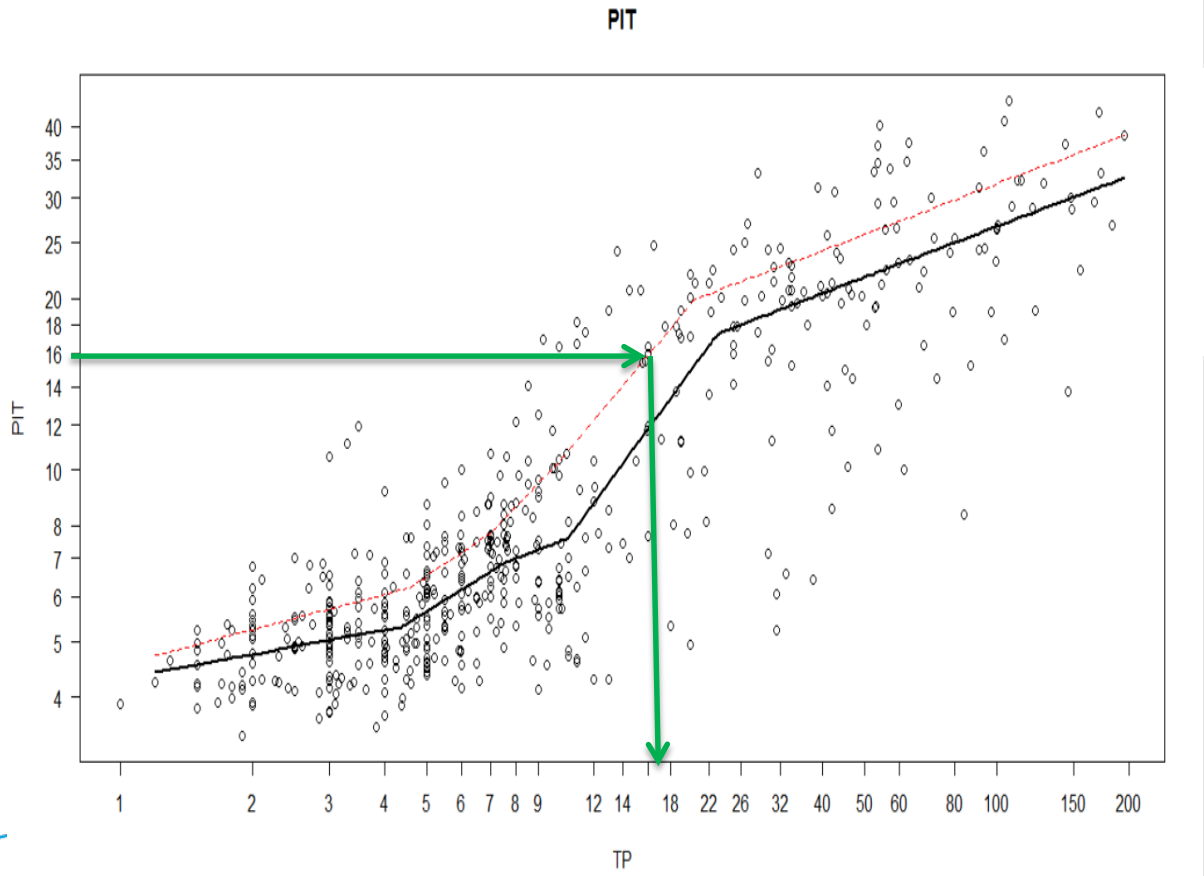
Norwegian Rivers:
Total P vs Benthic algae (non-diatoms) (PIT)

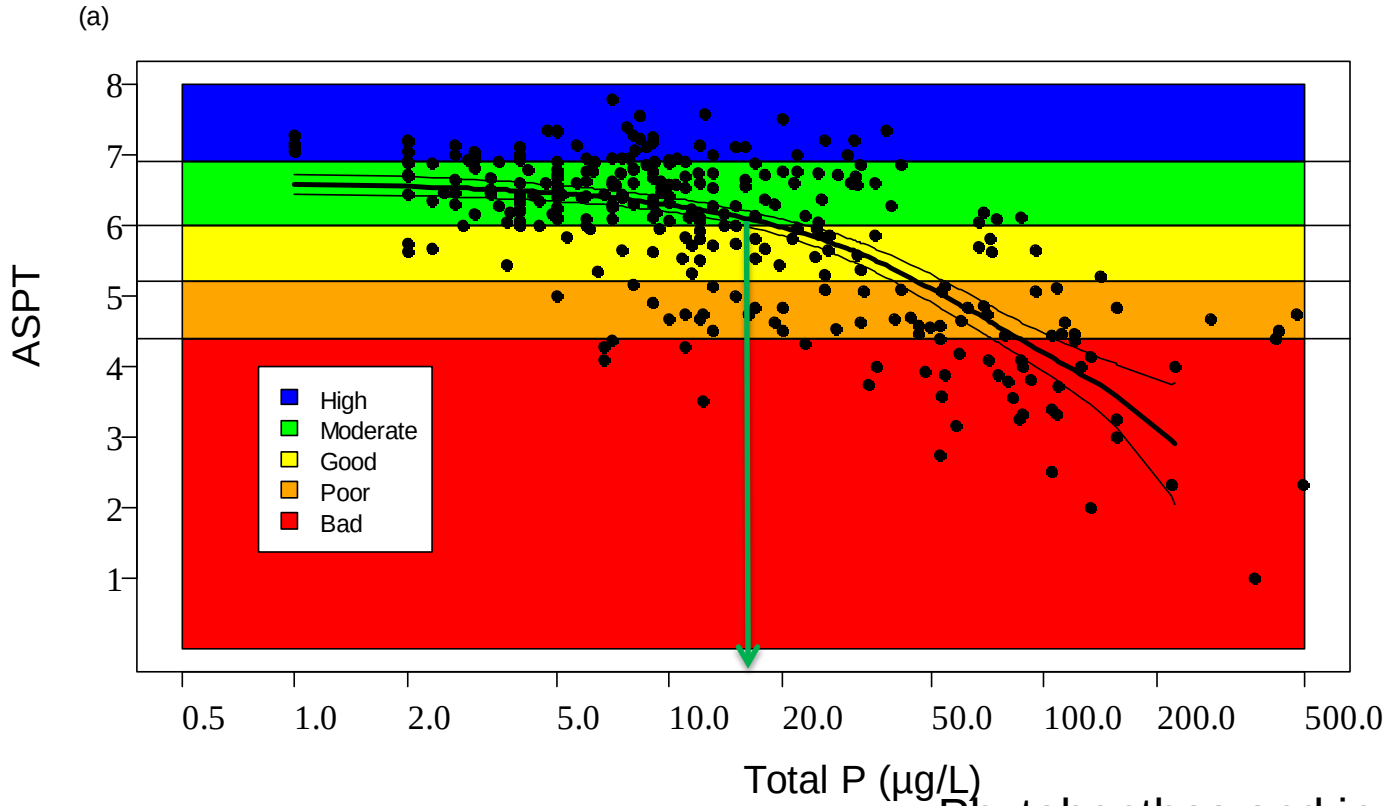


Lower 75th %ile used to set GM boundary

(precautionary principle to ensure a 75 % probability for restoration)

Example shown for low alkalinity, clear rivers
(graph by Eriksen, data by Schneider and Lindstrøm, NIVA)

Norwegian Rivers:
Total-P vs. Benthic invertebrates (ASPT)



Lower stdev used to set GM boundary (pre-cautionary principle)

Example shown for low alkalinity, clear rivers
(graph made by Moe & Eriksen, data from Bækken, NIVA)

Phytobenthos and invertebrates regressions gave the same TP standard: **17 µg/l**

RIVERS:
Norwegian Total-P classification system for different river types

			Total Phosphorus (µg/L) in rivers					
Type description	***National river type no.***	***NGIG type***	**Ref value**	**high**	**good**	**moderate**	**poor**	**bad**
Lowland, low alk, clear,	1,2,4,**5**,18	R-N2	6	1 - 11	11 - 17	17 - 30	30 - 60	>60
Lowland, low alk, humic	3,**6**,19	R-N3	9	1 - 17	17 - 24	24 - 45	45 - 83	>83
Lowland, mod alk, clear	**7**,9,	R-N1	9	1 - 15	15 - 25	25 - 38	38 - 65	>65
Lowland, mod alk, humic	**8**,10,		11	1 - 20	20 - 29	29 - 58	58 - 98	>98
Mid-altitude, low alk, clear	12,13,15,**16**	R-N5	5	1 - 8	8 - 15	15 - 25	25 - 55	>55
Mid-altitude, low alk, humic	14,**17**,22,25	R-N6	8	1 - 14	14 - 20	20 - 36	36 - 68	>68
Highland, low alk, clear	20,21,23,**24**	R-N7	3	1 - 5	5 - 8	8 - 17	17 - 30	>30

*** fet skrift er mest lik NGIG typen**

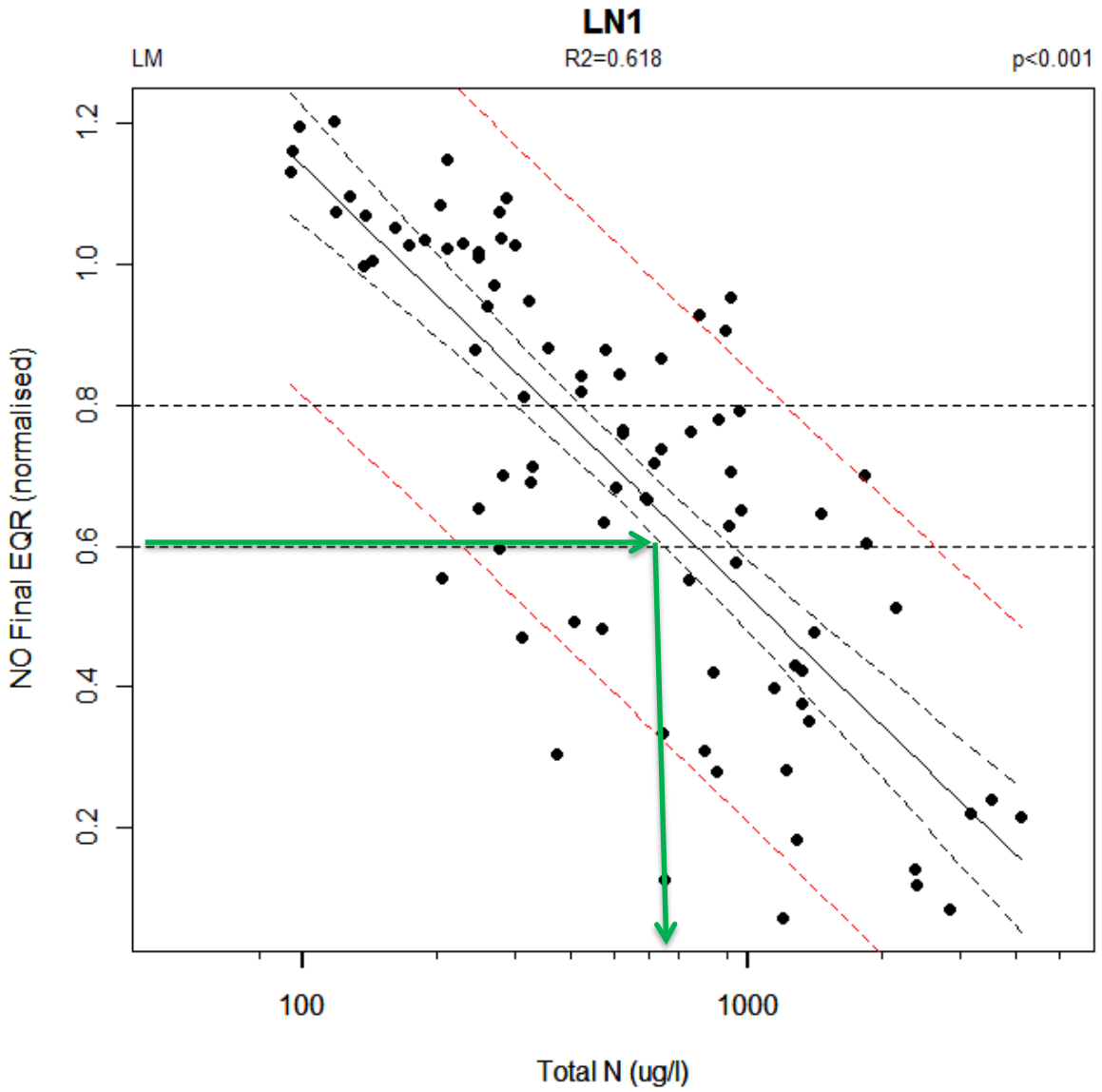
Methods to set nitrogen standards

Total Nitrogen:

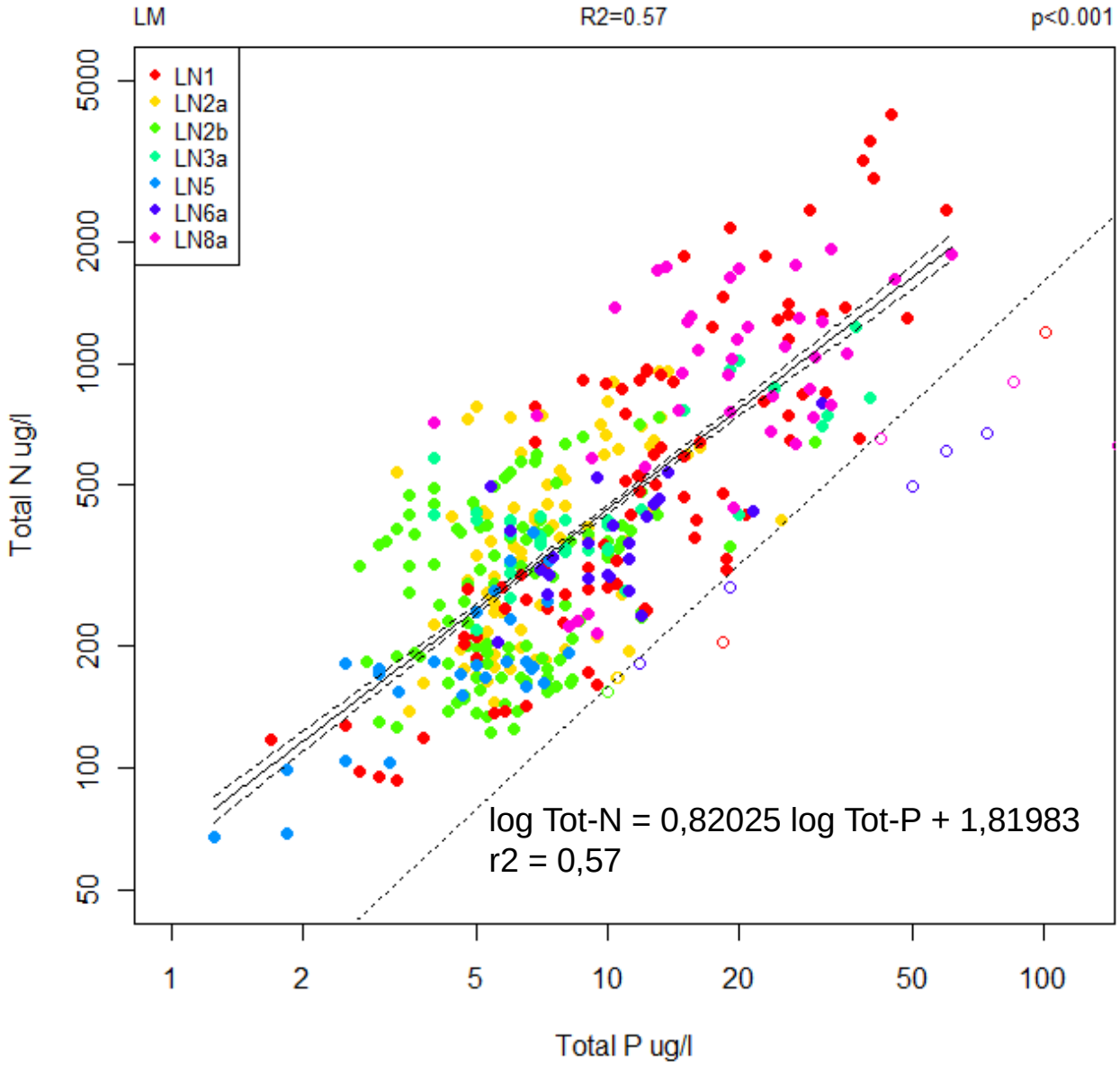
- Regressions between the intercalibrated GM boundary for phytoplankton (nEQR) vs Total-N (lakes)
- Regressions between Total-N vs Total-P, using the Total-P GM boundary as a basis (lakes and rivers)

Nitrogen standards setting:
Norwegian Lakes: Total N vs Phytoplankton nEQR

using the lower stdev (precautionary principle due to higher variability for TN than for TP regressions)



Total-N vs Total-P regression:



Norwegian Total-N classification system for different lake and river types

Type description	*National lake type no.*	*NGIG type*	*National river type no.*	*NGIG type*	Total nitrogen (Tot-N) in lakes and rivers (µg/L)					
					Ref value	high	good	moderate	poor	bad
Lowland, low alk, clear, shallow	1,2,4,**5**,18	L-N2a	1,2,3,4,**5,**18	R-N2	200	1-325	325-475	475-775	775-1350	>1350
Lowland, low alk, clear, deep	6	L-N2b	na	na	175	1-200	200-400	400-650	650-1300	>1300
Lowland, low alk, humic	3,**7**,19	L-N3a	**6**, 19	R-N3	275	1-475	475-650	650-1075	1075-1775	>1775
Lowland, mod alk, clear	**8**,10,	L-N1	**7**, 9	R-N1/ R-N4	275	1-425	425-675	675-950	950-1425	>1425
Lowland, mod alk, humic	**9**,11,	L-N8a	**8**, 10, 11		325	1-550	550-775	775-1325	1325-2025	>2025
Mid-altitude, low alk, clear	12,13,15,**16**	L-N5a	12,13,15,**16**	R-N6	150	1-250	250-425	425-675	675-1250	>1250
Mid-altitude, low alk, humic	14,**17**,22,25	L-N6a	14,**17**, 22, 25	R-N7	250	1-400	400-550	550-900	900-1500	>1500
Highland, low alk, clear	20,21,23,**24**	L-N7	20,21,23,**24**	R-N6	125	1-175	175-250	250-475	475-775	>775

Bold font type most similar to NGIG type

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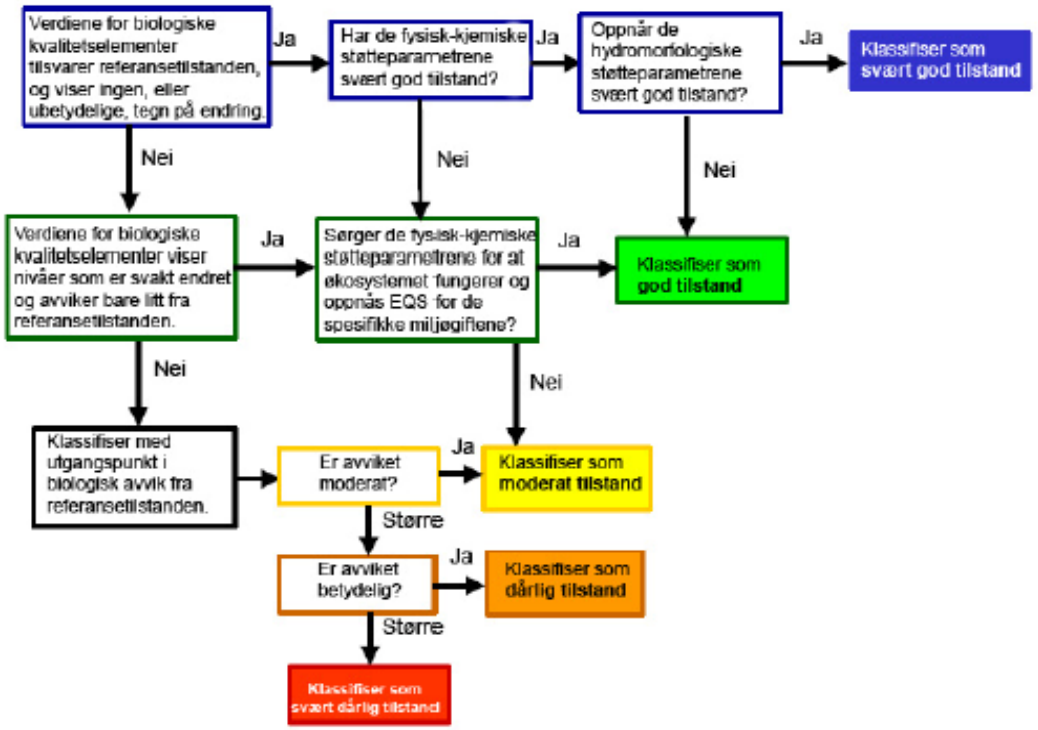
How have the standards worked in practice? (status assessment)

- Used for assessing ecological status together with the BQEs acc. to the CIS guidance on classification:



How have the standards worked in practice? (status assessment)

- Example: Lake Laugen in mid-Norway

Quality elements	Value	Class	EQR	nEQR
Biological quality elements				
Phytoplankton: chlorofyll-a, µg/l	5	H	0,70	0,88
Phytoplankton: Totalt volum, mm^3/l	0,69	H	0,95	0,84
Phytoplankton: Trofisk indeks, PTI	2,36	H	0,92	0,83
Phytoplankton: $Cyano_{max}$, mm^3/l	0,43	G	0,96	0,74
Total phytoplankton assessment		H		0,81
Macrophytes eutrofieringsindeks: TIc	47,4	G	0,87	0,69
Total macrophytes assessment		G		0,69
Total assessment BQEs (using OOAO)		G		0,69
Physico-chemical quality elements				
Total phosphorus, µg/l	9,7	H	0,72	0,88
Total nitrogen, µg/l (not used as not limiting nutrient)	768	G	0,42	0,604
Secchi depth, m	2,8	M	0,71	0,57
Total assessment Physico-chemical quality elements (eutrophication parameters)		G		0,73
Total assessment for the whole water body (OOAO)		G		0,69

How have the standards worked in practice? (status assessment)

- Do these standards cause mismatch between BQEs and the supporting QEs for classification?
  - *Norway has not yet reported WFD data to WISE*
  - *Limited experience so far indicates very few cases of TP (or TN) giving lower class than the BQEs, if BQEs are high or good, mainly for rivers*

How have the standards worked in practice? (basis for mitigation measures)

The standards are used as a basis for assessing the need for reduction of nutrients

- Does the current concentration exceed the standard?
- If yes, the deviation from the standard is translated to loads that should be removed to get the concentration down to the standard (or below)
- A Programme of Measures is constructed based on source apportionment of current load
- Cost efficiency is estimated for each measure to priotise the best measures that would be needed to reach the target and thus to restore the water body