A REPORT SETTING OUT THE RESULTS FROM THE CLOSE MOSS BUND TRIAL

MoorLIFE 2020

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MOORS FOR THE FUTURE PARTNERSHIP

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1. Introduction

The trial's primary aim is to investigate whether or not bunding is an effective restoration technique on blanket bogs within UK uplands. This is a pertinent question as peat bunding has been used extensively on English lowland peatlands for nearly fifty years, and on a variety of different landscapes including blanket bogs in other locations *(*IUCN, 2011*)*.

Bunds have been used for conservation *(*IUCN, 2011*)* and in agriculture as a way to reduce water flow and increase sedimentation *(*SSWM, 2018*)*. Historically on blanket bog habitats there have been limited examples of bunding being constructed outside of grip and gully systems as a way of raising and stabilising the water table, helping to restore the acrotelm, which in turn helps improve the exchange of greenhouse gasses *(*Martinelli, G. et al, 2015*)*. The wetter conditions created by bunds promote the growth and abundance of blanket bog species such as Sphagnum moss spp and Common Cottongrass (*Eriophorum angustifolium)* (Price et al, 2002).

The types of bunds available can vary both in size (YPP, 2011 and Agri info, 2015) and in the available types; contour bunds which follow the contours of the hill, fish-scale bunds which are interconnected semi-circular bunds (SSWM, 2018) and scallop bunds which are independent horseshoe-shaped bunds. Each of these types of bunds can be used for a specific purposes (SSWM, 2018), and has its own set of advantages and disadvantages.

1.1. Aims

<u>Aim one</u> – To ensure that bunding can be built on blanket bog sites without damaging the habitat and its qualifying features during the construction phase. Equally it is important to determine if bunding has created erosion channels along the side of the bund wall, as a result of water flowing around the side of the bund.

<u>Aim two</u> – To demonstrate the benefits of bunding to land managers and practitioners through site visits.

<u>Aim three</u> – To collect scientific data, see below, to ascertain the impact different bund-types have on the environment, and to inform knowledge of functional differences between the different bund-types.

1. Water table heights
2. Surface pooling
3. Impact on vegetation – can bunding be used to control *Molinia caerulea* (Purple Moor Grass)
4. Sedimentation behind the bund

The outcomes associated with these aims will be fulfilled over different time periods. The aims of determining if bunding can be built on blanket bog ecosystems, and the degree of surface pooling can be identified in the short term, whereas the impact on the water table (WT) would be identifiable within the medium to long term, with the impacts on vegetation and sedimentation being long-term goals of the trial.

2. Methodology

2.1. Location

The bund trial took place on Close Moss, which is located approximately 4km west of Marsden and 4.2km north-east of the village of Delph, see Figure 1 below. The site is located on a blanket bog habitat that primarily consists of graminoids (*Molinia caerulea*, and *Eriophorum spp*), with an understory of mosses including *Acrocarpus* and *Pleurocarpous* mosses and a limited number of Sphagnum moss species.

Figure 1 Site location

2.2. Bund construction

In February 2020 bunds were constructed using an excavator, see methodology in Appendix 1. The scallop, and fish-scale bunds were approximately 20m x 20m with the contour bunds being 60m in length, see Figure 2 below.

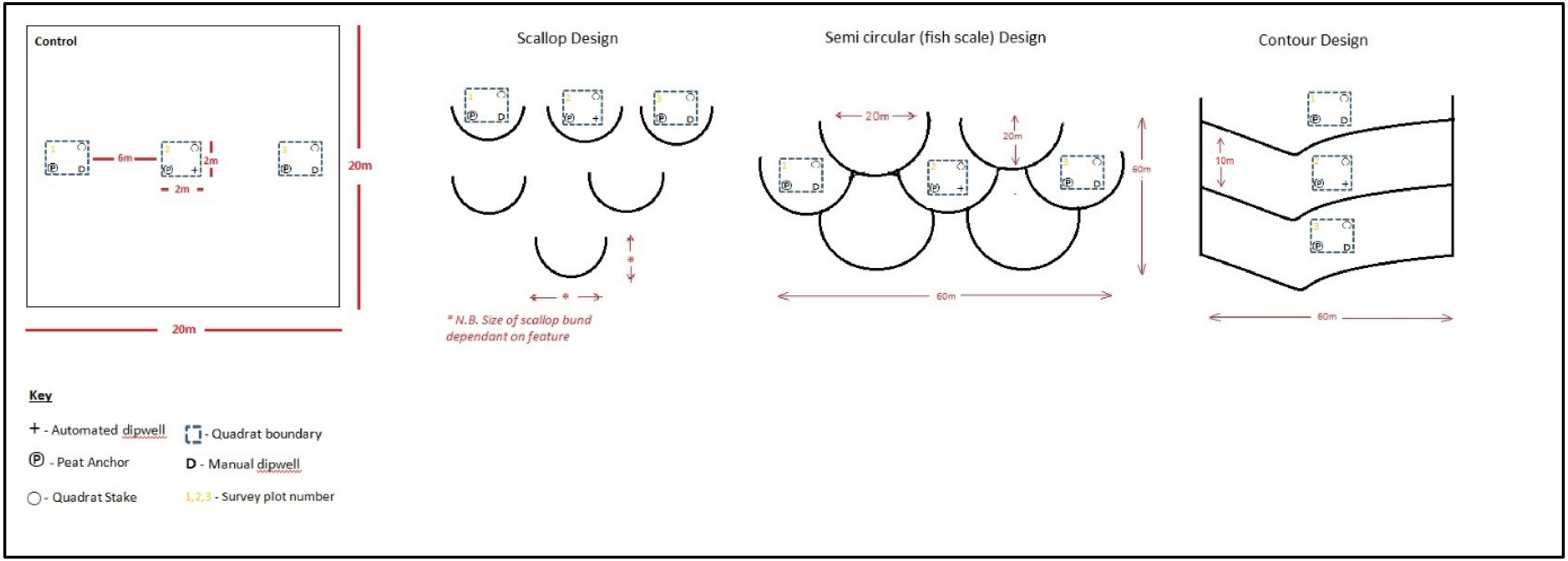


Figure 2 Indicative layout of the monitoring units in each bund-type

2.3. Monitoring

Within each bund-type (fish-scale etc.) three monitoring stations were set up as shown in Figure 3 below.

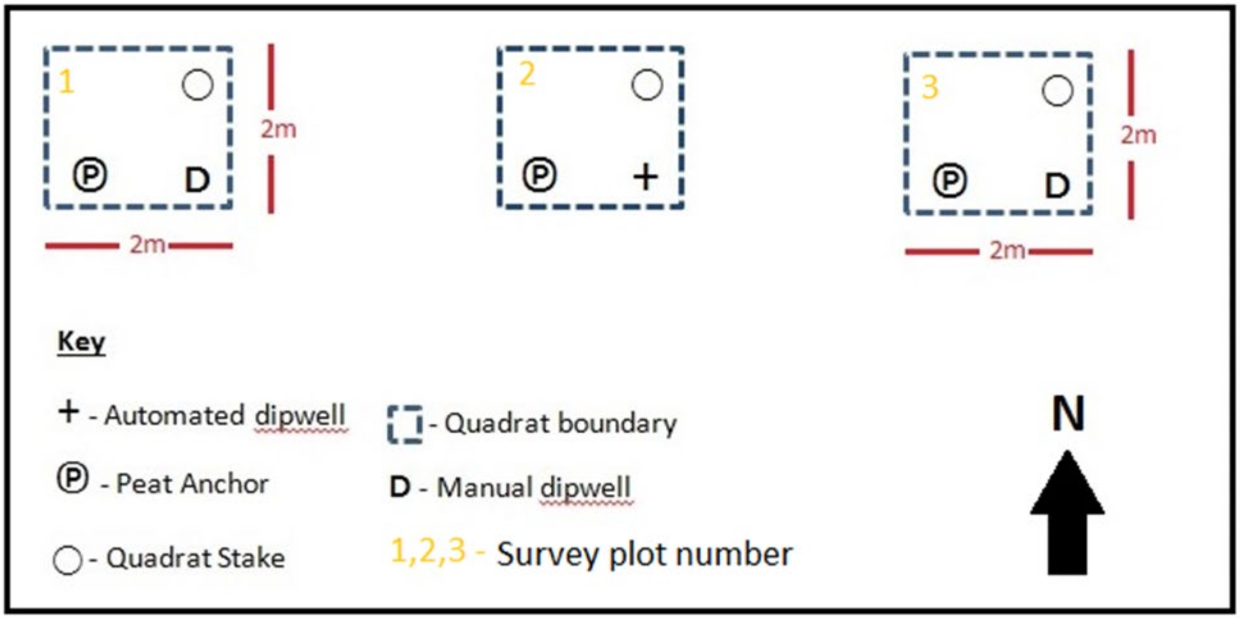


Figure 3 Plan of monitoring stations

The monitoring stations were positioned with the automated or manual dipwell 2m behind the bund wall at the apex of the bund. This means that three individual bunds per type (e.g. fish-scale) had monitoring stations located within them. Monitoring stations of the same design were also set up in a control area approximately 10m away from the nearest bund.

In order to collect baseline data the monitoring stations were set up prior to construction. This meant that in some instances the monitoring station are not precisely 2m away from the bund wall due to the tolerances involved with the construction of the bunds, which were built to ensure that water was held correctly behind the bund. Additionally, the automated loggers were removed during the construction phase as a precaution to avoid damage to them from the excavator.

2.3.1. Water table heights

Water table heights were measured using Hobo pressure transducers (Tempcon Instrumentation Ltd, West Sussex) – termed “loggers” from this point onwards – which took pressure readings every 10mins. The loggers were suspended in their dipwell tubes using non-stretch wire. Another logger was located 0.8m above the ground surface taking air pressure readings, making it possible to calculate the water table height by comparing the different pressures. This water table height was calibrated using the manual water table height data.

2.3.2. Manual water table heights

Manual recording of water tables was accomplished by inserting a length of tubing down the dipwell and blowing until bubbles were heard. At this point the corresponding length of tube represented the depth from the top of the tube to the level of the water in the tube. The distance from the top of the tube to the ground surface was also measured, and subtracted from the distance measured from the top of the tube to the water table. This calculation gave the depth of the water table below the ground surface.

2.3.3. Surface pooling

Within the apex of each bund the height of the pooled surface water being retained by the bund was measured at a fixed point. The measurements were taken by putting a ruler into the water until it met resistance and reading off the height of the water.

2.3.4. Vegetation analysis

The vegetation cover was surveyed annually using a 2m x 2m quadrat focusing on the monitoring stations outlined in Figure 3. The primary aim of the vegetation survey was to establish what impact bunds had on the dominance of *Molinia caerulea,* and to determine if the area behind the bund being submerged by water increases the amount of bare peat present.

2.3.5. Sedimentation analysis

Within each quadrat, a peat anchor was installed to estimate the build-up of any sediment that may occur from the overland flow. The depth of peat prior to installation was measured, and then a peat anchor was constructed from A12 threaded rod. This was hammered into the ground until bedrock was reached, with the top of the threaded rod left protruding from the surface of the blanket bog. This peat anchor was coated in Noxyde paint in order to stop corrosion occurring. During monitoring, the peat anchor was measured from the ground to the top of the anchor on the northern side, to determine if the distance between the peat and the top of the anchor was changing. A decrease in the distance between the blanket bog surface and the top of the anchor indicated sediment build up occurring.

Analysis of peat anchors involves looking at the overall trend associated with the distance from the ground to the top of the peat anchor. This is because measurements can vary depending on where the measurement was taken from and the structure of the vegetation around the dipwell tube.

2.4. Limitations of the trial

There are a number of limitations associated with this trial, which are presented below:

2.4.1. Replication

The trial was designed as a proof of concept for bunding on upland blanket bogs, therefore it was only installed on one unreplicated site. In order to reduce the impact of this, where other comparable sites have been constructed since the inception of this trial, the results have been incorporated into this trial to increase the replication.

2.4.2. Additional quadrats

Due to the variability of results in years 1–3 for the percentage cover of *Molinia caerulea*, in year 4 additional 2m x 2m quadrats were set up in all bunds that did not have a monitoring station. This provided an extra seven quadrats (quadrat numbers 13–20) split between the scallop and fish-scale bund-types. These additional quadrats were set up 2m away from the apex of the bunds. This was done to increase the sample size for the vegetation survey, to help ascertain which results previously recorded were more likely to show the impact of bunds. As a result of their late installation no baseline data were obtained for these additional quadrats, therefore the average *Molinia caerulea* cover associated with the relevant bund-type was used instead.

2.4.3. Additional automated water table loggers

Initial results identified that the contour bund-types were behaving differently to the scallop and fish-scale bund-types, because analysis showed that the WT results were higher than the scallop and fish-scale bunds which didn't match up to the surface water pooling data obtained from the different bund-types. Therefore in order to determine if there was a problem with the contour bunds an additional hobo pressure logger was installed on the same contour bund (bund 10). This new logger produced a different result to those originally seen, and thus a third hobo pressure logger was added to a different contour bund (bund 12) to determine which results were correct. The results from this third logger was similar to the second logger installed, it is therefore thought that there was a problem with the location or installation of the original logger. The data from the original hobo pressure logger is provided in this report because it is the only baseline data available for the contour bunds, but it isn't considered an accurate representation of the WT associated with contour bunds.

Due to the issues identified above, additional loggers were installed on the scallop and fish-scale bund-types to determine if these data were accurate. Analysis of these loggers indicated that there were no issues associated with the original loggers and therefore all data accurately represented these bund-types.

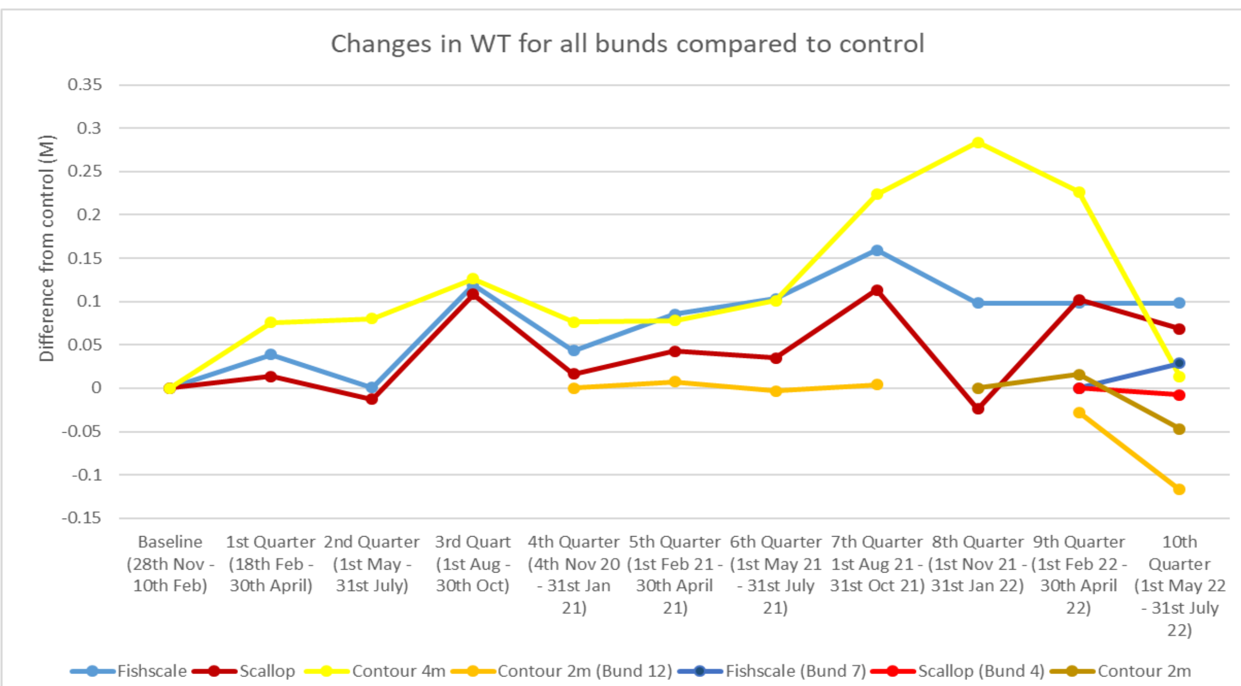
Appendix 2 provides the evidence to show the accuracy of the WT data by bund-type.

3. Results

The data presented below represent the current results associated with the bund trial. Whilst monitoring is no longer taking place following the end of the MoorLIFE 2020 project due to the lack of available ongoing funding, the loggers have been left in-situ to continue collecting data, allowing for further updated analysis at a later date should additional funding be found.

3.1. Water table heights

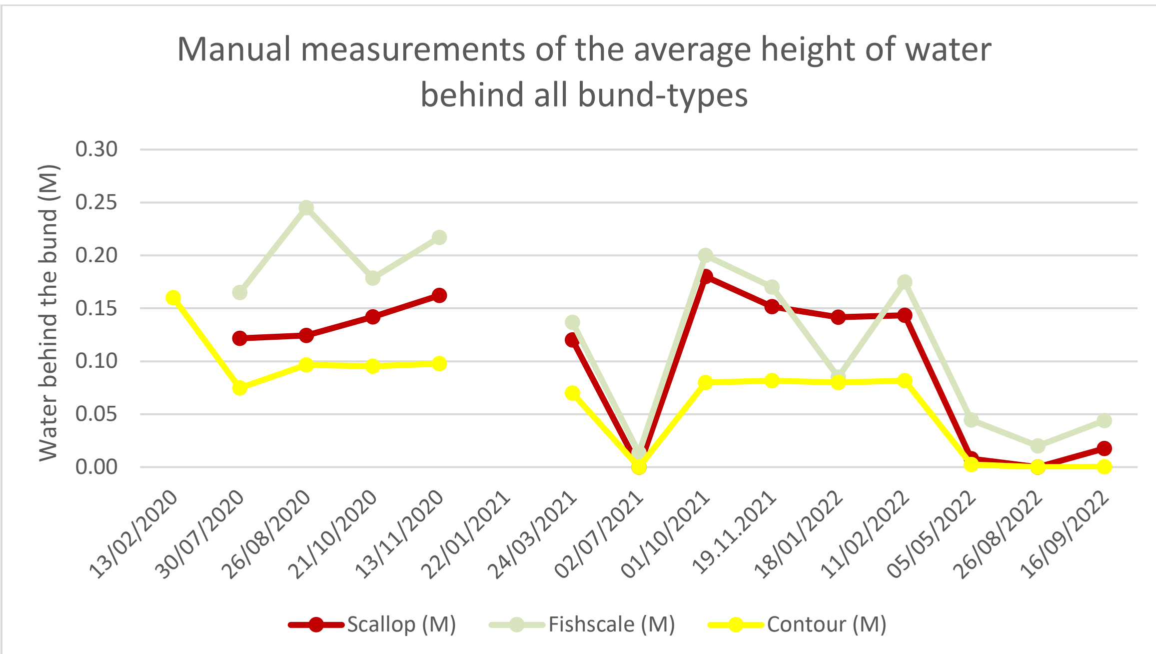
Graph 1 below indicated that the fish-scale and scallop bunds have comparable fluctuations in the WT height relative to control, with this measurement in both bund-types decreasing to around 0m in quarter 2 and then peaking around 0.11m (110mm) in quarter 3. From quarter 5 onwards the fish-scale bund-type shows a slight increase in WT height (relative to control) compared to the scallop bund-type with them both peaking at 0.15m (150mm) and 0.11m (110mm) respectively. The only significant difference between the two appears in quarter 8 where the relative WT height within scallop bunds shows a steeper decrease than that in the fish-scale bunds, but in quarter 9 the scallop bunds returned to similar levels as the fish-scale bund-type at 0.09m (90mm).



Graph 1: Water table heights compared to control by bund-type

3.2. Surface water pooling

The measurements of the average height of water being held behind the different bund-types are presented in Graph 2 below. This shows that the fish-scale bunds on average held 0.147m (147mm) of water behind the bund. The contour bunds were the least successful design in holding water behind them, with an average of 0.076m (76mm), with scallop bunds coming in between these with an average water height of 0.11m (111mm).

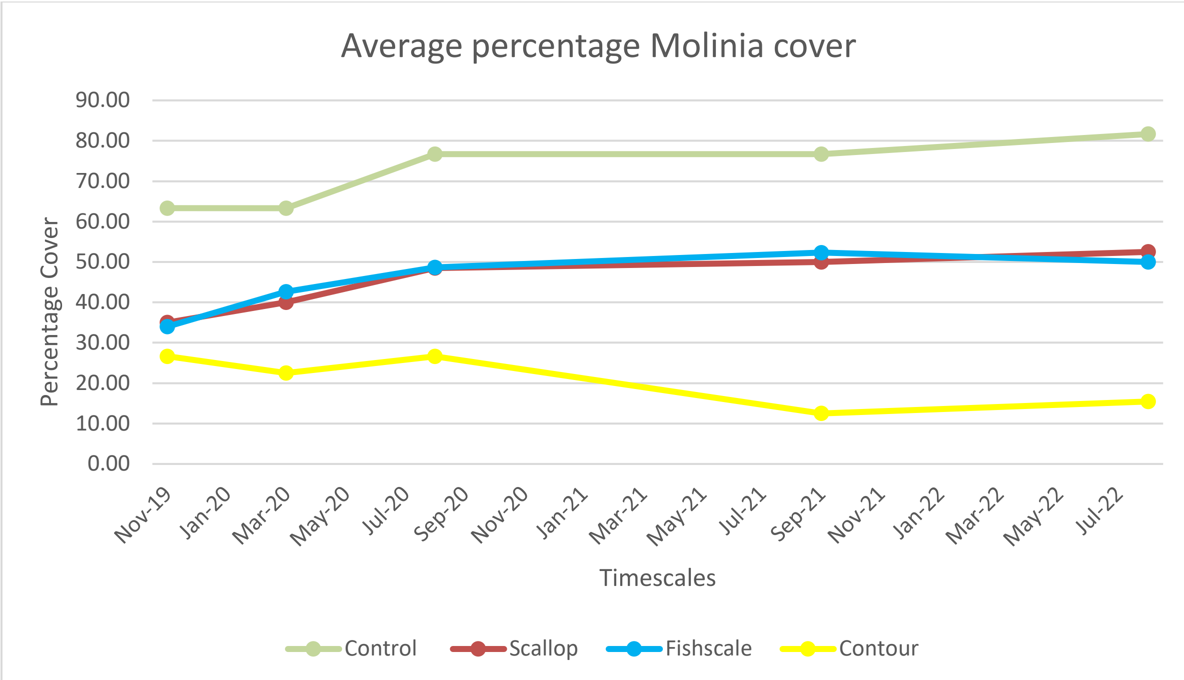


Graph 2: Average height of water being retained behind the different bund-types

3.3. Vegetation

3.3.1. *Molinia caerulea* cover

Graph 3 below identified that average *Molinia caerulea* cover only decreased in the contour bunds, falling from 26.6% cover in November 2019 (baseline) to 15.5% in August 2022. The other bund-types (scallop and fish-scale) exhibited an increase (17.5% and 16% increase respectively) in *Molinia caerulea* cover. This is similar to the control plots which exhibited an 18% increase in *Molinia caerulea* cover.

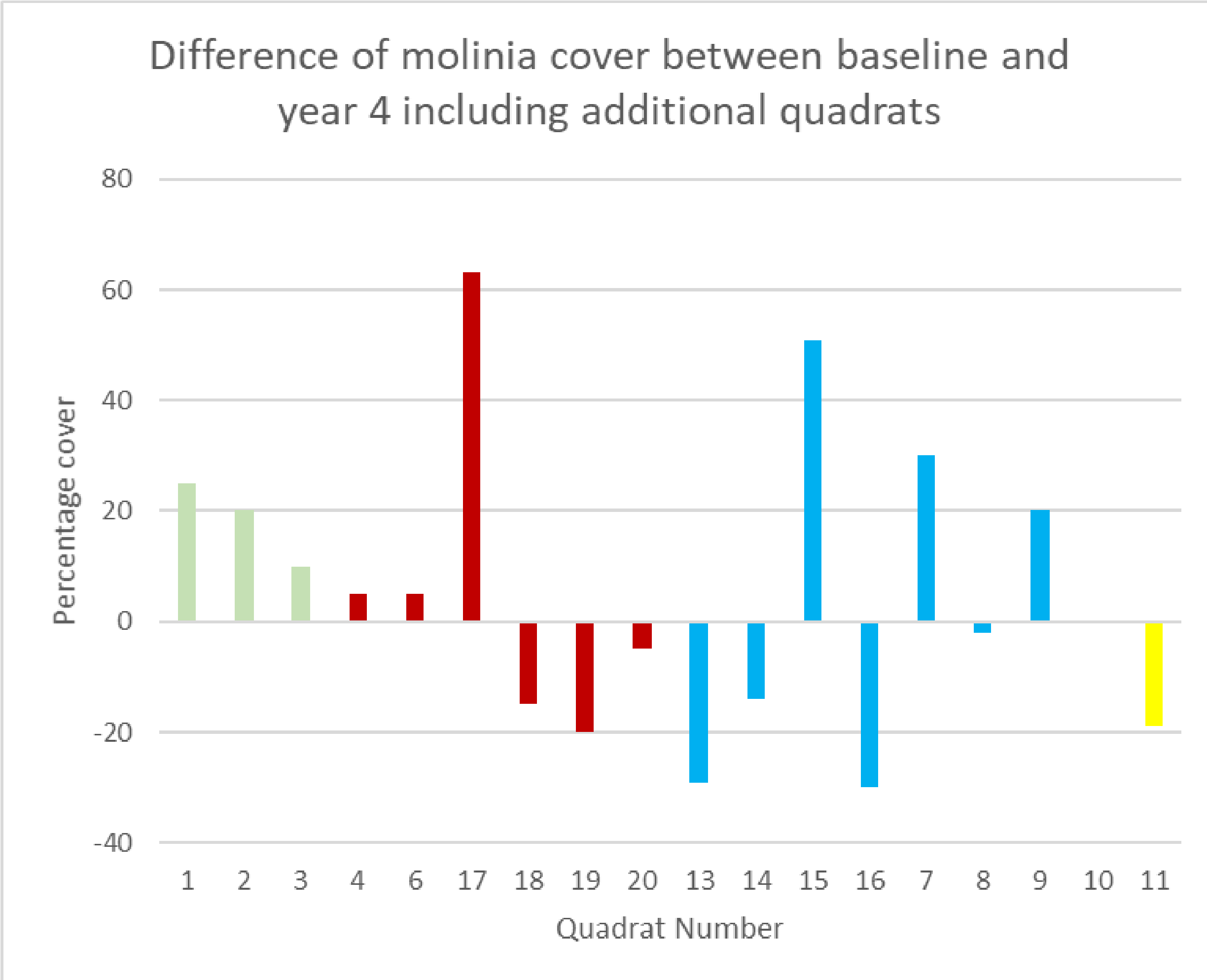


Graph 3: A graph showing the change in percentage cover of *Molinia caerulea*

Examination of the change in *Molinia caerulea* cover for individual quadrats situated 2m away from the bund wall (Graph 4), identified that all the control quadrats displayed an increase in *Molinia caerulea* cover from baseline levels, the only set of quadrats to all show an increase in *Molinia caerulea* cover. For the scallop bunds the original quadrats also all show an increase in the cover of *Molinia caerulea*, however the additional quadrats added (quadrat numbers 17, 18, 19, 20) generally show a decrease in cover, except number 17, which showed the biggest increase in *Molinia caerulea* cover of any single quadrat surveyed. Analysis of the fish-scale bunds showed that 3 individual quadrats had displayed an increase in *Molinia caerulea* cover and three individual quadrats had demonstrated a decrease in *Molinia caerulea* cover.

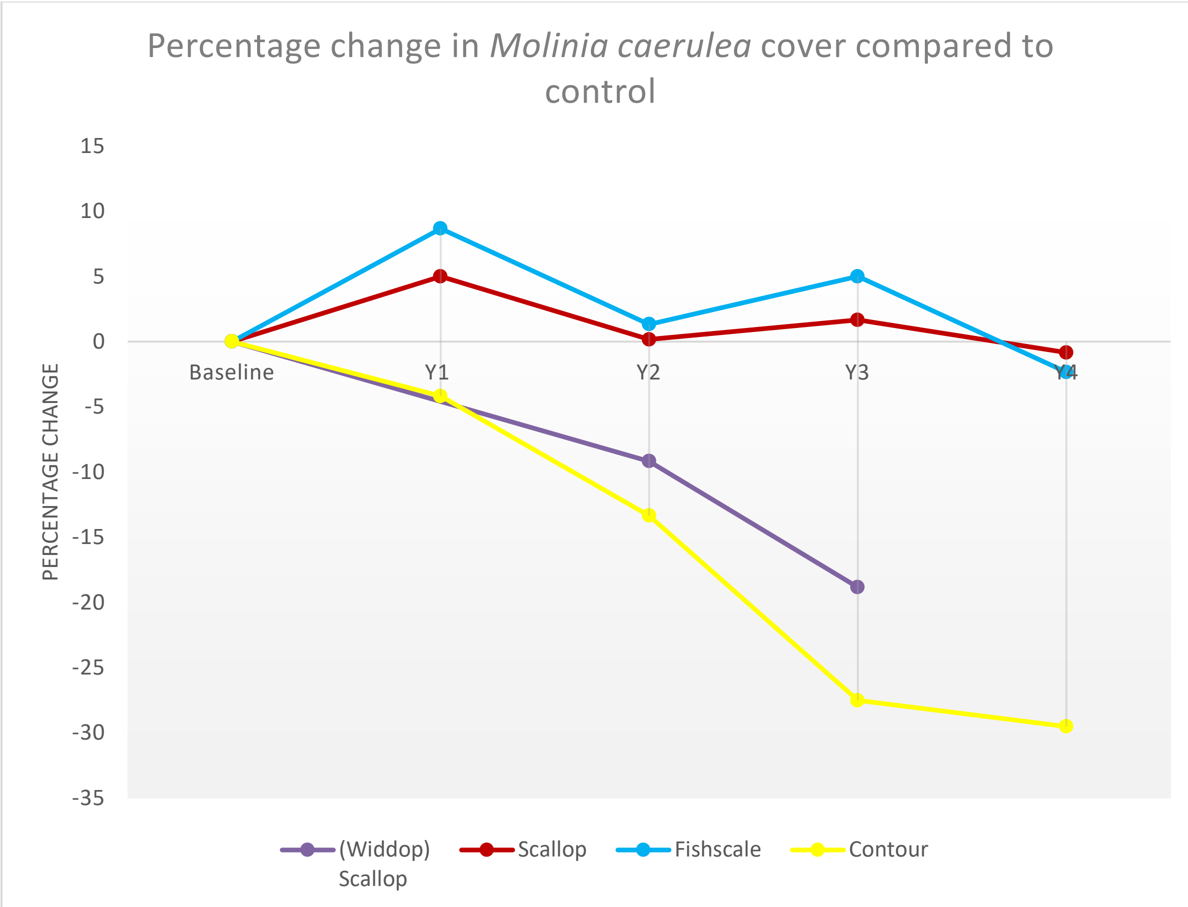
The largest decrease in *Molinia caerulea* cover for an individual quadrats was seen in the fish-scale bund-type, where two individual quadrats showed a 30% and 29% decrease in *Molinia caerulea* cover. Conversely, two quadrats within fish-scale bunds showed a 51% and 30% increase in *Molinia Caerulea* cover as well.

The contour bunds are the only set of quadrats to show either no change or a decrease in *Molinia caerulea* cover for all quadrats.



Graph 4 : Percentage change in *Molinia caerulea* cover for each quadrat that is 2m away from the bund wall. Green = control, red = scallop, blue = fish-scale, contour = yellow

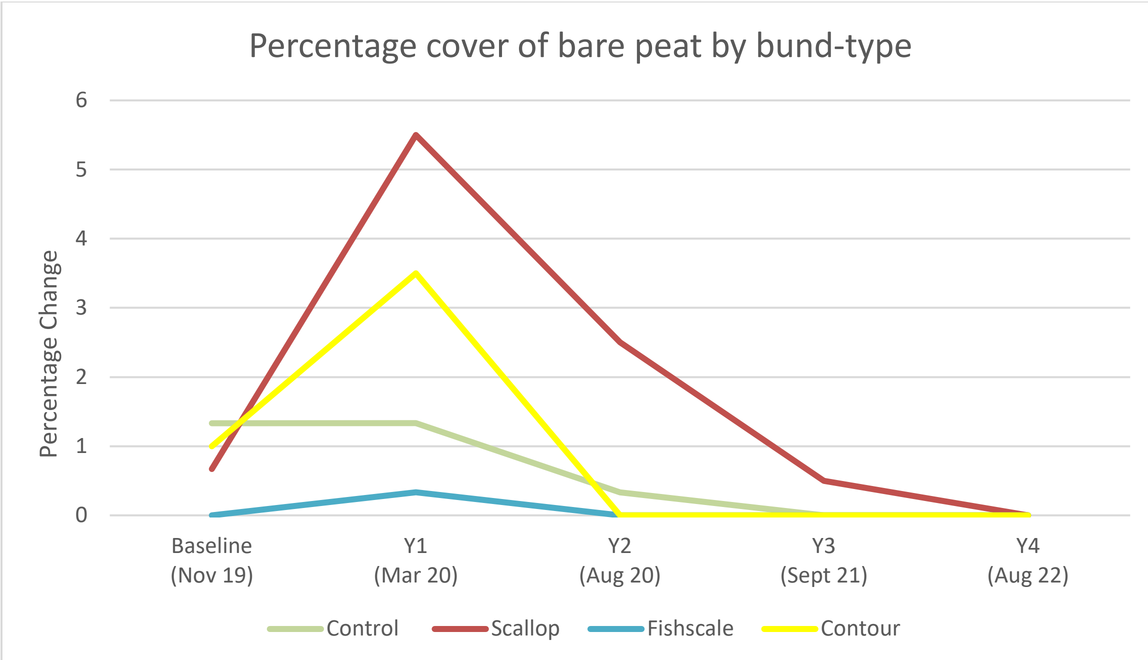
The average percentage *Molinia caerulea* cover relative to the control for the original quadrats (quadrat numbers 1–10, Graph 5 below), showed a decrease in *Molinia caerulea* cover for all bund-types. Furthermore the change in *Molinia caerulea* cover for another site (Widdop) featuring scallop bunds has also displayed a decreased in *Molinia caerulea* cover. The trend for the scallop and fish-scale bunds on Close Moss has fluctuated year on year suggesting that there is currently no impact on *Molinia caerulea* cover, whereas the contour bunds on Close Moss and scallop bunds on Widdop have shown a year on year decrease in *Molinia caerulea* cover.



Graph 5 : Percentage change relative to control for *Molinia caerulea* cover on Widdop and Close Moss bunds. N.B. Year 1 on the graph represents the vegetation survey undertaken immediately after the bunds were installed. This survey wasn't undertaken for the Widdop trial

3.3.2. Bare peat

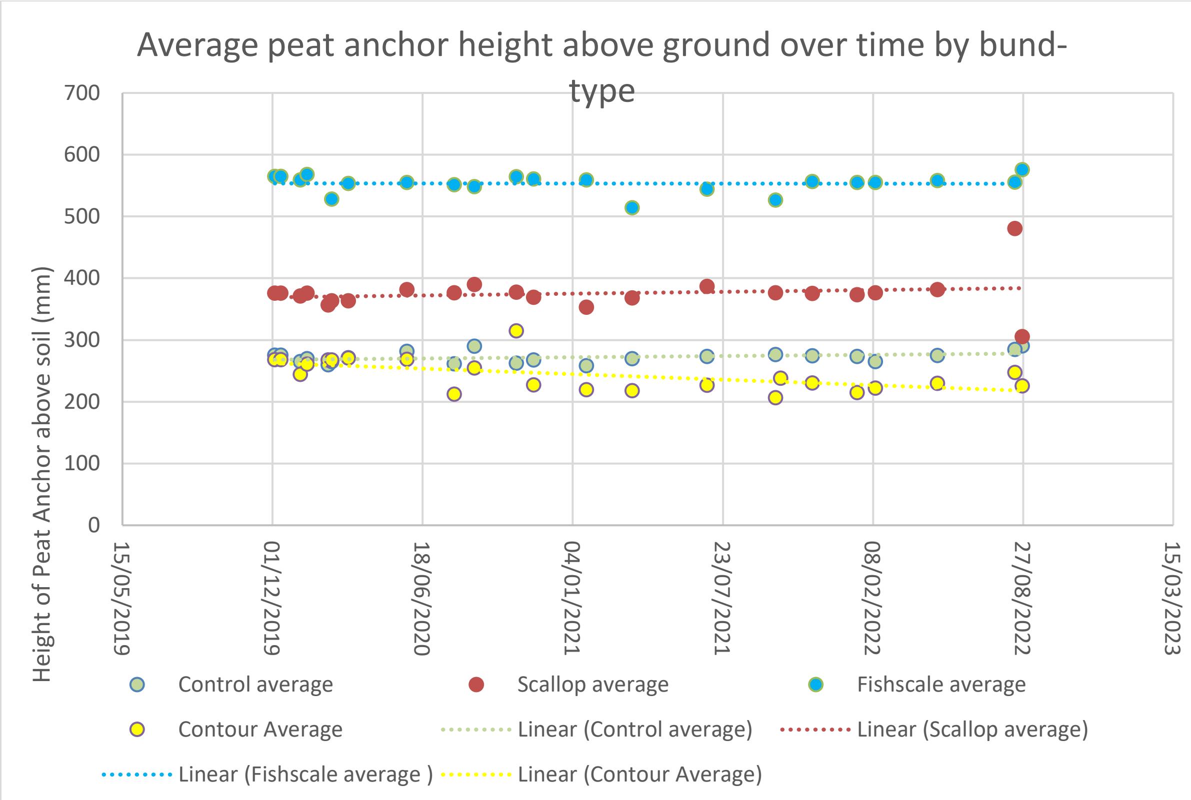
Bare peat area increased immediately after installation of the bunds (see Graph 6 below). The largest change was seen in the scallop bunds which showed a 5.3% increase. The control plots exhibited the smallest change (0%) during this period. The amount of bare peat had decreased back to the baseline levels for all three bund-types by year 4, with fish-scale and contour dropping back in year 2 and then maintained the baseline levels in year 3 and 4.



Graph 6: A graph to show the change in bare peat for all bund-types

3.4. Sedimentation build up

Graph 7 below identified that the average height of the peat anchor above the peat for each type of bund. The trend showed that there is minimal change in the build-up of sediment for the different bund-types, with the control and scallop bund-types on average showing a decrease in sediment by 4mm and 7mm respectively, whereas on average the fish-scale and contour bund-types have shown a build-up of sediment (5mm and 1mm respectively).



Graph 7: Height of the peat anchor above the soil

4. Discussion

Aim I – Damage to the habitat

Whilst the data showed a sharp increase of up to 5.3% in bare peat immediately after construction, it is likely that this is due to the *Molinia caerulea* dying back during the winter months revealing more of the understorey to the surveyor rather than as a direct result of the construction process. This hypothesis is strengthened by the fact that the bare peat cover reverted back to the baseline level within 9 months for two out of the three bund-types (fish-scale and contour), with the bare peat within the third bund-type (scallop) coming back to baseline levels within 53 months of construction. Despite it taking the bare peat in the scallop bunds' much longer to recover/ revegetate than that of the other bund-types, the amount of bare peat was still less than 5% cover at the worst point. This suggested that building bunds had minimal impact upon the vegetation cover identified on site.

Whilst undertaking the field surveys visual inspection of the bunds did not shown any evidence of channelling from water erosion on or around the bund wall.

Since construction the bunds had been subjected to unauthorised off road vehicle(s) driving over them. Where this had occurred the bund wall was not damaged or caused to subside, suggesting that the bunds were constructed robustly.

Aim 2 – Use as a demonstration site

The site has been visited by a number of different stakeholders in the company of Moors for the Future staff to showcase the positive benefits of using bunds on habitats dominated by *Molinia caerulea*. Measurement/ quantification of the success of these activities was outside the scope of this project, but this physical demonstration site has proven useful to aid the understanding of all parties during on-site discussions.

Aim 3 – Investigating the impact of the bunds on the environment

Analysis of the WT data showed that on average there has been an increase in WT height relative to control for all bund-types. Fish-scale bunds have marginally had the biggest impact in increasing the WT, it being on average 0.04m (4mm) higher than that in the scallop bunds, but 0.12m (120mm) higher than that in the contour bunds. It is thought that this is due to the more cellular structure holding more water.

Currently it is unclear as to why the contour bund-type has not raised the water table as much as the other bund-types. The reason for this could range from undiscovered underground peat pipes located in this area to the construction of the contour bunds themselves. One hypothesis for this behaviour is because the fish-scale and contour bunds are both 20m x 20m, whereas a contour bund is 60m in length with smaller sides, it might allow the water to flow around the bund more easily.

Furthermore, less surface pooling is seen behind the contour bunds when compared to the other types. Again, the reason for this is not clear, but could be similar to that described above for the WT.

The vegetation results indicated that on average all bund-types showed a decrease in *Molinia caerulea* cover relative to control in year 4. This does not accurately reflect the trend associated with the fish-scale and scallop bunds on Close Moss, as the percentage cover of *Molinia caerulea* compared to control fluctuated each year, with it sometimes showing more cover and sometimes less. This suggests that so far these bunds types are having a limited impact on *Molinia caerulea* cover on this site. However, this is not the case for the scallop bunds on the Widdop site which has demonstrated an 18.5% decrease in *Molinia caerulea* cover relative to control. Why the Widdop scallop bunds have demonstrated a decrease in *Molinia caerulea* cover while the Close Moss scallop bunds did not is currently unknown, and further investigation is required.

This yearly decrease in *Molinia Caerulea* cover on Widdop is also seen in the contour bunds on Close Moss with a 30% decrease. Additionally on these two sites an increase in bare peat was not observed, suggesting that bunds are not creating small peat pans immediately behind them.

It is unknown as to why the contour bunds on Close Moss are decreasing the *Molinia caerulea* cover when the other bund-types aren't, especially as the contour bunds are displaying the least amount of surface water pooling, which is detrimental to *Molinia caerulea* growth (Bustlingnest, 2022).

Sediment build-up behind the bunds has been negligible with the average difference between baseline and Y4 ranging between -7mm to +5mm. This was to be expected over this timescale given the intact (vegetated) soil on this site. This variable would need to be monitored over the long term to determine if there were any significant impacts as a result of bunding. However, while these results are not conclusive it is worth noting that some bund-types have shown an increase in sediment build-up (fish-scale and contour) and some have shown a decrease in sediment build-up (control and scallop). The reason for this is unclear from the data collected.

5. Conclusion

Aim 1 – The results showed that the construction of different bund-types has had little to no negative or harmful impact upon the blanket bog ecosystem or its designated features. This meets one of the key aims of the trial. This is because:

- Currently the bunds have not shown any increase in bare peat over the longer term. Additionally it is suspected that the apparent increase seen at the start is actually due to *Molinia caerulea* dying back in the winter months as part of its life cycle.
- A visual inspection of the site revealed no signs of erosion channels adjacent to the bunds.
- The bunds have withstood unauthorised off-road vehicles driving over them, suggesting that they are constructed robustly and capable of withstanding the environment they are in.

Aim 2 – A number of site visits with practitioners and land managers have been undertaken to demonstrate the positive impact of bunds, thereby satisfying Aim 2.

Aim 3 – Analysis of the scientific data identifies that:

- The scallop and fish-scale bund-types showed the largest amount of surface water pooling (average 147mm and 111mm respectively). The contour bunds have still shown an increase in surface water pooling (76mm) but this has been less successful than the other two bund-types trialled.

- All three bund-types have shown seasonal fluctuations in the WT, with the wetter months showing the greatest increase in WT relative to control, and the WT then falling in the drier months. On average the fish-scale and scallop bund-types have increased the WT by 115mm and 111mm respectively.
- The contour bunds have only shown a 1mm increase in WT. From the data available it is not known why the contour bunds have not performed as well as the other two bund-types.
- The percentage *Molinia caerulea* cover relative to control for the fish-scale and scallop bunds on Close Moss varied year on year, with no strong evidence that these bunds have limited the growth of *Molinia caerulea*, despite the fact that year 4 showed a slight decrease in *Molinia caerulea* cover compared to baseline
- The contour and scallop bunds on Widdop, however do show a year on year decrease in the cover of *Molinia caerulea* when compared to the control. It is not known why this difference occurs between sites/ bund-types and further research is required to understand the reasons for this difference in performance.
- Currently there has been a limited change in the amount of sediment build up recorded behind the bunds, with a range of between - 5mm to +7mm being seen. The results did show an increase in some bund-types and a decrease in other bund-types, which was unexpected, and the reason for which is unclear.

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Appendix 1: Methodology used to construct bunds

The specification below focuses on peat bunds that are situated on the surface of blanket bog habitats away from fluvial systems, and on areas of deep peat. The peat bunds should be installed on slopes between 1–4 degrees to slow the flow of overland water and improve blanket bog habitat condition. This will improve the storage and cleansing of water supplies; reducing the risk of flooding downstream, sequester and lock up more carbon and creating temporary and long-term standing water and pools which will help the wildlife associated with blanket bog habitats. Additionally, this increased wetness will significantly aid resilience against wildfires.

1. With the excavator located on the downhill side of the bund, remove a vegetation turf from the area where the peat bund will be constructed and place to one side. This should include enough peat to ensure that the roots remain intact.
2. The vegetation from the area where the peat will be excavated from, should then be removed on the upstream side of the bund as specified in step 1.
3. Excavate the peat from the appropriate area, this area of excavation will eventually form a trench on the upstream side of the bund as you work along the bund. Place the excavated peat on the line of the bund, and then push the excavator bucket down on top of the excavated peat to compact the bunds to a height of approximately 300mm (with the peat eventually settling to around 200mm). Pressing down with the excavator bucket will help stop water seeping through the bund by compacting the peat.
4. **It is critical** to ensure that a consistent elevation is achieved across the top of each constructed feature. The **key reasons** for this are:
    a. To ensure the maximum amount of water is retained behind the bund without unnecessary excavations taking place.
    b. Additional bunding above the waterline increasing time and cost of capital works.
    c. The peat itself is a protected feature of these (often SSSI) sites and only those excavations necessary to deliver multiple benefits – including slowing the flow, carbon retention, biodiversity benefits and increase water table height – are justifiable.
5. The lip of the trench should then be pushed down with the excavator bucket to create a shallower gradient within the bund.
6. Place the excavated turf back on the top and downstream sides of the bund to avoid erosion and oxidation of peat. The vegetation turves can be teased out and stretched to increase coverage across the bund if required.
7. Place the turf back on the area of excavated peat.
8. Continue along the line of the bund using steps 2 to 7 until you reach the end. The end of the bund should be far enough back to stop water escaping out the side of the bunds.
9. At the ends of each bund, it may be necessary to create a small section of bunding up-slope to ensure containment of the water. In order to do this an additional "borrow pit" may be necessary to source additional wet "putty-like peat".

a. Additional borrow pits could also be used for the join into another bund (Fish-scale) or to allow additional material to be used to re-enforce the end of the bund.
b. If a further borrow pit is required it should be located within the pool area behind the bund (see figure 2).
c. The vegetation surrounding any borrow pits should be stretched back over the top to reduce erosion and any visual impacts.

10. The completed bund should be a raised feature with gentle slopes on the upstream pool side of the bund to allow vegetation to establish. The pool should have a depth of approximately 400–1000mm (see figure 2 below).
11. When the bunds reach capacity, it is expected that the water will overtop the bunds along their full length (without distinct isolated spillways, which cause erosion), and disperse across the moor.
12. The excavator is expected to start at the furthest point of the area where the bunds are being installed and work methodically back towards the access point using the procedure outlined above.

Figure 1: Bund specification in profile

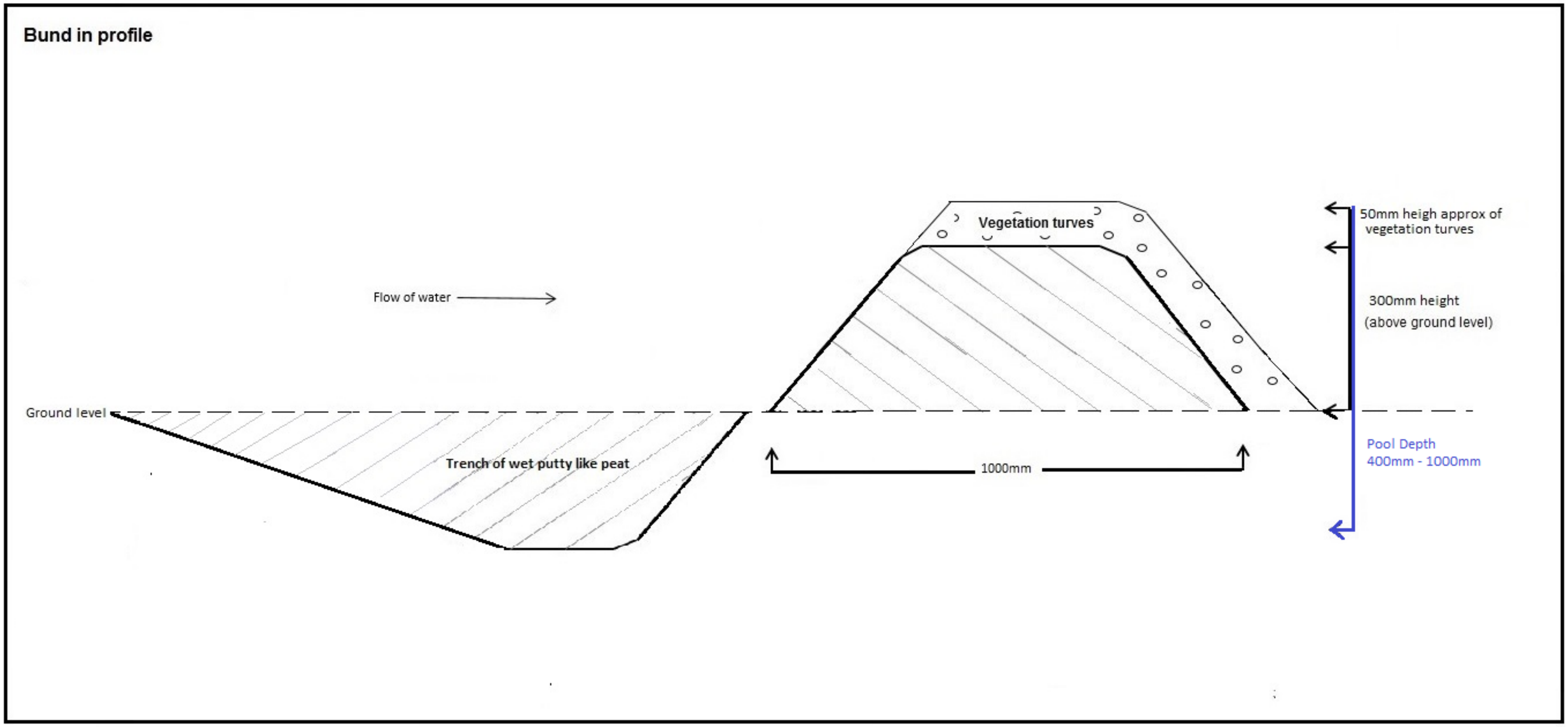
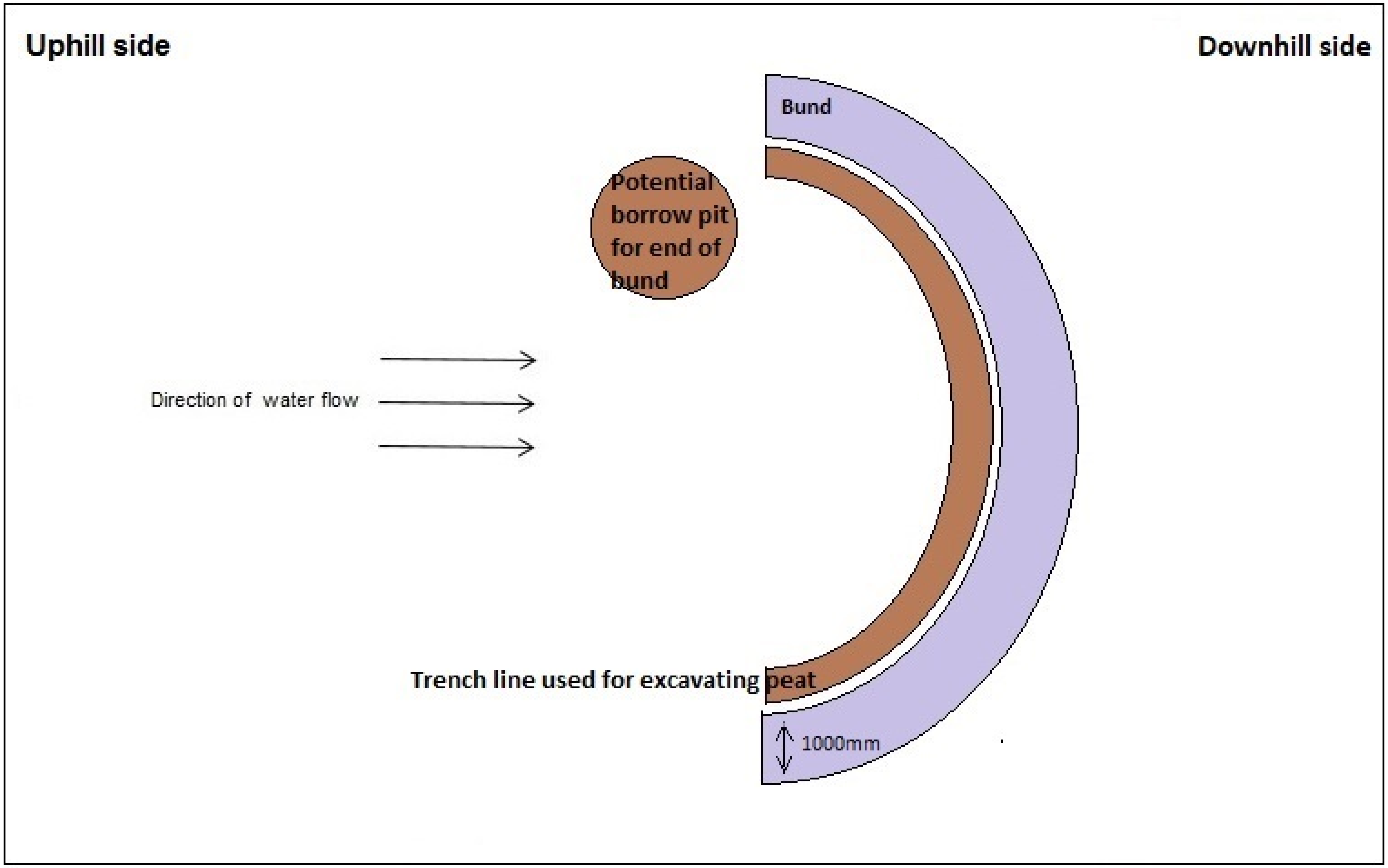


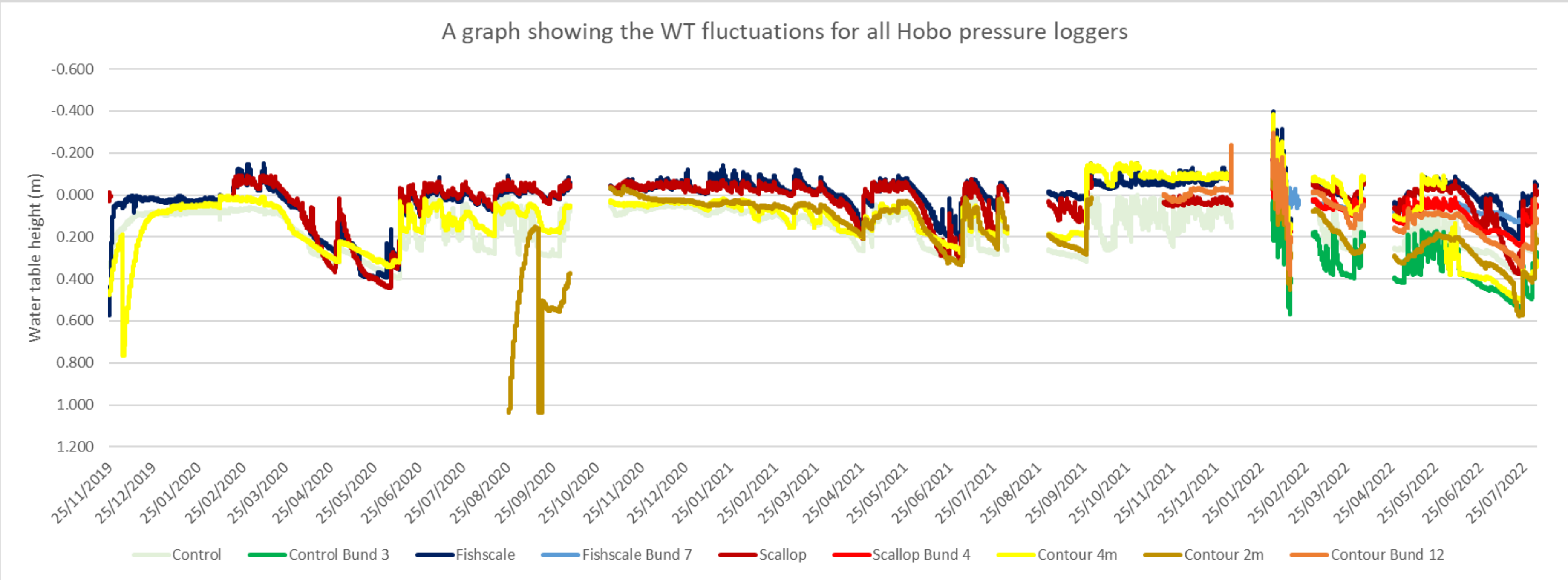
Figure 2: Bund specification in Overview



Appendix 2: Accuracy checking of water table data

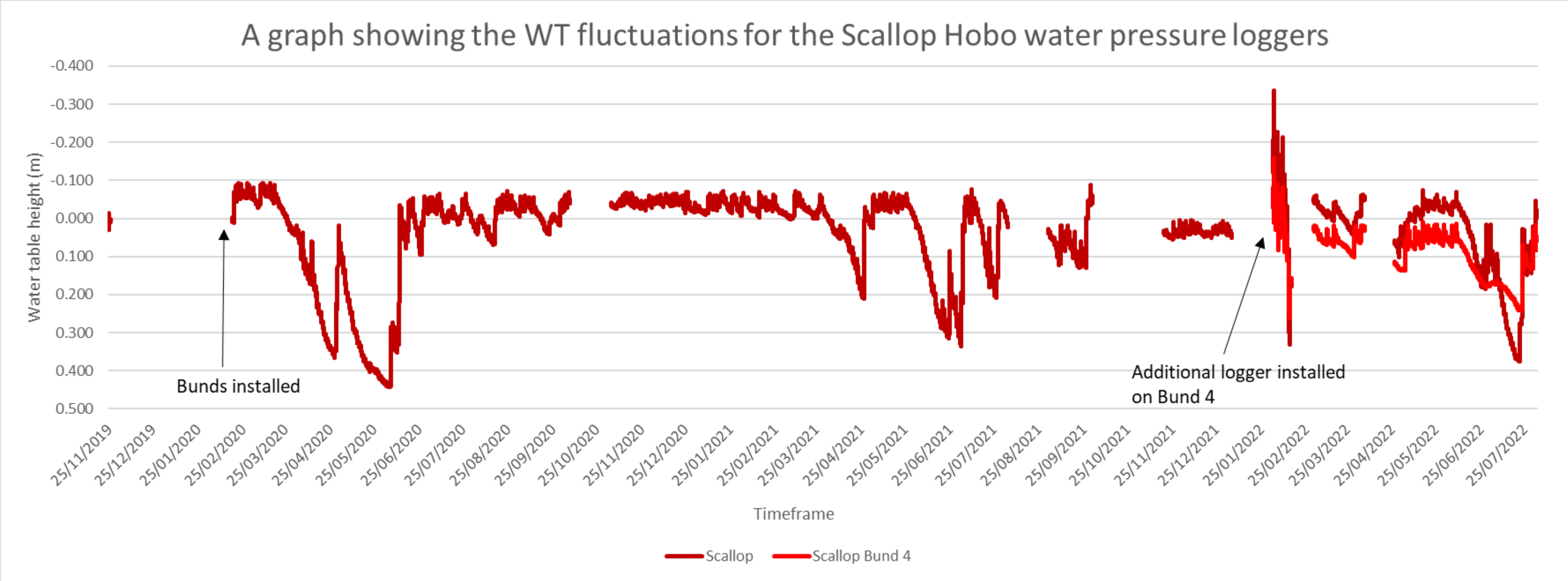
As the trial was not replicated across sites, additional water table loggers were installed on the different bund-types to check that the WT data was accurate. The data analyses in this appendix sets out which WT data is accurate and which is not.

The continuous water table data for all bund-types is presented in Graph 8 below. The data shows that the WT for the fish-scale and scallop bunds have similar water table heights across the whole time series. On average the fish-scale bunds have recorded a higher WT than the scallop bunds by 0.001m (1mm). The contour bunds and control plots on average have a slightly lower WT than those in the fish-scale and scallop bunds with the control plots having the lowest recorded WT level on average for the whole time series.

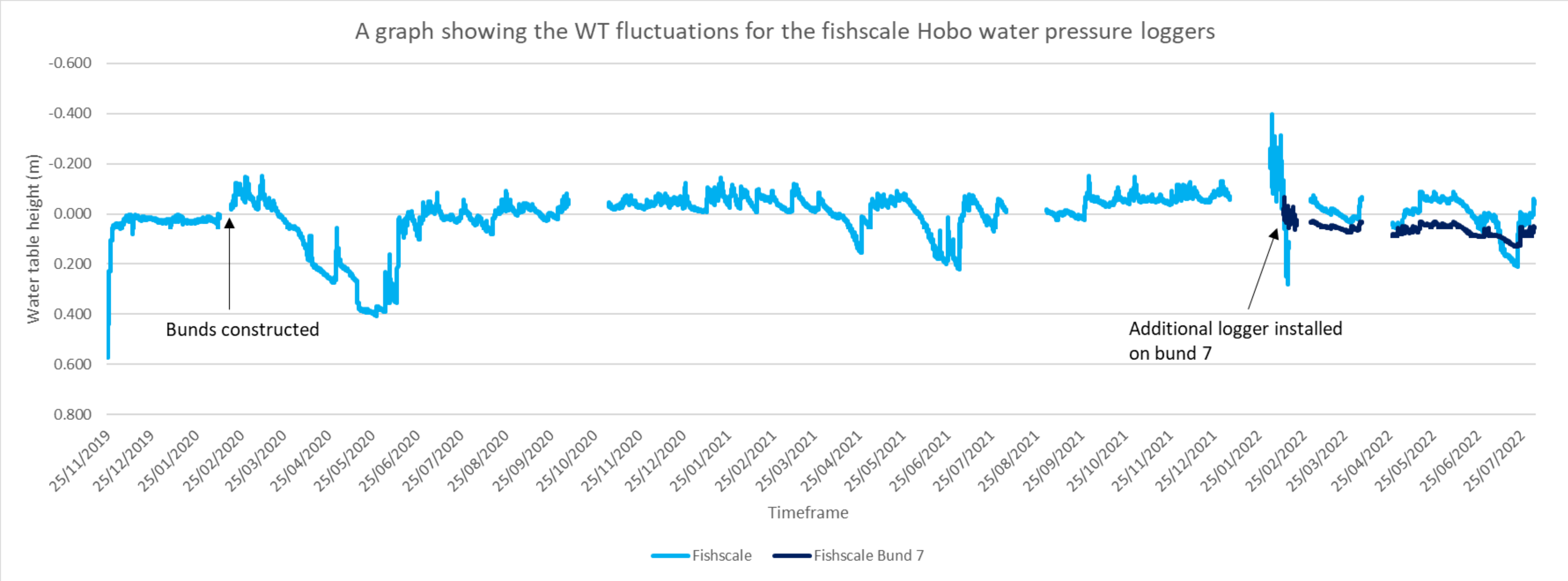


Graph 8: Changes in water table heights for all bunds types and control from 25 November 2019 to 3 August 2022

Comparison of the WT results for the scallop bund-type – Graph 9 – and fish-scale bund-type – Graph 10 – identified that there is minimal difference between the results recorded by the different WT loggers within each bund-type. The scallop bunds on average showed a 0.003m (3mm) difference between the original logger and the additional logger installed on bund 4. Whereas the fish-scale bunds exhibited a 0.004m (4mm) difference in WT height between the two automated loggers.

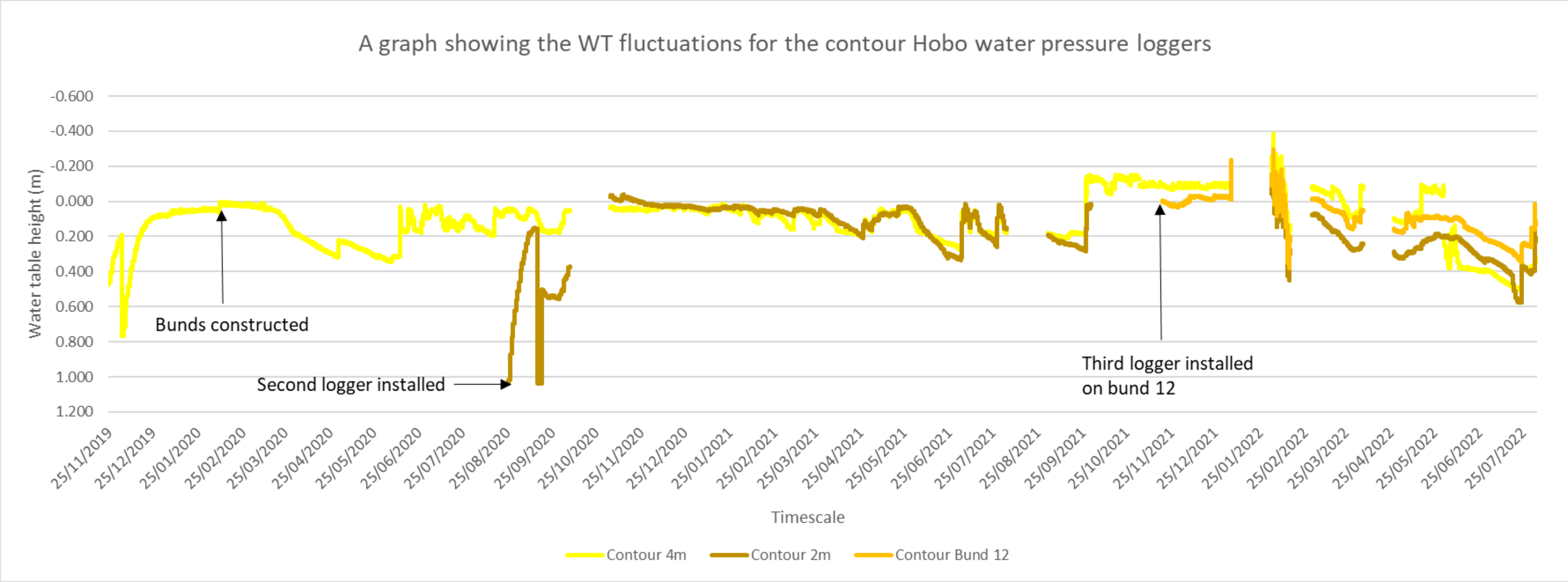


Graph 9 : Changes in water table heights for scallop bunds from 25 November 2019 to 3 August 2022



Graph 10 : Changes in water table heights for fish-scale bunds from 25 November 2019 to 3 August 2022

When comparing the WT height for the contour bunds – Graph 11 – the second logger installed exhibited only a 0.001m (1mm) difference between its readings and those of the third logger installed on bund 12, whereas on average there was a 0.007m (7mm) difference in readings between the original logger and the second logger installed. This suggest that there was an issue with the original logger, and that this did not accurately reflect the WT for the contour bunds. Therefore any further analysis will focus on data from the second and third loggers installed on this bund-type.



Graph 11 : Changes in water table heights for contour bunds from 25 November 2019 to 3 August 2022

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