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A Strategic Water Quality Plan for Semerwater

Position Statement:

The Water Framework Directive (WFD) is used to monitor water conditions in the UK. The WFD sets goals for the condition of Europe's water, with means and processes to achieve them. The goal of the WFD is to achieve 'good' and non-deteriorating status for all waters, through organisation and planning at a hydrological (river basin) level and implementation of pollution-control measures, if necessary, on top of those already demanded by existing legislation. 'Good' is meant in terms of ecological and chemical quality, and is achieved through a water body only having a slight departure from the biological and chemical status expected in conditions of minimal anthropogenic impact (Kallis and Butler, 2001)

Currently Lake Semerwater, in the Raydale catchment (figure1), which is a Site of Special Scientific Interest (SSSI) does not meet the conditions for 'good' chemical and biological status under the WFD, and it is not alone with 22,000 hectares of SSSI's in the UK in unfavourable conditions due to diffuse pollution from agriculture (Environmental Agency, 2007). As a result, a 25 Year Environmental Plan, seeking to restore 75% of freshwater sites by 2043 has been implemented (Department for Environment, Food & Rural Affairs, 2018). It is the duty of the Yorkshire Dale National Park (YDNP) to ensure Semerwater meets the government initiative goals. However, the YDNP has a long way to go to achieve a status of 'good' water quality for Semerwater. In 2016, Semerwater's status shifted from 'unfavourable recovering' to 'unfavourable no change' due to large levels of sedimentation

and phosphate. Addressing these water quality issues should be of the upmost importance to the YDNP (YDNP Management Plan 2019-24).

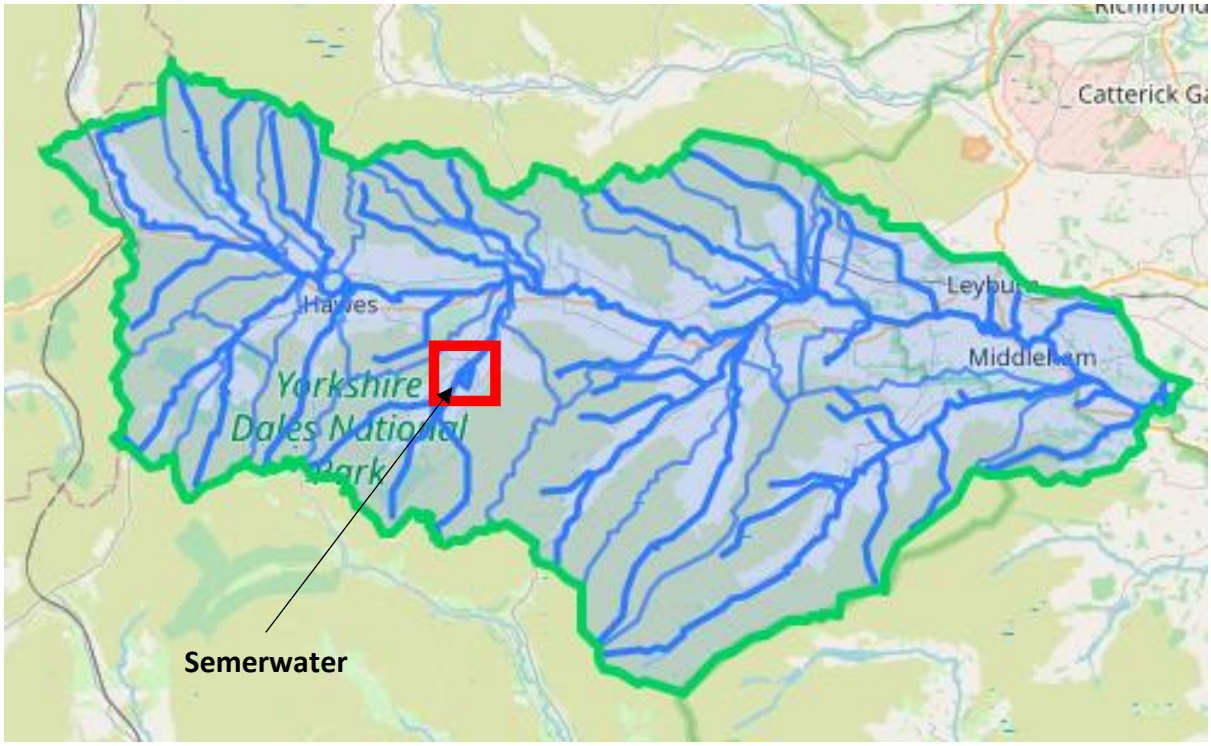


Figure 1: The Raydale catchment, with Semerwater indicated
Source: Department of Environment, Food and Rural Affairs

Literature Review

Semerwater, with a surface area of 0.27km² is located in the Raydale catchment, receiving drainage from three headwater tributaries: Bardale Gill, Raydale Beck and Cragdale Water. At the higher elevations of the catchment is blanket peat (Fleet Moss) (figure 2), which is extensively eroded. Over 90% of the catchment is grazed, with less than 5% woodland cover (Chiverrell *et al.,* 2008). Semerwater was designated as a SSSI in 1975, due to it being a Marl Lake, with extensive wetland vegetation, a mesotrophic status and a rarity of wildlife including the White Clawed Crayfish and Curlew, as well as aquatic plants such as the Yellow

Water Lily. These rare species and the rarity of Marl lakes, make it imperative to work towards 'good' water quality.

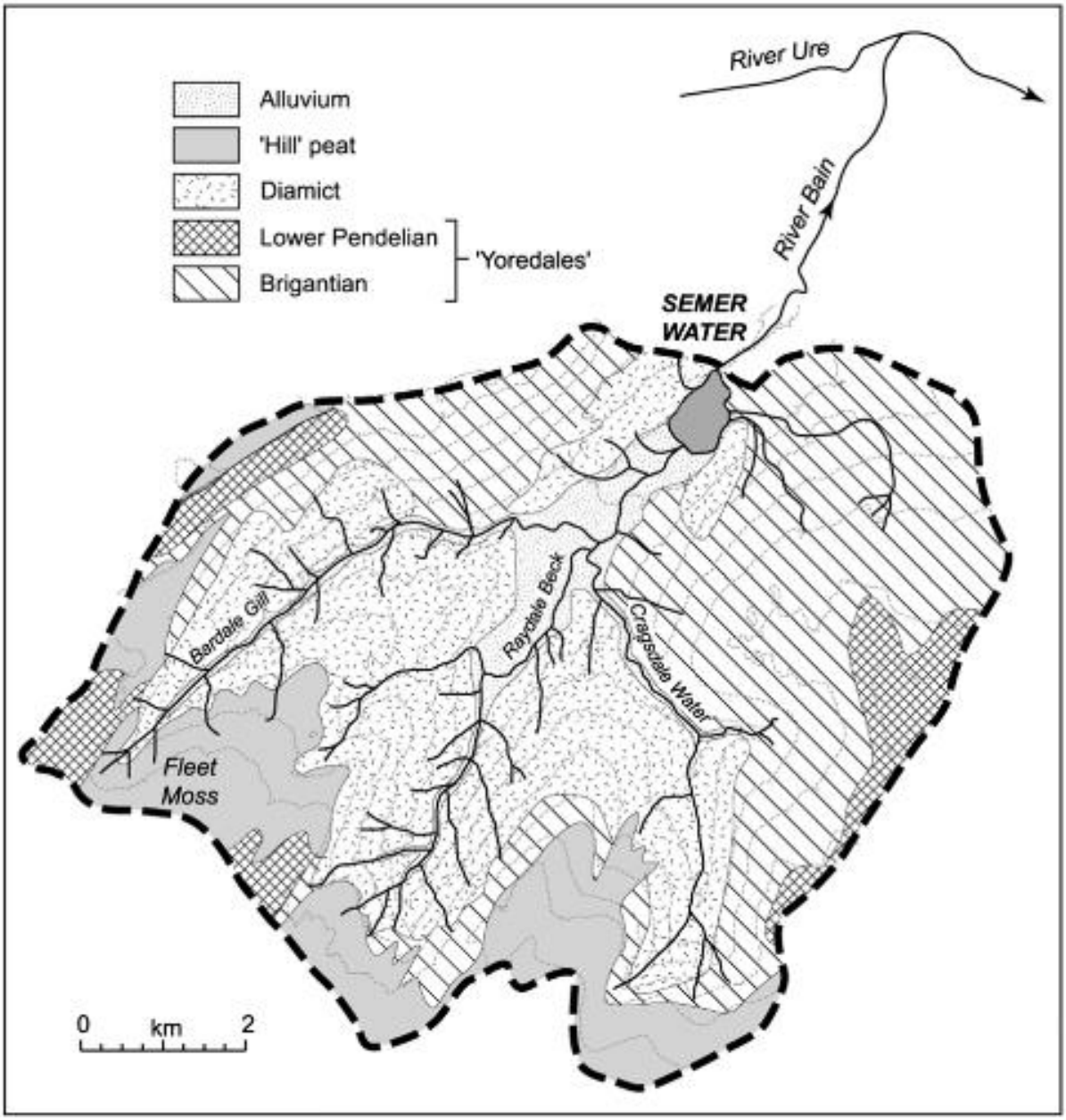


Figure 2: Map showing the Semerwater water catchment and land type
Source: Chiverrell *et al* (2008)

Within the UK, most of the highly calculous (marl) lakes, including Semerwater, lie within heavily agricultural areas with a long history of human impact (Pentecost, 2009). Found in basins of impermeable rock surrounded by geology of limestone (Wiik *et al.,* 2014), in their

natural states Marl lakes are highly alkaline, carbonate-rich lakes that precipitate calcite and contain distinct macrophytes (Pentecost, 2009, Wiik *et al.,* 2013). In a Marl Lake that is in good condition, high water transparency, low phosphorus and phytoplankton concentrations are facilitated by the coprecipitation of marl and phosphorus, removing large amounts of phosphorus and buffering against eutrophication (Wiik *et al.,* 2015). Marl precipitation may be inhibited by high phosphate or organic matter concentrations, which encourage eutrophication (Wiik *et al.,* 2014). The scarcity of marl lakes (only 1% of UK lakes) and their unique chemical and biological features, underline the importance of careful conservation and management, not only for achieving good ecological status as stipulated by the WFD but also for preserving biodiversity and ecological services (Wiik *et al.,* 2014). Farmers in the UK are bound by the Water Resource Act 1991 to not cause general degradation of water sources, however, diffuse pollution from agricultural practices still occurs and is a major issue that needs tackling (Kleinman *et al.,* 2015).

Semerwater which should be nutrient poor as a Marl Lake has entered a state of eutrophication, due to high levels of Total Phosphorus (TP) present, which are both internally derived from the lake-bottom sediment and externally derived because of diffuse pollution from the surrounding agricultural areas (Natural England, 2013). This is impacting the water quality and biodiversity found within the lake. There is also possibly human sewage present from poorly managed septic tanks. The latest JNCC Common Standards Monitoring guidance sets the maximum annual mean TP for mesotrophic lakes at 20 ugl-1. The EA's 2015 TP annual average for Semerwater was 40 ugl-1.

A report by Natural England (2013) found that Raydale Beck and the River Bain (the main tributary and outflow) which are monitored by the EA, were recorded as rivers of moderate ecological conditions due to the moderate levels of diatoms. This would suggest that most of the pollution found in Semerwater, is entering the lake as diffused pollution from the agricultural areas in direct proximity to the lake. To reduce phosphorus entering the lake mitigation measures should focus on the agriculture present near Semerwater. This can be done through the Catchment Sensitive Farming Partnership (CSF), funded by Defra, and supported by the EA, which works together with farmers and catchment communities in priority areas across England to improve the quality of water. The partnership provides local expert advice, training, and grant support to enable farmers to take voluntary action. In 2009 the YDNP initiated a CSF project in Semerwater, with the main pollutants targeted phosphate and sediment in the watercourses. CFS enables access to grants such as the Water Capital Grant and the Countryside Stewardship scheme (YDNP, 2022). A good way to identify sources of pollution and their pathway into Semerwater is through the transfer continuum, which describes the four-tier source-mobilisation-delivery-impact structure of pollutants pathways into water bodies (Haygarth *et al.,* 2005).

Sheep grazing and dairy farming occurs in the lower fields, often in relative proximity to the banks of Semerwater. As previously stated, 90% of the Raydale catchment is grazed. Holz (2010) states that contaminates in water from intensively grazed catchments have shown to cause significant environmental impact and effective intervention is needed to reduce contaminate loads. To do this their sources need to be identified as well as their process of mobilisation and transport.

The water quality degradation induced by grazing animals, unless livestock have direct access to water courses, are secondary affects resulting from the impacts of the grazing animals on the soil and vegetation of the grassland (Bilotta *et al.,* 2007). Animal grazing can result in high loads of sediment, nitrate, phosphate and pathogens to soils and water courses.

Compaction of the soil by livestock treading on it can reduce the porosity of the soil, in turn decreasing the infiltration capacity (Mulholland and Fullen, 1991) therefore promoting surface runoff generation as drainage becomes impeded (Bilotta *et al.,* 2007). Hethwaite *et al* (1990) found infiltration capacity was reduced by 80% and surface runoff volumes were increased by nearly 12 times on heavily grazed land compared to un-grazed land. Livestock produce large quantities of waste, 50% of which is excreted in the field whilst grazing and the rest collected as manure or slurry and spread across the fields (Mawdsley *et al.,* 1995). This waste is a potential source of nutrients (phosphorus and nitrogen) as well as pathogens. Due to compaction these pollutants cannot be absorbed into the soil and are therefore easily mobilised during surface-runoff events and transported to the lake. Sheep farmers at Semerwater tend to slurry spread as their form of fertiliser, whereas dairy farmers use phosphorus fertilizer. Sheep dipping can also impact water quality, if sheep go into streams after being dipped in chemicals or the chemicals are improperly disposed of this can kill biota in streams (Hooda, 2000).

One other way sediment is being transported to the lake other than poaching by animals and surface-runoff, is through transport of sediment from erosion from the Fleet Moss blanket bog via Barden Beck. Peatlands are sensitive systems, that require poor drainage to

grow (Parry *et al.,* 2014). Blanket peatlands are suspectable to damage from low levels of sheep grazing, which can initiate and exacerbate erosion (Ellis and Tallis, 2001). One of the Chief causes of Semerwater having high levels of suspended sediment is erosion of peat at Fleet Moss making Semerwater more acidic and increasing turbidity (Fagg, 2019).

Action plan:

Actions have been colour coded with a traffic light system based on cost, actions marked green and yellow should be attempted and reviewed for effectiveness. If water quality of Semerwater has not improved enough then the red marked actions should be implemented in addition.

Riparian Fencing

Justification:

Fencing of streams prevents livestock from entering water causes and decreases non-point source pollution loading into adjacent waterways (Aguiar *et al.,* 2015). By installing fencing to prevent grazing animal entering watercourses can mitigate against in-stream defecation, and stream-bed disturbances, whilst also enhancing riparian areas (vegetation grows around fencing), to decrease non-point source pollution loading from pastures (Grudzinski *et al.,* 2020). A study by Grudzinski *et al* (2020) found 85% of study areas experienced a reduction in sediment, phosphorus, nitrogen, and bacteria after a >5-10m riparian fence buffer was put in place. One area that would immediately benefit from the installation of Riparian fencing is the field owned by Low Blean farm. This field is grazed by sheep and

shows signs of erosion as well as having an open access stream the feeds straight into Semerwater (figure 3)

Cost:

Fencing costs approximately £1,750 per 600m

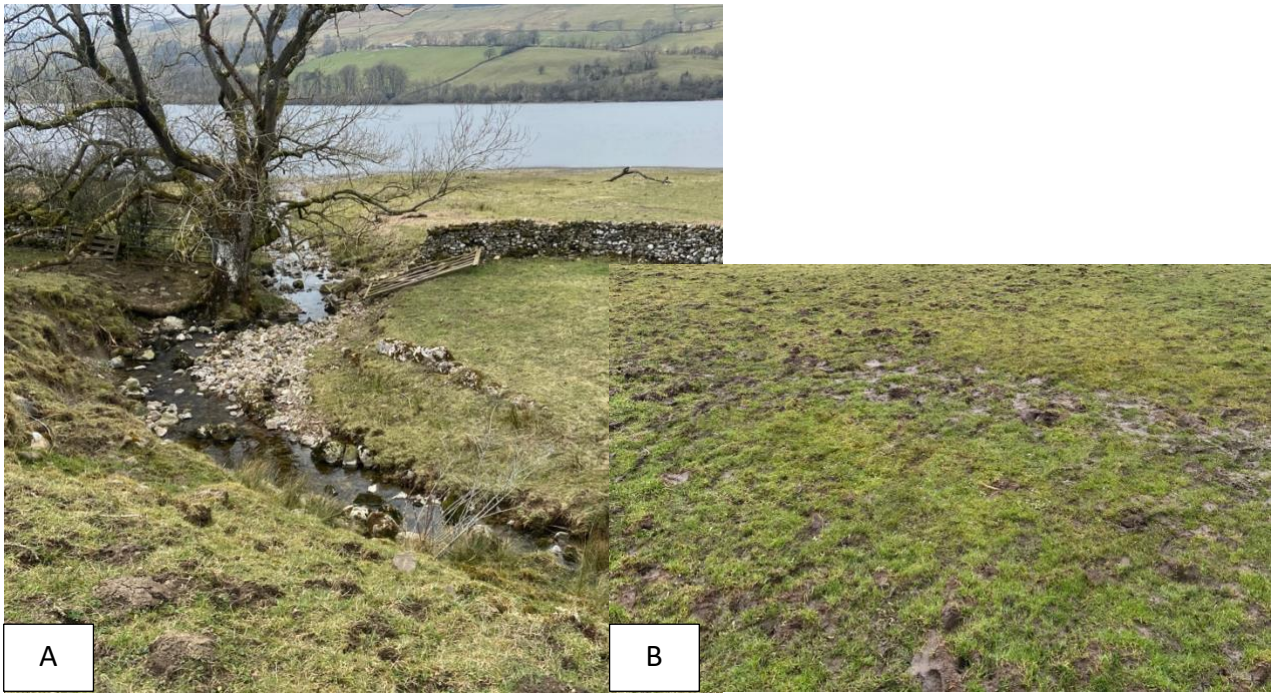


Figure 3: Field owned by Blean Farm, figure A show unfenced open access stream, Figure B shows erosion in field from poaching
Source: Authors own picture

Fleet Moss restoration

Justification:

Martin-Ortega (2014) found strong evidence of rapid ecological responses to peatland restoration related to reduced suspended sediment loads, with sufficient evidence that re-wetting prevents further decline in water quality. Drainage of peatlands, including Fleet Moss occurs for agriculture, in the form of ditches to increase peat drainage and lower the water tables (Holden *et al.,* 2004). This results in erosion of the peat and reduced water quality, affecting the acidity, colour, and concentration of suspended sediment in

Semerwater, through sediment mobilisation and transport (Martin-Ortega, 2014). This can impact Benthic habitats and reduction of species diversity by deposition on benthic habitats (Ramchunder *et al.,* 2012). Revegetating areas of bare peat to stabilise erosion and blocking erosion gullies can be used for restoration (Anderson *et al.,* 2008), which will result in less erosion and suspended sediment transported to Semerwater.

Cost:

Pennine peatLIFE, Yorkshire water and the EA believe it will cost £1.3 million to restore Fleet Moss (YDNP,2021).



Figure 4: Erosion at Fleet Moss
Source: Fagg (2019)

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Slurry and septic tank management

Justification:

Slurry is a valuable fertiliser but a potential source of water pollution such as phosphorus and pathogens if poorly managed (SOAEFD, 2005). According to a study conducted by Aitken (2003), the inability for manure collection and storage systems to cope with the volumes of waste produced and the spreading of slurry on water saturated or near to land was the main cause of water pollution from slurry. By having adequate slurry storage capacity, this will allow farmers to delay spreading until soil and weather conditions are suitable. Farmers should also check the weather forecast before spreading to avoid spreading before rain events, reducing the transportation of slurry into waterways via runoff. Rainwater draining into slurry storage unnecessarily increases volumes of slurry, roofing over slurry stores can help prevent this. Slurry should not be applied to steeply sloped hills or poorly drained land (Aitken, 2003).

To reduce diffuse pollution from septic tanks it is important to correctly install them, and monitor and maintain them (Aitken, 2003).

Cost:

A steel tower slurry tank costs £510 per cow for 22 weeks of storage (Short, 2015).

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Tree planting

Justification:

Contour planting has been found to reduce runoff by 49%, thereby reducing sediment, TN, and TP losses to waterbodies. These buffers can be designed to improve water quality with minimal land taken out of production (Udawatta, 2011). The trees do this by promoting infiltration into the soil. The best place to plant tree buffers is in mid-slope and down slope field edges (Calder, 2008).

Cost:

Establishment would cost £1,500 per hectare with a £200 maintenance cost (EA, 2015)

Other low-cost management strategies

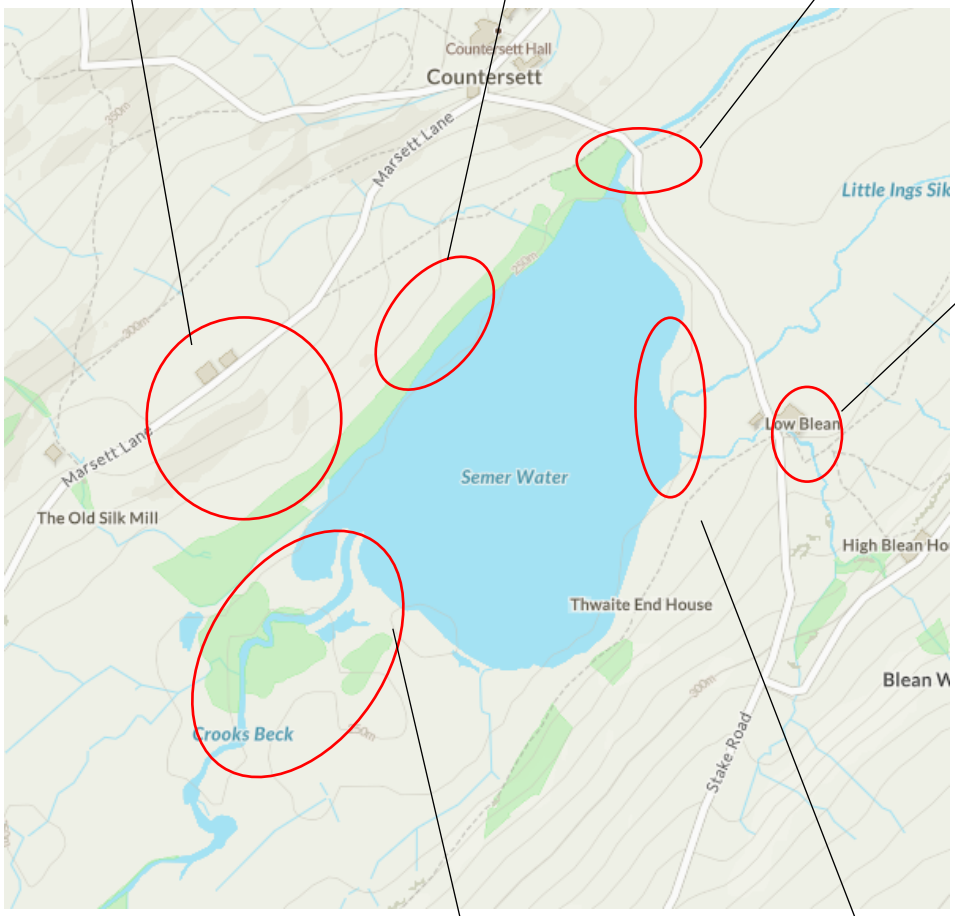
- Banning power boats in Semerwater to reduce turbidity, boating can churn up sediment
- Banning sheep dipping
- Reduce livestock's dietary intake of P and N
- Livestock rotation to reduce compaction of fields

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- Area of dairy farming
- Test soils to limit phosphorus use
- Heavily compacted area, thus limit slurry spreading and implement livestock rotation

- No tree planting in this area, Curlew breeding site

- Area of recreational use
- Install signs 'NO BOATING



Source: Ordinance Survey

- Maintenance of septic tanks and roofing over slurry pits

- Tree planting and fencing to prevent soil erosion of riverbank

- Install riparian fencing in this area
- Plant trees along contour of the eastern banks at mid and lower levels of slopes

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