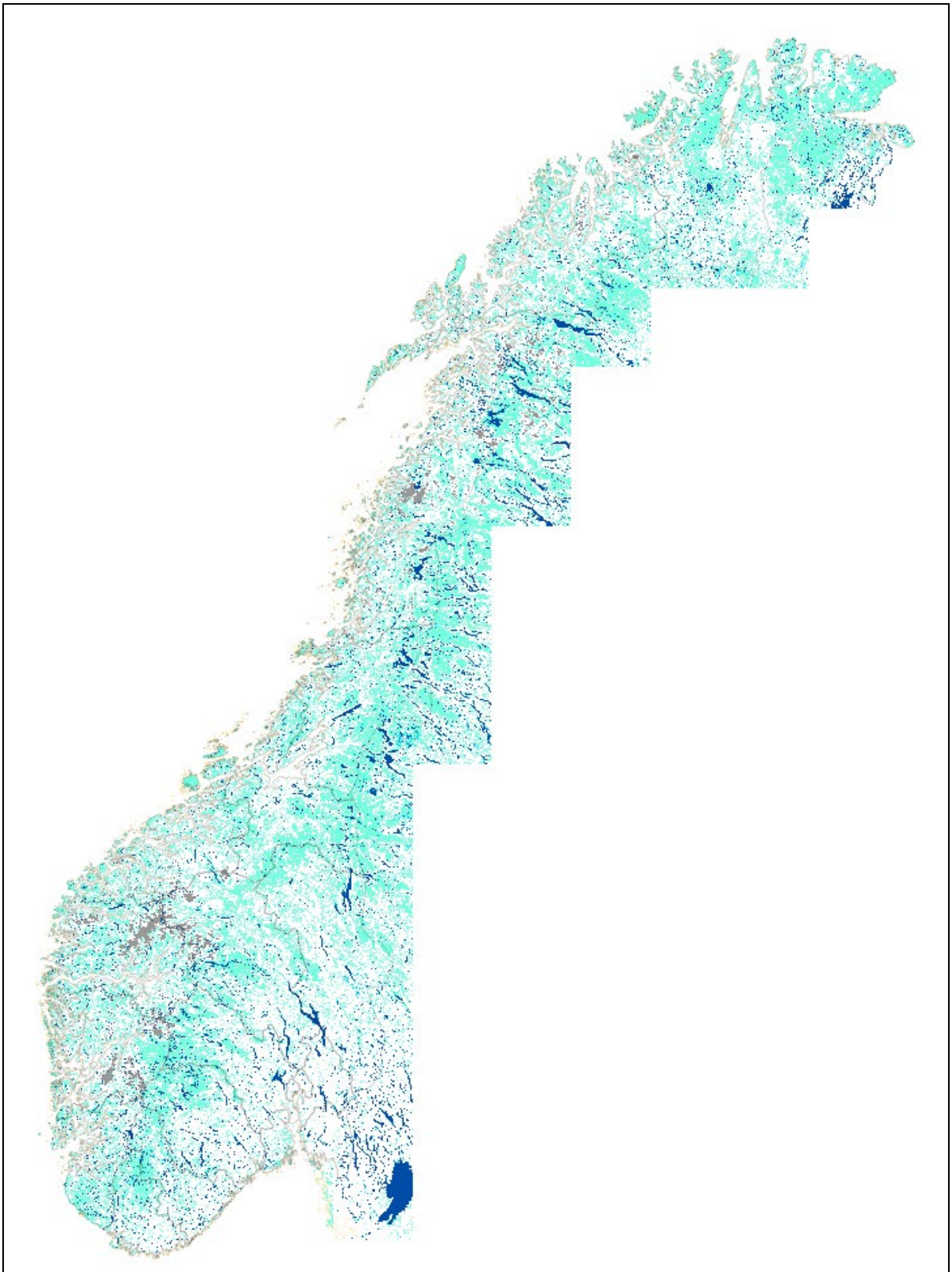
HRL 2018 look & feel verification report for Water and wetness (2018) Norway

I. Administrative part

HRL	*Water and Wetness 2018*
Verified area, region	*Norway*
Institution carrying out the work	*NIBIO Survey and statistics*
Overall visual checking done by (name, position and e-mail)	*Geir-H Strand, Director R&D, ghs@nibio.no*
Look & feel verification done by (name, position and e-mail)	*Geir-H Strand, Director R&D, ghs@nibio.no*
In situ data used..	*National orthophoto database Norge-i-bilder* *Ref: http://www.norgeibilder.no*
	National spatial data infrastructure *Ref: http://kilden.nibio.no*
	Orthophoto, topographic and thematic maps available as wms services were integrated with the HRL data using qGIS
	AR18X18, a Norwegian area frame survey of land cover resembling LUCAS
Reporting done by (name, position and e-mail)	*Geir-H Strand, Director R&D, ghs@nibio.no*
Date and place of writing the report	*Ås 30.03.2021*

II. General overview of the verified data



WAW2018 Norway. The delivery is organized as tiles partly extending into Sweden and Finland. The verification is limited to areas inside Norway.

Statistical overview

Class	Value	Haa	%
Dry land	0	19 673 000	60,75%
Permanent water	1	1 544 500	4,77%
Temporary water	2	70 400	0,22%
Permanent wet	3	43 200	0,13%
Temporary wet	4	10 456 800	32,29%
Unclassifiable	254	593 000	1,83%
Total		**32 380 900**	**100,00%**
Ocean	253	26 000	-

National statistics, based on field surveys, show that Inland water covers 5,49 % of the country. WAW Class 2 is mostly alpine lakes that dry up in the summer or lakes and rivers that are temporary dry due to hydropower production. Classes 1 and 2 together cover 4,99 %, slightly less than the official statistics. The figures show that inland water is appropriately represented by WAW-2018, although slightly underestimating the area of inland open water.

This interpretation is supported by a "visual inspection" of the product. Water (lakes and rivers) is mostly mapped as class 1 (or 2) but small lakes (ponds) and narrow rivers are omitted. The waterbody of larger lakes is also often drawn too "narrow", leaving the edge of the waterbody as class 0 (see Figure 1 for an example).

Figure 1: WAW-2018 on top of orthophoto: Most of the lake (Gravolstjernet, Øystre Slidre UTM33: 4261168, 4244092) is correctly shown as class 1, but the edge of the water is not included in the class.

Intertidal zones along the coast are mostly omitted from class 2 (but should be included according to the WAW Manual, page 13)

The national statistics show that wetlands (peat bogs, fens and other mires) cover 8,89 % of the country. Another 4 % is covered by peatland forest and swamp forest. Still, only 0,13 % is mapped as permanent wetland (class 3) in WAW-2018. This omission error is considerable.

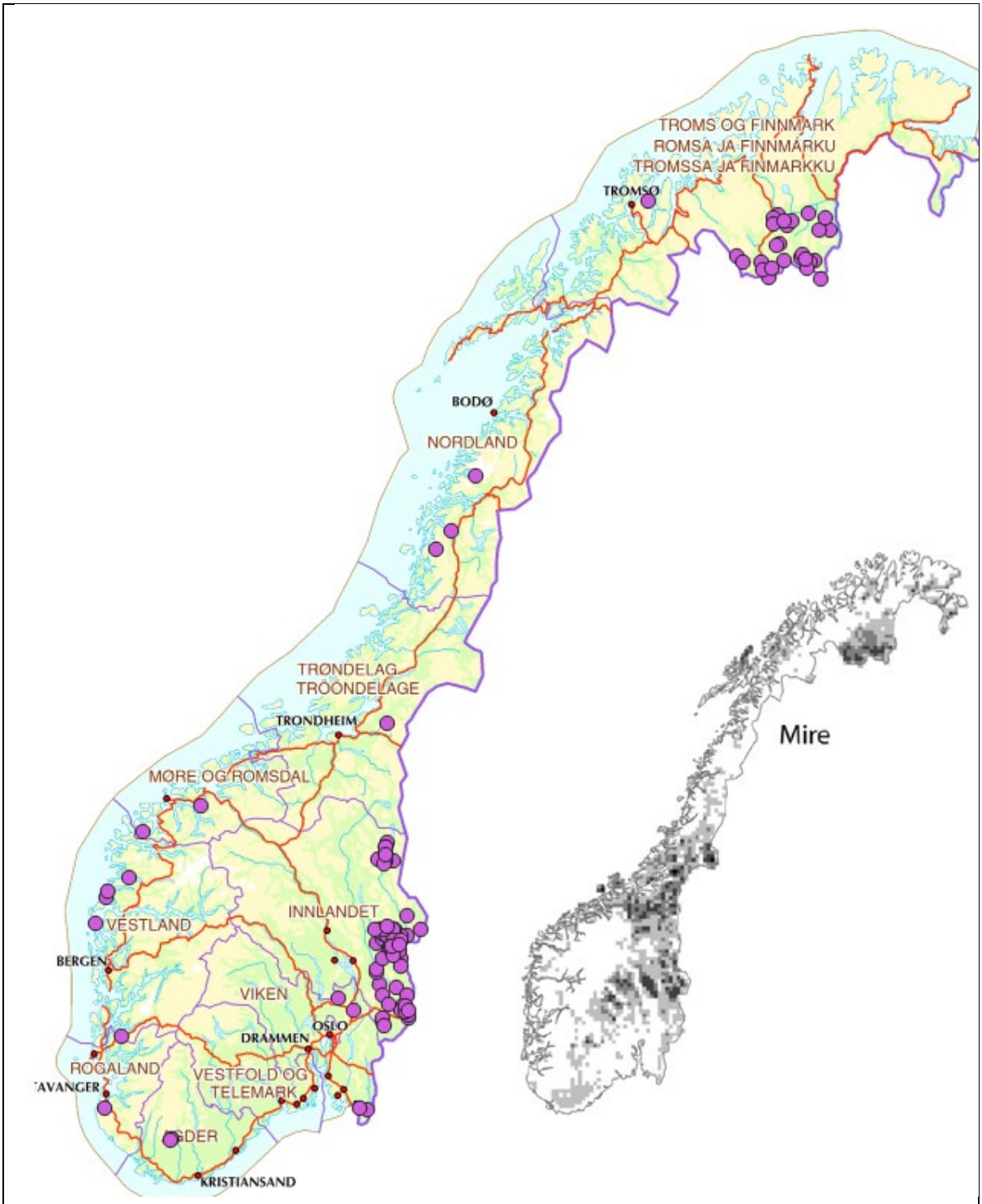


Figure 2: Map of random sample points classified as class 3 (permanently wet) to the left. Map of open mire and peatland inset to the right (black and white)

The map in Figure 2 shows the approximate distribution of class 3 (permanently wet) in WAW-2018 as dark blue dots, and the actual distribution of mire and wetlands in the smaller (black and white) inset. There are large wetlands, but no WAW-2018 class 3 in the mountains and very little in the central Trøndelag area. Some of the mire-rich areas in eastern and northern Norway are, however, reasonably well represented.

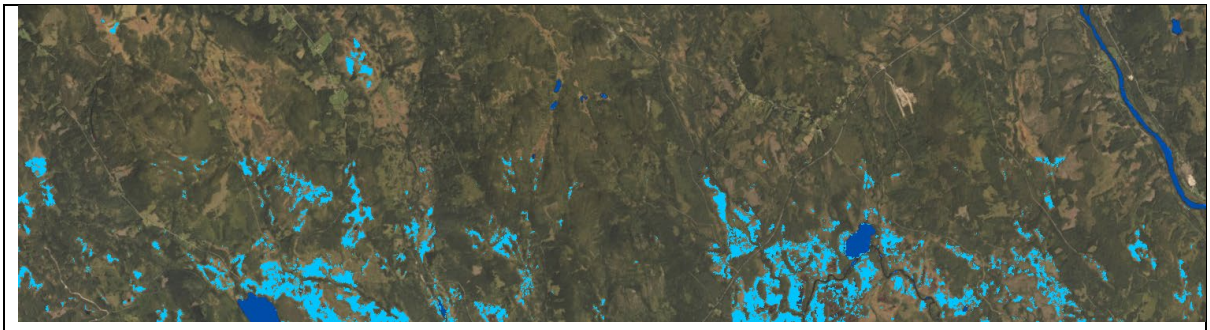


Figure 3: Slice through WAW_2018_010m_E44N42_03035_V011 on top of orthophoto.

Figure 3 shows a slice through tile WAW_2018_010m_E44N42_03035_V011. Careful inspection of the map reveals a horizontal divide where class three is abundant south of the line and almost absent north of the line. Class 3 south of the line corresponds quite well with mires in this area, while there are large omission errors north of the line. Due to the sharpness of the line, we suspect that it corresponds with the edge of imagery used in the production, and that the imagery used in the northern part of the tile is less suitable than the imagery used in the southern part of the tile with respect to detection of wet areas.

The omission of class 3 throughout most of Norway must be a production error. We expect that the same method is used everywhere, so the differences must be due to differences in the imagery used in the production (?). The imagery used in the few regions where class 3 occurs frequently (see Figure 2) is more suitable for this purpose than the imagery used in the rest of the country.

Only 25 % of the land classified as WAW class 4 (temporary wet) is mire and peatland or swamp forest and most of it should have been classified as permanently wet (Class 3). Oher land cover types found in areas assigned to class 4 are alpine heath and inland water. Around 70 % of class 4 seem to be composed of mire, heath and water (this statistic is not accurate). The remaining 30 % is a mixture of forest, snow beds, alpine meadows and various, more marginal vegetation types. The widespread use of class 4 may be linked to the late snow melting during the summer at higher altitude. The class is mostly found in the sub-alpine region, from 800 to 1500 meter asl in southern Norway, and from 400 to 1000 meters asl in Northern Norway.

Two suggestions:

- *Examine how snow-melt is handled to avoid classifying some of the temporary wet areas always occurring during snow-melt (everything is wet for a while during snow-melt) as class 4 (or alternatively define areas that are temporary wet during snow-melt as class 4 and classify all soil-covered areas in Norway outside classes 1, 2 and 3 as class 4).*
- *Examine why mire is quite well classified (as class 3) in the two distinct regions shown in Figure 2. We expect that this is linked to the kind of imagery used and that the product can be improved considerably by choosing the appropriate kind of imagery.*

In order to improve the understanding of class 4, we obtained statistics from areas where vegetation maps were available. These statistics will be biased, but still provide interesting insight into the content of class 4. Our hypothesis was that certain vegetation types would be found more frequently in areas mapped as class 4.

III. Overall visual checking

Positional accuracy			
Relative positional accuracy	Quick visual comparison of HRL data with available EO imagery (identifying large positional errors)	*OK / correct,*	*The positional accuracy was checked by comparing the HRL and orthophoto for lakes and rivers. Checks were carried out at several latitudes and the positional accuracy is OK*
Thematic accuracy			
Classification correctness	Simple look & feel thematic check (identifying basic thematic mistakes)	*OK / correct,* *NOK / not correct*	*The thematic accuracy is high for rivers and lakes, although the delineation is fuzzy.* *The thematic accuracy for wet areas is very poor. Most mires and wetlands are missing or classified as temporary wet. Very large areas of sub-alpine forest and dwarf shrub heath, especially on the eastern side of the mountain range, are classified as temporary wet.*

IV. Look & feel verification results

1.Included elements,

Stratum	Name of the stratum	Number of samples verified	Results of the verification by strata (using qualitative evaluation as: Excellent, good, acceptable, insufficient, very poor).
1	Lakes	5	*Excellent* *All controlled lakes were present. Some surface missing along the shoreline*
2	Ponds/Reservoirs	8	*Insufficient* *Ponds and reservoirs are often missing*
3	Natural ponds	6	*Good* *Most natural ponds are present. Delineation is some times inaccurate*
4	River	5	*Excellent* *All controlled rivers are present*
5	Channels	6	*Poor* *Rare type in Norway. Large parts of the two known channels that were checked were missing*
6	Estuaries	4	*Poor* *Often mapped as Ocean*
7	Liquid dump	3	*Good* *Rare type in Norway. The known dumps next to mines were mostly (two) excellent but one was inadequate.*
8	Temporary water	4	*Acceptable* *The type is hard to evaluate. Hydropower reservoirs usually has a zone of temporary water part of the year. This is sometimes mapped, sometimes not (but usually found as permanent water instead)*
9	Intermittent rivers	1	*Excellent* *The type was hard to locate during look-and-feel, but several examples were seen during the statistical verification. The overall impression is that the representation was correct*
10	Intertidal zone	8	*Poor* *The intertidal zone is mapped as Ocean or missing*
11	Reeds	8	*Poor* *Reeds (inland) were usually neither mapped as water nor permanent wetland*
12	Peatland	9	*Poor* *Peatland was either not mapped or mapped as temporary wet,*
13	Fens	16	*Poor* *The mapping is insufficient in two regions where part of the fens are shown as permanent wet. For most of the country fens are either omitted or shown as temporary wet.*

14	Coastal marshes	6	*Insufficient* *This is a rare type in Norway. The mapping is some places inaccurate, other places omitted*
15	Sea and ocean	9	*Excellent*
Overall evaluation (based on look-and-feel)			*Good for permanent water, with some omission errors* *Good for temporary water (intertidal areas are consistently missing)* *Poor for (permanent and temporary) wetland*
Comments			

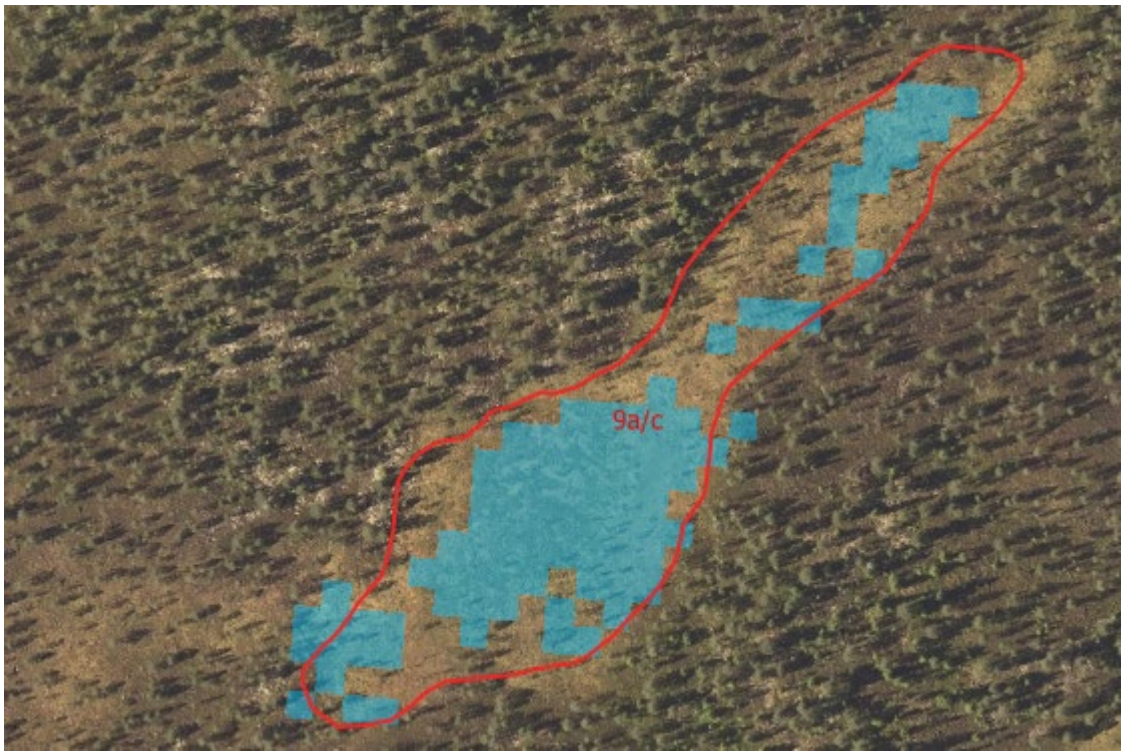
2. Excluded elements

Stratum	**Name of the stratum**	**Number of samples verified**	**Results of the verification by strata (using qualitative evaluation as: Excellent, good, acceptable, insufficient, very poor).**
16	Snow and glaciers	6	*Undetermined* *Consistently mapped as class 254 unclassified. This is correct according to the instructions*
17	Fish ponds	1	*Excellent* *Rare type in Norway. The one identified was (correctly) not mapped as WAW*
	Subalpine forest	Scanned	*Poor* *Often mapped as Temporary wet*
	Heath and moor	Scanned	*Poor* *Often mapped as Temporary wet*
Overall evaluation (based on look-and-feel)			*Excellent for (permanent and temporary) water* *Insufficient for permanent wetland (containing large areas of permanent wetland, forest (mostly subalpine) and open heath and moor*
Comments			

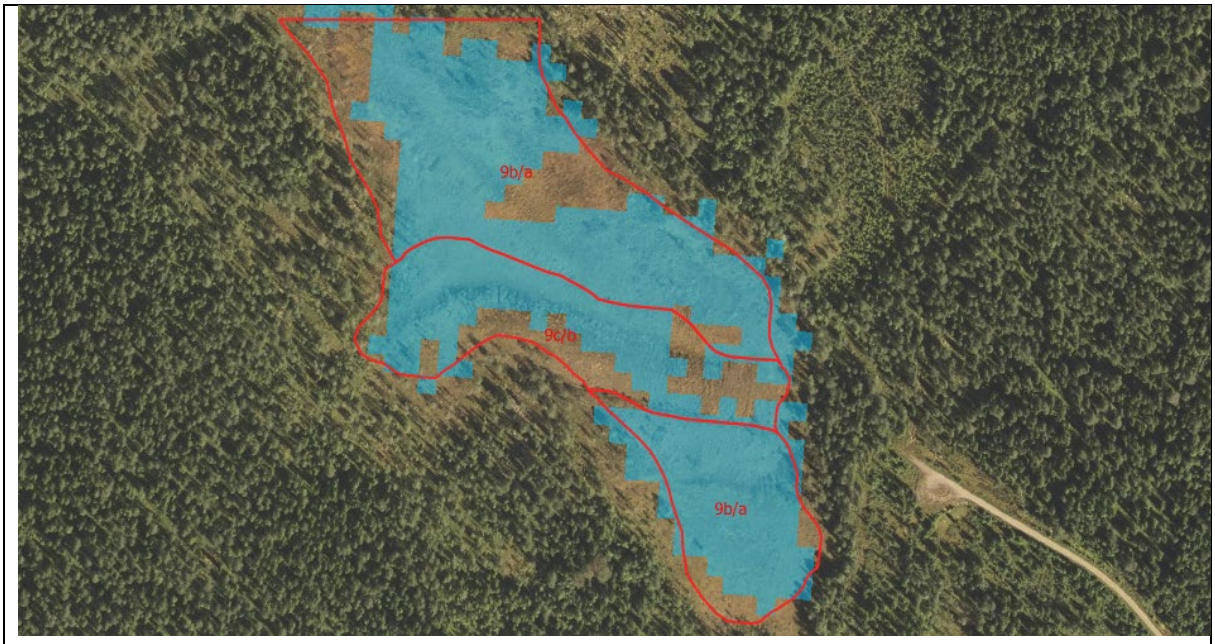
V. Documentation of errors and critical findings

Please include detailed descriptions, meaningful examples and screenshots of errors, critical findings. Please make sure the nature, location and frequency of the issue is described in some detail. Screenshots should contain ETRS1989 LAEA coordinates.

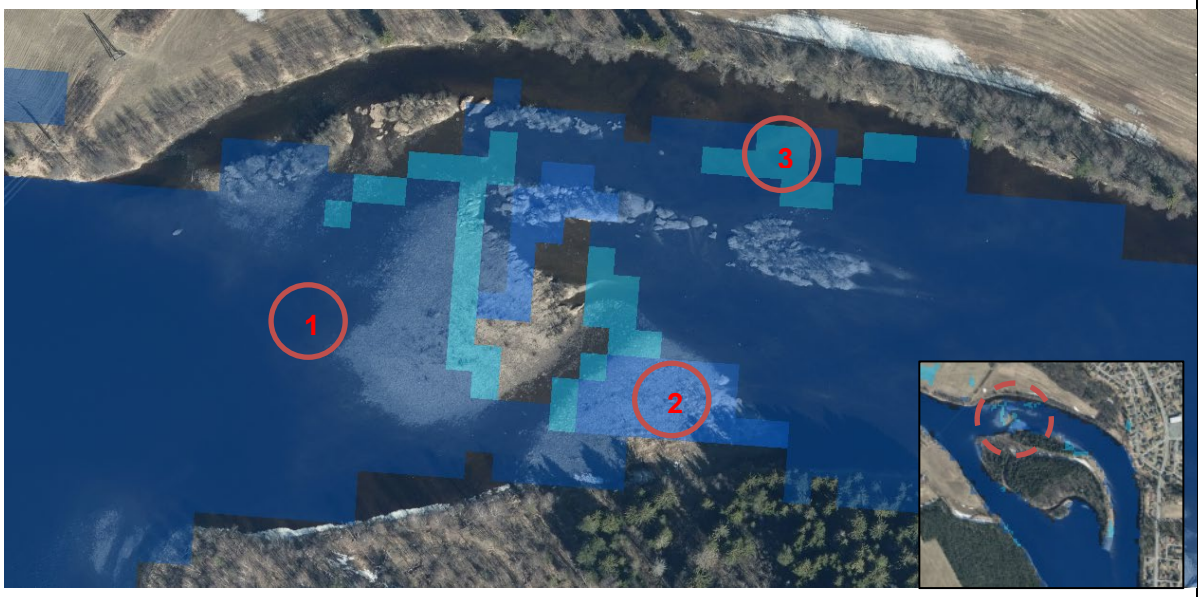
Peatbog omitted in WAW-2018 [4432211, 4232006]



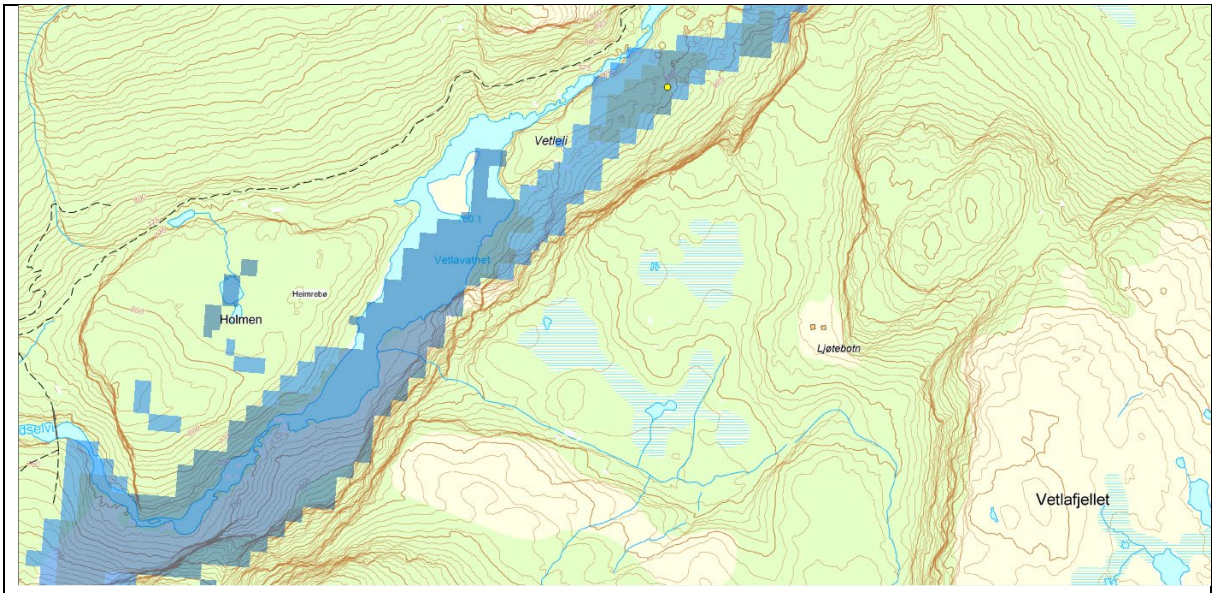
Reasonably well mapped mixture of peatbog and fen with some omissions [4414147, 4230717]. Light blue pixels are WAW-2018 class 3.



Reasonably well mapped deer-grass fen in the upper and lower polygons, separated by a section dominated by fen [4449887, 4233761]. Light blue pixels are WAW-2018 class 3.

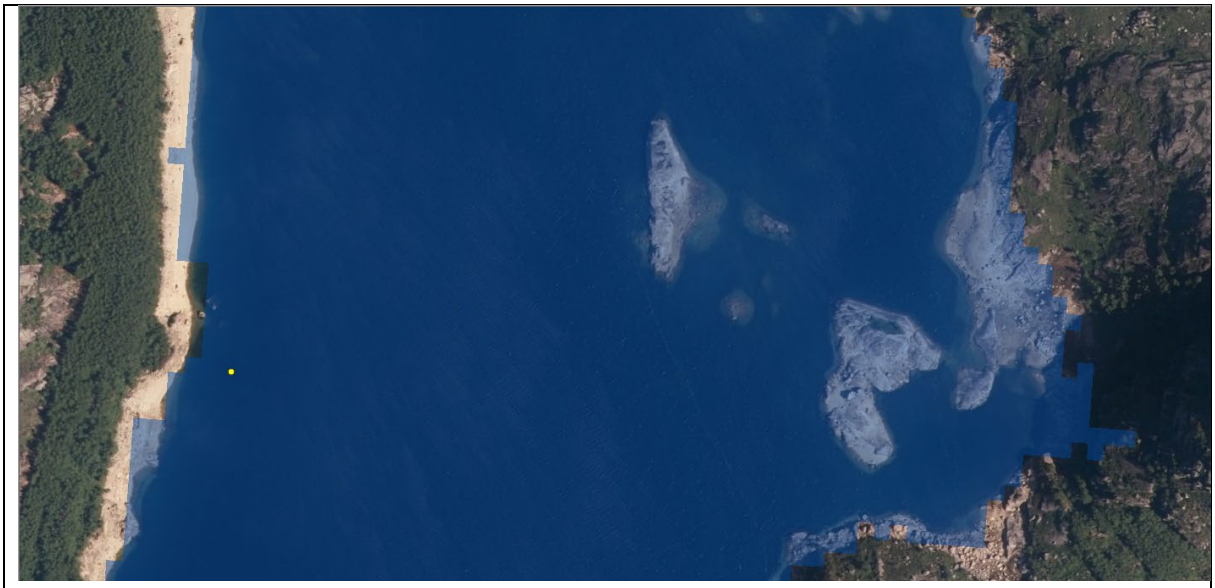


River Glomma divided by an island (see inset) where the northern branch usually dries up during the summer, leaving an exposed area with dry rocks and gravel [4341394, 5004358]. This area is partly mapped as WAW-2018 class 1 (permanent water, dark blue, wrong), class 2 (temporary water, mid-blue, correct) and class 3 (permanent wet, light blue, wrong).

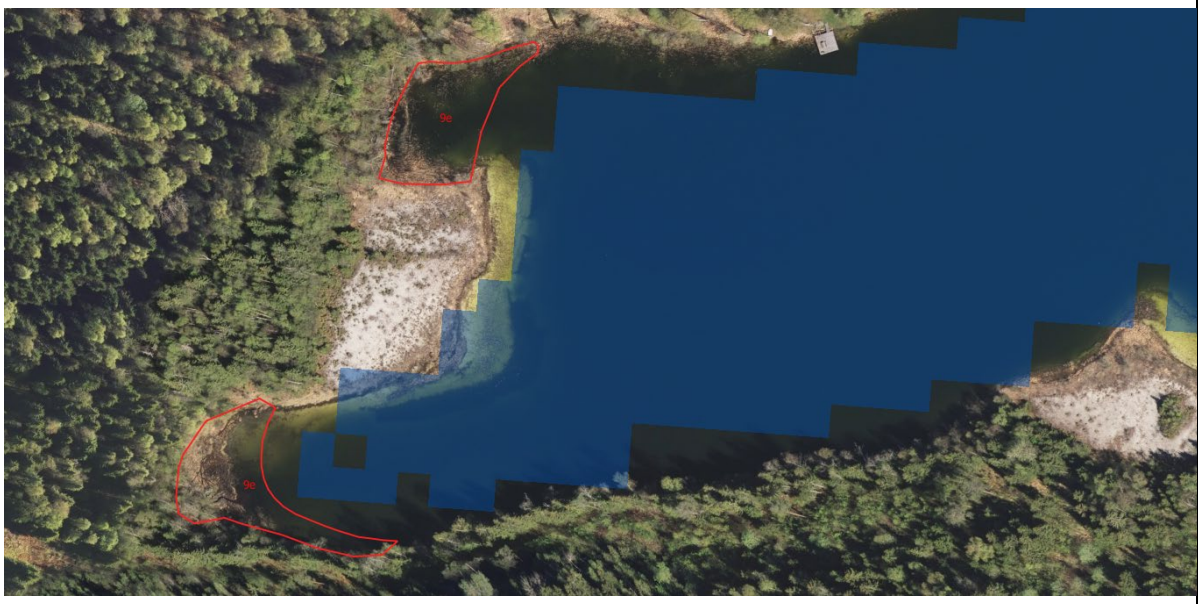


North-west facing steep slope (probably in deep shadow in the imagery) resulting in a partly inaccurate, partly wrong mapping of class 1 and 2 [4181533, 4194746]. By looking at aerial imagery from different years, we find that the mountains can cast very dark shadows along this valley.

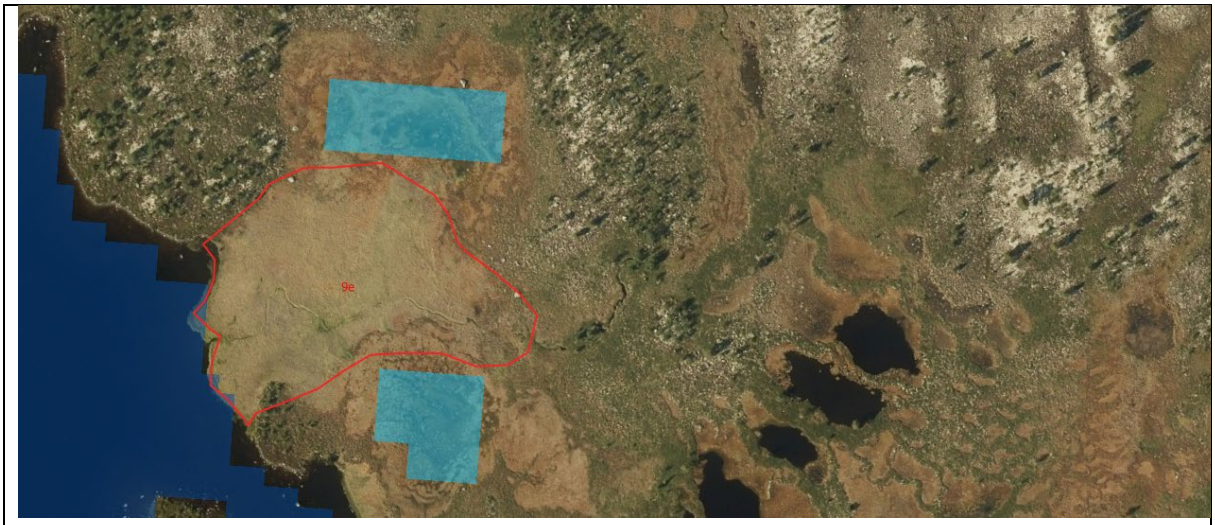
An aerial photo of approximately the same area as above shows how the mountains to the south and east cover the valley with very dark shadows.



Lake used for hydropower production. The difference between the highest and lowest watertable is seven meters. Most of the lake is correctly mapped as class 1 (permanent water) but we would expect the area along the shoreline and the temporary exposed islands in the middle of the lake to be classified as class 2 (temporary water). These areas are wrongly classifed as class 0 (shore) and 1 (islands) in WAW-2018. [4094324, 3936633]



Two examples of Sedge marsh along a lake. These sedge marshes are neither included in the water (blue pixels, class 1) nor mapped as wetland (class 3) in WAW-2018. [4349308, 4136165]



Sedge marsh (polygon with label 9e) between two peat bogs. The two peat bogs are partly mapped as class 3 (light blue) in WAW-2018. The Sedge marsh is omitted and mapped as class 0 (dry) in WAW-2018. Notice also the four ponds to the right with open water surounded by mud-bottom bogs. This very wet area is also mapped as class 0 (dry) in WAW-2018 [4410253, 4284753]

VI. **Statistical verification** (optional)

Description of methodology and software	*Samples were obtained by stratified random sampling using locations recently surveyed in the AR18X18 survey. Additional random samples were added for small classes. The HRL was considered "correct" when the HRL agreed with the AR18X18 survey. Sample point where the two surveys disagreed were examined on topographic maps and recent orthophoto using qGIS.* *Accuracy was calculated following standard methodology using SPSS*
Stratification	*The HRL contained the following strata* *0: Dry land* *1: Permanently water* *2: Temporary water* *3: Permanently wet* *4: Temporary wet* *253: Ocean*
Comments	*The interpretation of ground truth was conservative. The HRL was accepted as correct when the analyst was in doubt. Misclassification was only recorded when the analyst was confident that an error was present.*

Please copy here the (weighted) confusion matrix and main accuracy parameters and provide the corresponding Excel file in attachment.

IMD2018 Verification strata sizes

		Haa	%	
HRL	0	19 673 000	60,75	
	1	1 544 500	4,77	
	2	70 400	0,22	
	3	43 200	0,13	
	4	10 456 800	32,29	
	253	26 000	0,08	Ocean - Not counted in national total
	Unclassiifed	593 000	1,83	
	Total	32 380 900	100,00	

IMD2018 Verification raw data confusion matrix

HRL	Ground truth 0	1	2	3	4	253	Total
0	166	8	10	14	2	0	200
1	3	189	5	2	0	0	199
2	19	7	59	6	2	0	93
3	4	5	1	52	0	0	62
4	90	9	11	78	12	0	200
253	13	0	30	0	0	157	200
Total	295	218	116	152	16	157	954

IMD2018 Verification weighted confusion matrix

HRL	Ground truth 0	1	2	3	4	253	Total
0	0,50427	0,02430	0,03038	0,04253	0,00608	0,00000	0,60755
1	0,00072	0,04530	0,00120	0,00048	0,00000	0,00000	0,04770
2	0,00044	0,00016	0,00138	0,00014	0,00005	0,00000	0,00217
3	0,00009	0,00011	0,00002	0,00112	0,00000	0,00000	0,00134
4	0,14532	0,01453	0,01776	0,12594	0,01938	0,00000	0,32293
253	0,00005	0,00000	0,00012	0,00000	0,00000	0,00063	0,00080
Total	0,65089	0,08441	0,05086	0,17021	0,02550	0,00063	0,98249

IMD2018 Verification Overall accuracy

Accuracy	95% CI	Lower	Upper
57,2 %	3,3 %	53,9 %	60,5 %

IMD2018 Verification User's accuracy

		Accuracy	95% CI	Lower	Upper
HRL	0	83,0 %	5,2 %	77,8 %	88,2 %
	1	95,0 %	3,0 %	92,0 %	98,0 %
	2	63,4 %	9,8 %	53,6 %	73,2 %
	3	83,9 %	9,2 %	74,7 %	93,1 %
	4	6,0 %	3,3 %	2,7 %	9,3 %
	253	78,5 %	5,7 %	72,8 %	84,2 %

IMD2018 Verification Producer's accuracy

		Accuracy	95% CI	Lower	Upper
HRL	0	77,5 %	2,8 %	74,7 %	80,3 %
	1	53,7 %	12,1 %	41,6 %	65,8 %
	2	2,7 %	1,2 %	1,5 %	3,9 %
	3	0,7 %	0,1 %	0,6 %	0,8 %
	4	76,0 %	43,3 %	32,7 %	119,3 %
	253	100,0 %	0,0 %	100,0 %	100,0 %