GIS-3 Vector Analysis

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2025-02-20

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Introduction

In this paper, we will look into the sediment, soil, and bedrock charactistics of the Oslofjord area. The data used to build this analysis can be downloaded from Canvas (Girod, 2025). The software used is ArcGIS Pro.

Topics we will explore:

- Distribution of cultivated fields in a specified municipality
- Conflicting groundwater resources and cultivated land
- Elevations that marine areas exist it
- The land cover type (soil class) that dominates the selected municipality
- Which sediments primarily dominates cultivated fields
- Which sediments are typically found around groundwater resources

1 Load data

1.1 Municipality selection

In order to get sedimentary, soil, and bedrock data, we need to load in the `GIS3.gdb` file to ArcGIS. This can be done by locating the geo-database in the catalog pane, and adding the desired layers to a new map. To start, we'll load in the `municiaplity_borders` data, a shapefile that contains a cropped view of some municipalities in the Oslofjord area.

Through a preliminary tutorial exercise, the Bærum municipality has already been explored (Girod, 2025). Therefore, our current analysis will expand on that research, looking into the neighboring Asker municipality.

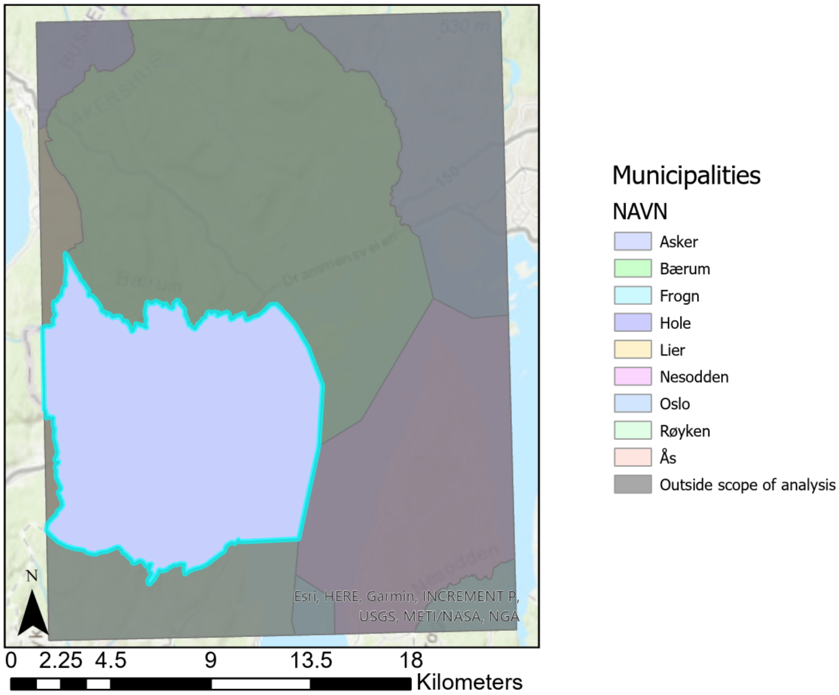

Figure 1: Asker municipality selection

The decision to explore Asker in this report was based on the coverage of the three layers we are analyzing. The data on soil classes that we will be using only exists for the same cropped region as the municipality borders, rendering most of the other municipalities present in this region unsuitable for analysis with these data. Asker was the second best represented municipality in the data, behind Bærum, and therefore a natural choice for this report. Figure 1 shows the outline of the Asker.

With the correct municipality selected by attributes in the `municipality_borders` dataset, we can clip out this region as a stand-alone layer. This will allow for municipalicty specific processing later.

1.2 Supplementary data

We need to add the sediment, soil, and bedrock data layers to our map as well. Each dataset contains a set of labels specifying the different subcategories of each dataset. These are added to the map using the `Symbology -> Unique colors` command.

Since we will only be focusing on Asker, we can clip that region out of each of the three dataset layers we've added to our map. The resulting color coded layers are shown in Figure 2, each with a legend specifying their corresponding subcategories.

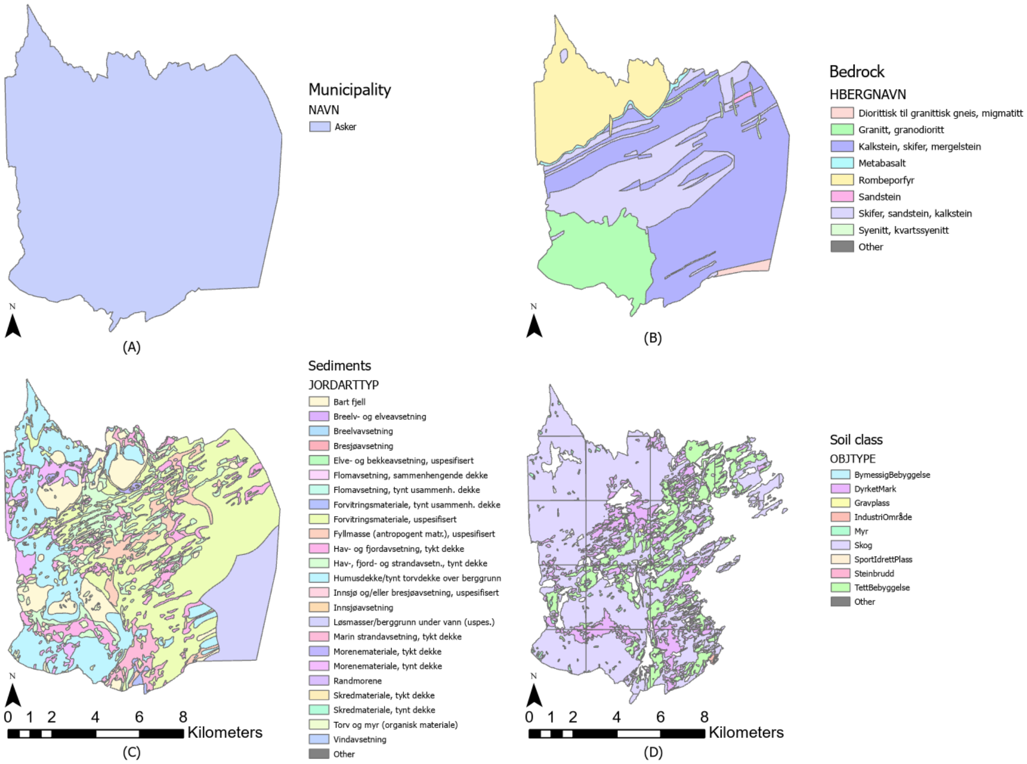

Figure 2: (B) Bedrock, (C) sediment, and (D) soil classes for the Asker municipality

2 Methods

This section outlines some simple operations we can do on our map layers to extract, join, and analyze the data present.

2.1 Selecting

Let's start by extracting a single type of land cover in our minicipality. As we'll be looking into groundwater resources later, it might be interesting to see how much land in Asker is used for agriculture. This is done using the `Select by Attributes` command on our soil-class data, where we select the `OBJTYPE` attribute and set it to `Dyrket mark`. A new layer can then be created from this selection, which we'll rename to `Cultivated fields`, as shown in Figure 2.

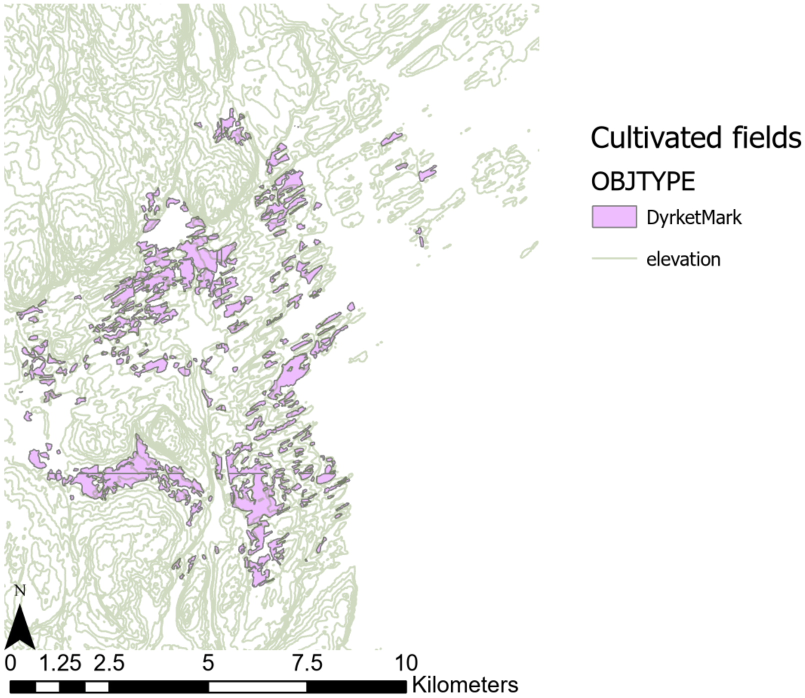

Figure 3: Cultivated fields in the Asker municipality

When looking at this layer alone (the magenta fields in Figure 3), it's hard to see any real pattern to the distribution of cultivated fields. However, if we overlay some semi-transparent elevation lines, we see these fields lie mainly on flat terrains, often at the bottom of valleys or cliff edges.

In later steps, we'll see how other factors like the underlying bedrock and sediment types might influence the distribution of these fields.

The steps taken to get from our `.gdb` files to the distribution of cultivated fields is outlined in the flowchart found in Firgure 4.

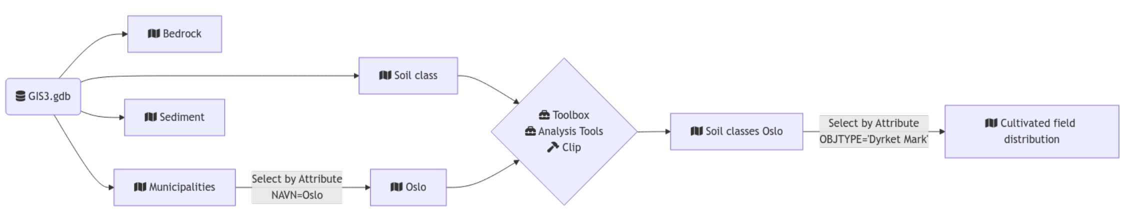

Figure 4: Flowchart outlining steps to get cultivated field distribution

2.2 Union

The next natural step is to look at where these regions overlap with potentially problematic areas, like for example groundwater resources. This is done by joining the sedimentary data with the soil class coverage, as shown in Figure 5.

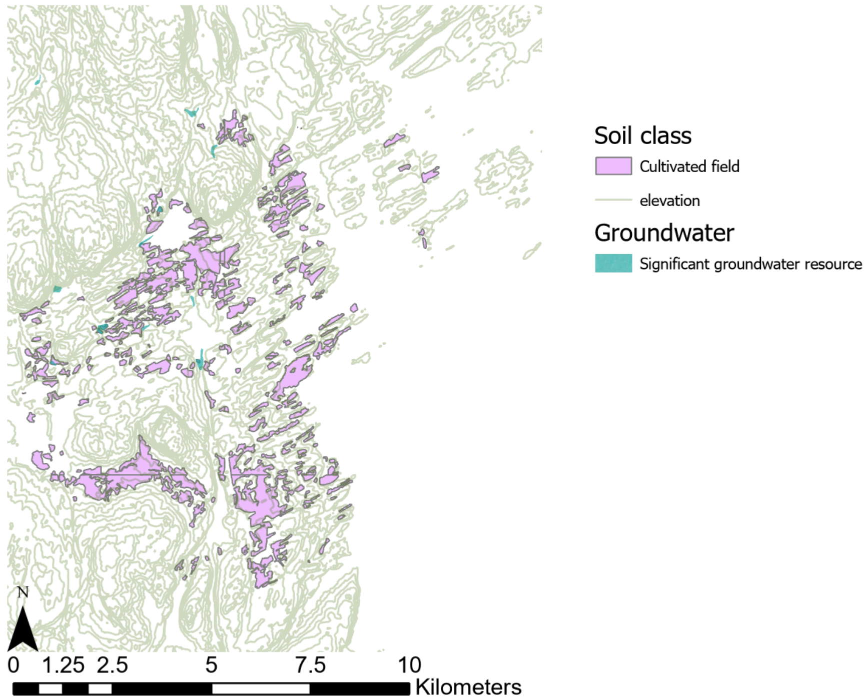

Figure 5: Cultivated fields and groundwater resources in the Asker municipality

Unfortunately, the region we are analyzing does not have much signifigant groundwater resources present. The few areas that do exist seem to overlap quite a bit with the cultivated fields, which might be problematic in terms of contamination. Contrarily, the fertile soil in these areas might be beneficial for agriculture, which could explain why these areas were initially designated for cultivation.

The ratio of groundwater resources thats overlap with cultivated fields can be calculated by first finding the intersect of the two layers, then sum the area of the intersected layer using the `Summary Statistics` analysis tool. When running such a calcuations, it is important to remember to recalculate the geometry for the area of the layers after our clipping and joining operations, as these operations often change the remaining area of the layers.

The resulting sum of the intersected area is 48283.71m^2, which is 17.66% of the total area of the groundwater resources layer. This number was smaller than initially expected. Though, considering there is very little groundwater in general, the ratio makes sense. It only takes a few pockets of groundwater that don't overlap with cultivated fields to skew the ratio significantly. This faulty assumptions highlights how hard it is to estimate the total size of many small areas judging merely by th elooks of the map, and is why GIS analysis tools like ArcGIS Pro are so useful.

3 Geological analysis

Moving on, we can look for other areas of land that might have been even better to use for agriculture. For example, it is well known that marine areas are often very fertile, since they are rich in nutrients due to the large amount of organic material that is deposited there. Or maybe there are some types of bedrock that are more suitable for agriculture, since they will naturally have a higher mineral content. If the above 17.66% of groundwater resources that overlap with cultivated fields is a problem, we might want to look for areas such as these to motivate a relocation of the fields.

3.1 Elevation

An interesting characteristic of Norway's landscape is that it was once covered by the sea, which is one of the reasons why we find fertile agricultural land around the Oslofjord today. Marine sediments, rich in nutrients from organic material and fine-grained particles, were deposited in these areas and later uplifted, creating the basis for productive soils. This means that even areas that are at high elevations and far from the coast can still have relatively large concentrations of marine sediments present.

To explore other fertile areas, let's start by examining the distribution of elevation in marine-influenced regions. We'll make a plot similar to Figures 3 and 5, but with marine areas instead of cultivated fields.

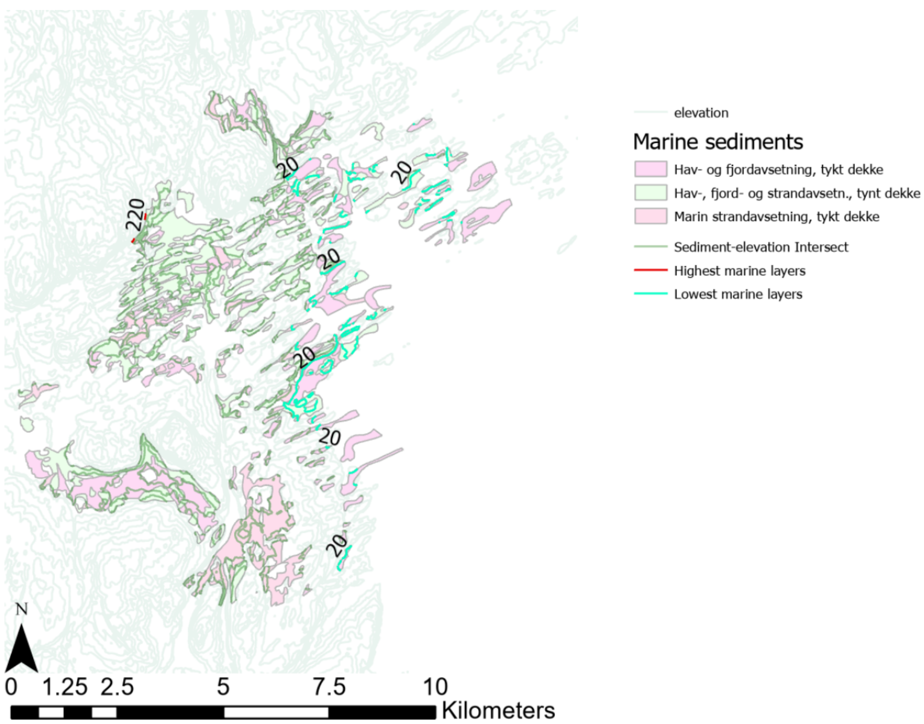

Figure 6: Marine areas with elevation layer overlap

Typically, maps like Figure 3 and 5 are not very useful on their own, as it's hard to discern patterns from noise of the elevation around the rough Oslo terrain. When we join in the maximum and minimum elevation data for the marine areas, we can get a better sense the elevation range present in the area of observation, as seen in Figure 6. These summary statistics were found by taking the intersection of the elevation layer with the marine sediment layer, and sorting every object in the marine sediment layer by height.

3.2 Area

We can also look into how much area a particular sediment type occupies in the Asker municipality. To do so we'd select by attribute a desired sediment type (as we did in 2.1 when looking at the `Cultivated field` soil class distribution). We would again need to re-calculate the geometry for the `Area` column for this layer, since the previous areas were calcuated per object id without any "arbitrary" municipality boundaries. We can the sum the area of the selected sediment type using this calibrated `Area` column.

Alternatively, we could calculate the sum area statistic for *each* sediment types in the Asker municipality, using the `Summary Statistics` command. These data were exported to an excel file at `data/sediment_area.xlsx` for further analysis, as shown in Table 1.

Table 1: Area of sediment types in Asker

OBJECTID	JORDARTTYP	FREQUENCY	SUM_AREA	percentage
6	Forvitringsmateriale, uspesifisert	47	6.5009e+07	33.6852
10	Humusdekke/tynt torvdekke over berggrunn	18	5.05831e+07	26.2102
11	Løsmasser/berggrunn under vann (uspes.)	1	2.36762e+07	12.2681
1	Bart fjell	88	1.29637e+07	6.71728
9	Hav-, fjord- og strandavsetn., tynt dekke	89	1.13015e+07	5.856
8	Hav- og fjordavsetning, tykt dekke	85	7.71407e+06	3.99713
14	Morenemateriale, tynt dekke	24	7.2619e+06	3.76283
7	Fyllmasse (antropogent matr.), uspesifisert	37	5.32729e+06	2.76039
12	Marin strandavsetning, tykt dekke	45	4.8451e+06	2.51054
17	Torv og myr (organisk materiale)	107	2.31196e+06	1.19797
16	Skredmateriale, tykt dekke	7	565694	0.293121
13	Morenemateriale, tykt dekke	7	458394	0.237522
5	Forvitringsmateriale, tynt usammenh. dekke	3	436451	0.226152
15	Randmorene	18	249834	0.129454
4	Elve- og bekkeavsetning, uspesifisert	8	151268	0.0783815
3	Breelvavsetning	4	120164	0.0622644
2	Breelv- og elveavsetning	1	14491.6	0.007509

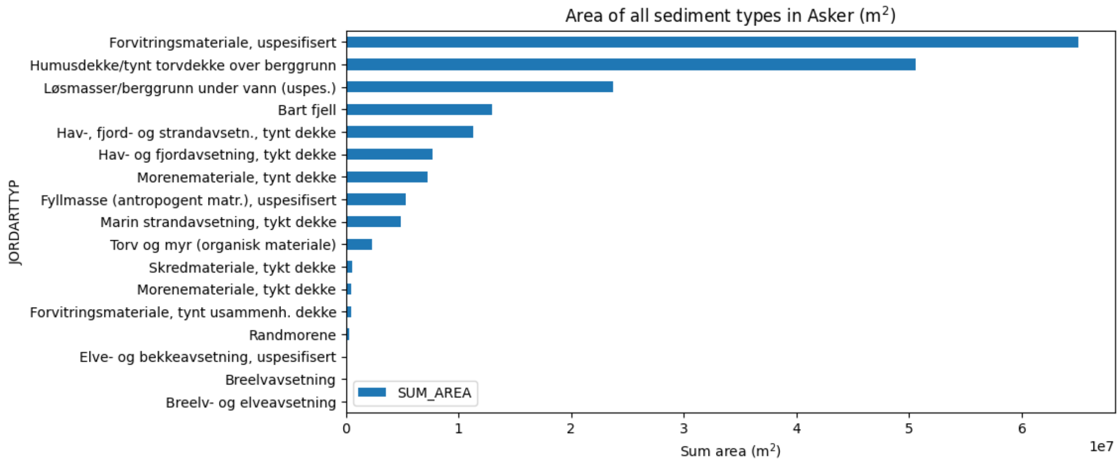

Figure 7: Plot comparing areas of sediment types in Asker

3.2.1 Intersecting area statistics

Digging further in to area analysis, we can find the most common sediment types to overlap with cultivated fields. The same procedure as above is used, but this time we intersect the sediment layer containing all sediment types with the cultivated fields layer.

Table 2: Area of sediment types that overlap with cultivated fields in Asker

OBJECTID	JORDARTTYP	FREQUENCY	SUM_AREA	percentage
7	Hav- og fjordavsetning, tykt dekke	106	3.52827e+06	28.7946
8	Hav-, fjord- og strandavsetn., tynt dekke	161	3.43967e+06	28.0714
10	Marin strandavsetning, tykt dekke	79	2.24906e+06	18.3548
5	Forvitringsmateriale, uspesifisert	182	1.92548e+06	15.714
12	Morenemateriale, tynt dekke	19	299499	2.44424
9	Humusdekke/tynt torvdekke over berggrunn	45	237019	1.93433
1	Bart fjell	59	200124	1.63323
15	Torv og myr (organisk materiale)	18	185775	1.51612
6	Fyllmasse (antropogent matr.), uspesifisert	28	87975.5	0.717976
2	Breelvavsetning	4	32663.9	0.266573
3	Elve- og bekkeavsetning, uspesifisert	4	19785.8	0.161474
13	Randmorene	3	17722.6	0.144636
4	Forvitringsmateriale, tynt usammenh. dekke	5	16407.8	0.133906
14	Skredmateriale, tykt dekke	3	9111.96	0.0743635

OBJECTID	JORDARTTYP	FREQUENCY	SUM_AREA	percentage
11	Morenemateriale, tykt dekke	1	4703.76	0.0383878

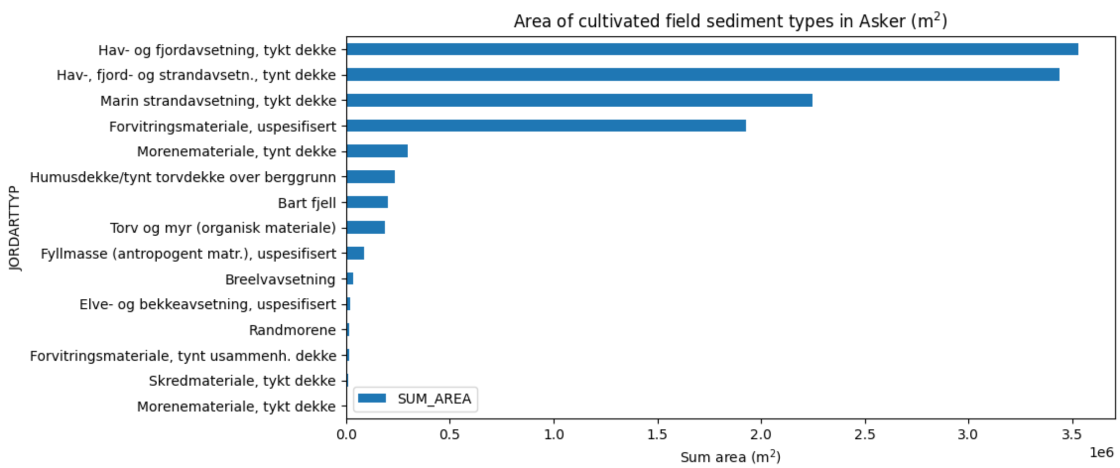

Figure 8: Plot comparing areas of sediment types overlaping w/ cultivated fields in Asker

[25]:
```
marine_types = [
    'Hav- og fjordavsetning, tykt dekke',
    'Hav-, fjord- og strandavsetn., tynt dekke',
    'Marin strandavsetning, tykt dekke'
]

# sum area of marine types / sum area of all types
(
    cultivated_field_sediment_area[
        cultivated_field_sediment_area['JORDARTTYP'].isin(marine_types)
    ].SUM_AREA.sum() / cultivated_field_sediment_area.SUM_AREA.sum()
).item()
```

[25]: 0.7522074172976729

As our hypothesis suggested, the most common sediment type to overlap with cultivated fields is marine sediments, which is present in 75.22% of the area. Interestingly, even though over 27% of the land in Asker is made up of layers with organic materials (`Humusdekke/tynt torvdekke over berggrunn` and `Torv og myr (organisk materiale)` in our data), these layers only overlap with cultivated fields in less than 4% of the area. This highlights the importance of not only the organic settlements of ancient seabeds, but also the mineral content as well, like the calcium-rich shell deposits and iron-rich clay.

One final element to analysis for this study would be the typical sediments that occur where significant groundwater resources are present. Given the high overlap of marine sediment with cultivated fields, and the relatively low overlap of groundwater and cultivated fields, it would be interesting to see if there is a significant overlap of marine sediments with groundwater resources.

Table 3: Area of sediment types in the Asker municipality that overlap with groundwater resources

OBJECTID	JORDARTTYP	FREQUENCY	SUM_AREA	percentage
3	Elve- og bekkeavsetning, uspesifisert	6	138688	50.7375
2	Breelvavsetning	4	120164	43.9609
1	Breelv- og elveavsetning	1	14491.6	5.30162

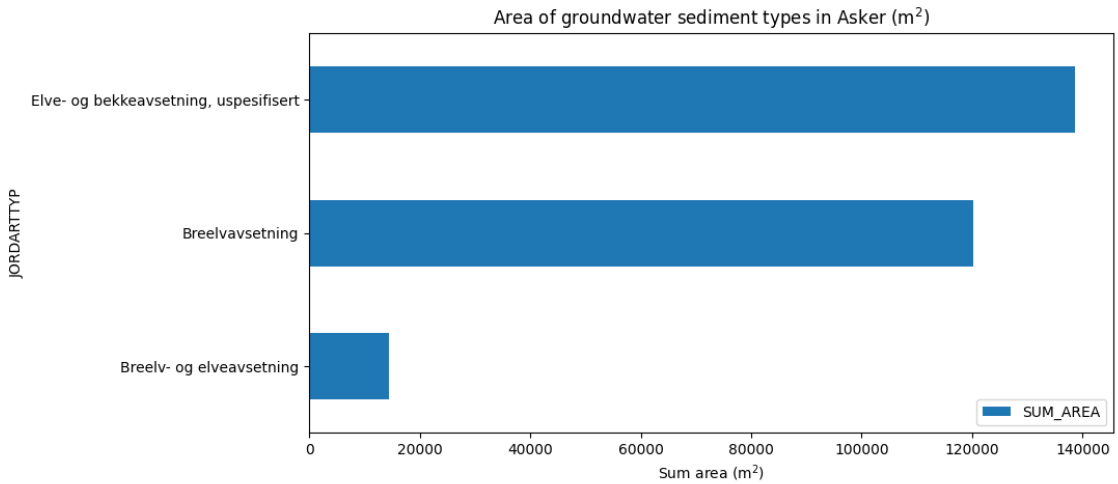

Figure 9: Area of sediment types overlapping w/ groundwater in Asker

Suprisingly, we see no overlap of any marine sediments with groundwater resources in the Asker municipality. Instead, only three types of sediment overlap with groundwater resources, two that are related to glacial deposits and the obvious river and stream deposits.

4 Conclusion

In this report, we've looked into sediments, soil classes, and bedrock in Asker. We've found that the most common sediment type to overlap with cultivated fields is marine sediments, which is present in 75.22% of the area. We also found that the range of elevations in marine areas is quite large, which is a result of the uplift of marine sediments that were deposited in the Oslofjord area. Luckily the overlap of groundwater resources with cultivated fields is quite low (17.66%), and the overlap of marine sediments with groundwater resources is non-existent. So while there exists some problematic areas with groundwater close to oro directly overlapping with cultivated fields, the majority of the cultivated fields in Asker are in good locations.

5 References

1. Girod, L. GIS3 datafiles. *GEO4460* **2025**. https://uio.instructure.com/files/3198654/download?download_f
2. Girod, L. GIS-3: VECTOR ANALYSIS. *GEO4460* **2025**. https://uio.instructure.com/files/3198653/download?download_frd=1