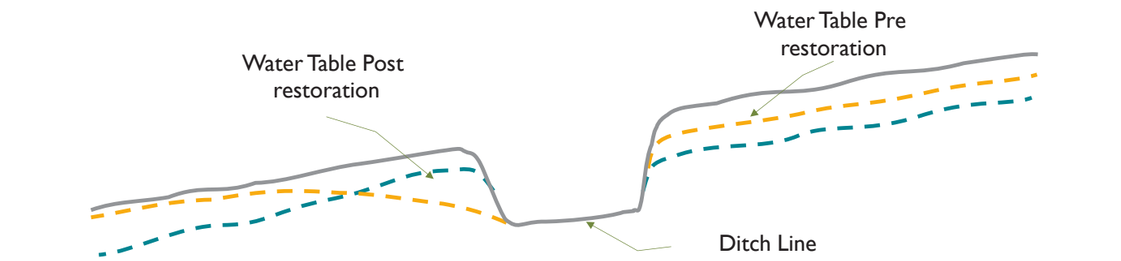
How does the restoration of a shallow peatland affect water tables, runoff and water storage?

- Restoration can significantly alter rainfall runoff regimes in restored catchments.
- Peak runoff from comparable rainfall events can be reduced by as much as 21 %.
- Total runoff generated from comparable rainfall events can be reduced by as much as 32 %, as water leaves the restored catchment more slowly, increasing catchment baseflow between rainfall events.
- Rainfall runoff response is catchment specific, smaller rainfall events can result in a limited increase in storm runoff.
- In the short term (<5 years post-restoration) average water tables remain at similar levels post-restoration.
- Water table responses to restoration are spatially complex and in locations where drainage had most significantly altered ground water storage, water tables are seen to rise by as much as 4 cm.

In an intact state, peatland landscapes form as wetlands with water at or near the ground surface for most of the year. These areas are home to specialist plant species adapted to grow in waterlogged ecosystems. The storage and release of water from such landscapes is inherently linked to the way the ecosystem functions as a store of carbon and regulator of river flow. Peatland restoration aims to re-establish more natural hydrological processes in historically drained and damaged peatlands. Across two restored headwater catchments (Aclands and Spooners) discharge was estimated in the main channel leaving the catchment. Additionally, water tables were monitored within and surrounding several drainage features using a network of dipwells extending to the bottom of the peat soil (Figure 12). Water tables are measured as depth to water down from the ground surface.



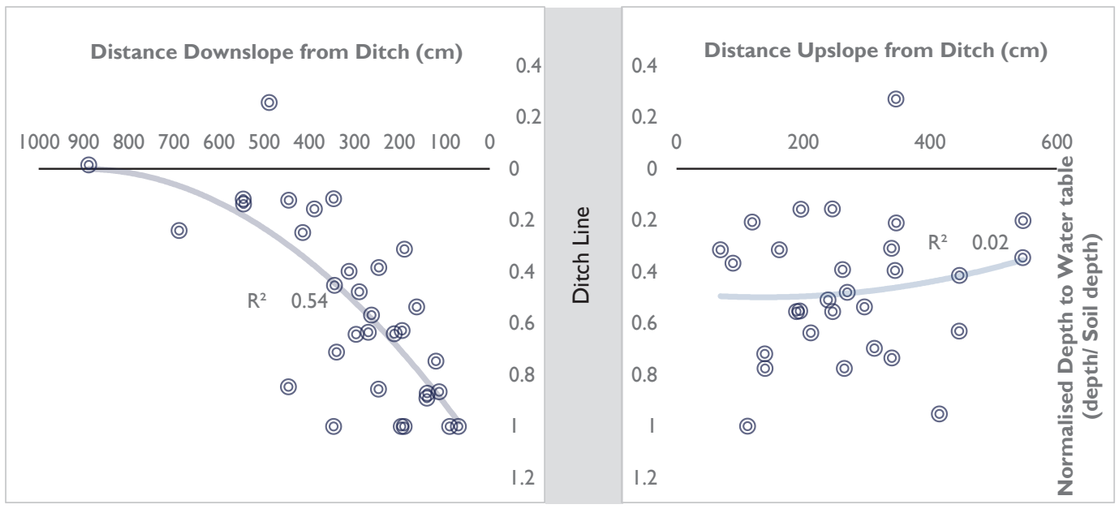


Figure 13 Above: conceptual diagram of water table response to restoration within Spooners catchment. Below: Average water table depth plotted for all monitored dipwells surrounding ditches in the Spooners catchment pre-restoration.

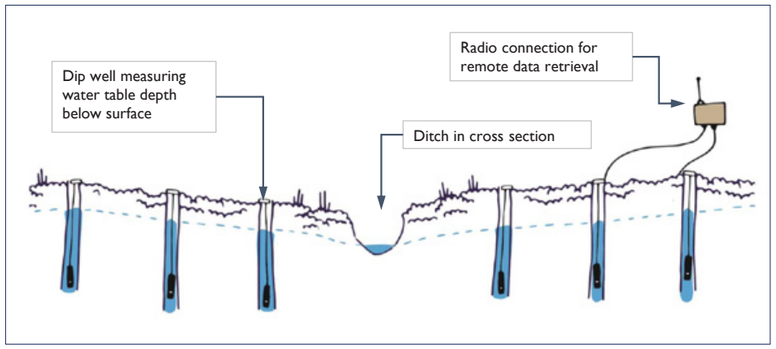


Figure 12 Illustration of a dipwell array surrounding a restored drainage ditch in Spooners catchment.

Water Table Depth

The response of water table depth to restoration is spatially and temporally complex, particularly as drainage features often cut across-slope (Figure 13). Pre-restoration, water tables are seen to be lower on the downslope side of drainage features, decreasing with proximity to drains (Figure 13 and 14). Upslope of cross-slope drainage, water tables do not vary with distance to the drain and are persistently below the soil surface[1].

Post-restoration, changes are observed in water table depths, but these are confounded by significantly reduced rainfall in the years monitored post-restoration, compared to those pre-restoration (Figure 15). Despite this, immediately downslope of drainage features, water tables are seen to increase by an average of 4 cm and become more variable (Table 1, Figure 14) following ditch blocking. However, immediately upslope of drainage features, water tables are seen to be lower (average of ca. 9 cm) illustrating the spatial complexity of the restoration effect. These results suggest restoration has equalised

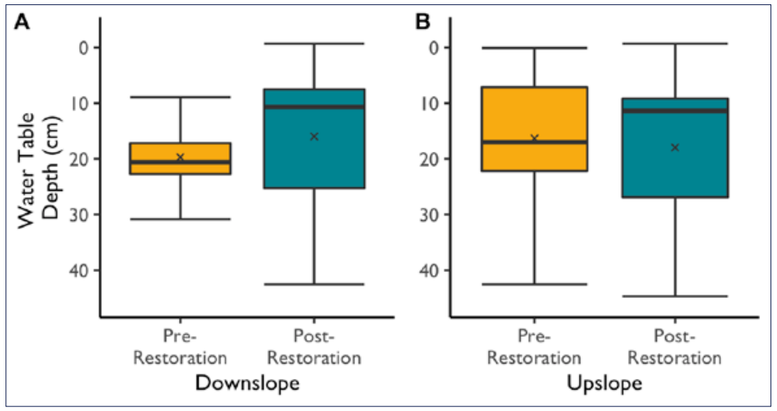


Figure 14 Box and whisker plot of water table depth within 1 m of a drainage ditch, relative to hillslope position, pre- and post- restoration at Spooners. Water tables downslope of drainage ditches are seen to rise by as much as 4 cm.

Table 1: Water table depth from soil surface (WTD) statistics for locations within 1 m of a drainage feature within Spooners catchment.

	Pre-restoration Downslope	Post-restoration Downslope	Pre-restoration Upslope	Post-restoration Upslope
Mean WTD (cm)	19.7	16.0	12.8	20.0
Median WTD (cm)	20.6	11.0	7.2	12.0
Standard Deviation	4.7	12.0	10.9	13.3
Range (cm)	42.4	43.2	40.5	41.4
Minimum (cm)	0.1	-0.7	0.3	3.3
Maximum (cm)	42.5	42.5	40.7	44.7
Number of measurements	71333	176336	69149	175027

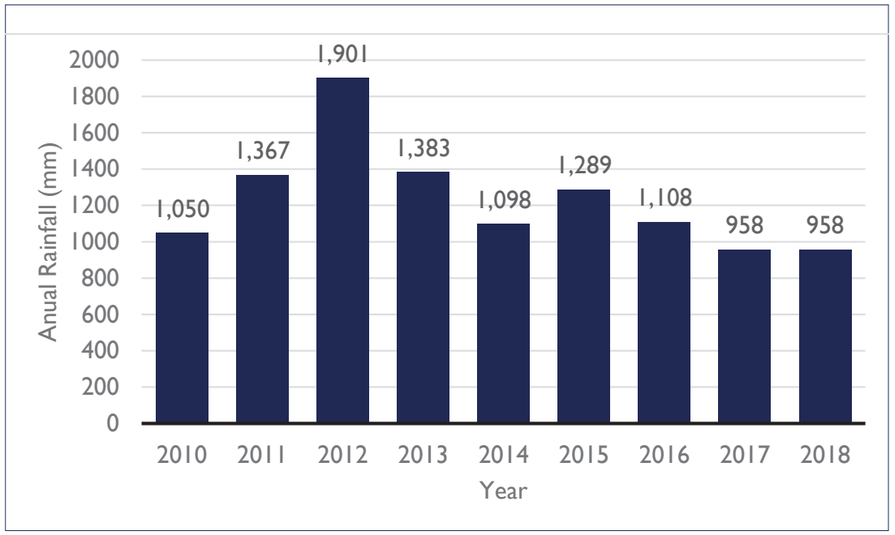


Figure 15 **Annual rainfall totals for Spooners catchment from 2010 to 2018; restoration occurred in 2013. The atypical pre-restoration rainfall of 2012 is notable at nearly double that of 2017.**

Restoration in progress at Spooners.

water table drawdown in the areas immediately adjacent to drains, and whilst water tables remain predominantly below the surface, drainage features may export less water from the soil.

Spooners Catchment Runoff

Runoff production within the larger Spooners catchment was significantly altered by restoration. Rainfall/runoff events with comparable contributing rainfall, had significantly less total discharge (Figure 16 and 17) and a lower peak event discharge post-restoration ($p<0.001$).

For smaller rainfall events (<10 mm), total event discharge and peak event discharge were reduced by 32 % and 29 % respectively ($p \leq 0.001$) post-restoration. For larger rainfall runoff events, this effect is less statistically significant ($p=0.002$ and $p=0.036$, for total discharge and peak event discharge respectively), indicating that the reduction in peak and total event discharge is more pronounced for smaller events. Overall, total discharge reduced by an average of 32 % and peak event discharge reduced by an average of 21 %. These results demonstrate that restoration has provided significant short-term buffering of rainfall runoff at Spooners, particularly for small rainfall events that do not overwhelm the temporary surface storage created behind peat dams.

Aclands Catchment Runoff

The restoration response within the smaller catchment (Aclands) was less pronounced. For larger rainfall events (>10 mm), total event quickflow and peak event discharge were not significantly different ($p>0.05$). Contrastingly, for smaller rainfall events (<10 mm), total and peak discharge were significantly higher post-restoration (mean >100 % at $p<0.05$). This indicates catchment rewetting may have caused a small increase in runoff connectivity for smaller rainfall events, post-restoration. However, for larger rainfall events, that are more important for flooding and water treatment, this change does not lead to significantly increased peak or total runoff.

REFERENCES

The appendices are available to view at **www.exeter.ac.uk/creww/research/casestudies/miresproject**

1. Luscombe, D. J., et al. (2016). "How does drainage alter the hydrology of shallow degraded peatlands across multiple spatial scales?" *J. Hydrol* **541**, Part B: 1329-1339.

Monitoring equipment in pools formed behind blocks following restoration.

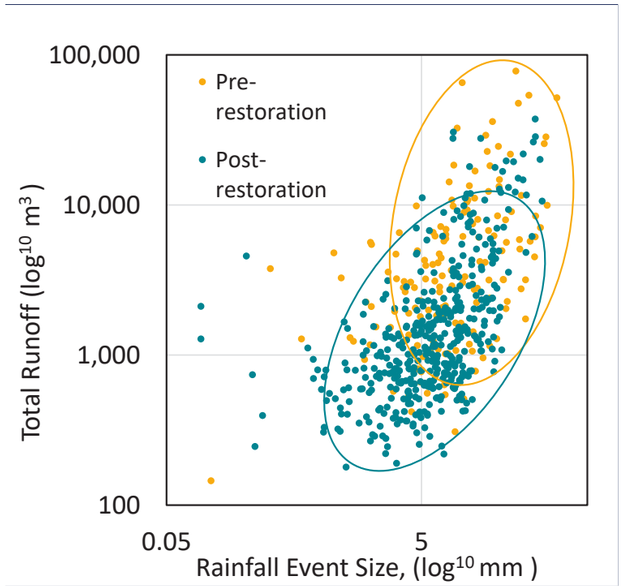


Figure 16 **Total runoff (quickflow) vs total contributing rainfall for individual response events at Spooners catchment, pre- and post-restoration. Coloured ellipses illustrate the broad change in response distributions post-restoration.**

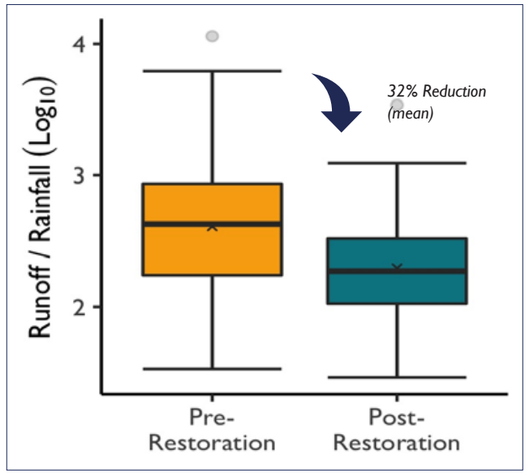


Figure 17 **Box and whisker plot of the ratio of rainfall to runoff response (log_{10} transformed) at Spooners catchment pre- and post-restoration. Runoff is reduced by 32 % (mean) post-restoration.**