Modelling the impact of nature-based solutions on catchment water quality: appendices

Chief Scientist's Group research report

Environment Agency

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Version: SC250008/R2

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This report is the result of research commissioned by the Environment Agency's Chief Scientist's Group.

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Dr Robert Bradburne
Chief Scientist

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Appendix A – ‘Recent past’ percentage change normalised by area maps

Figure 0-1 to Figure 2-14 show the percentage reduction of TP and TN normalised by the area of intervention (Soil and Land Management; SLM, and in-field wetlands).

Both Total Phosphorus (TP) and Total Nitrogen (TN) show more relative benefits in the headwater catchments on the Eden, when accounting for the reductions of nutrients compared to the areas of intervention, which can in part be due to the higher altitude, wetter climatology driving larger excess nutrient loads. However, headwaters do not always produce the biggest overall percentage reductions.

For in-field wetlands in the Thames, the greater benefits by area of intervention are also located on headwater catchments. Conversely in the Thames, the SLM reductions are located on the central band where SLM was implemented with similar patterns for TN and TP found. Generally, of the catchments showing benefits, the headwater catchments are showing greater percentage reductions per area of intervention.

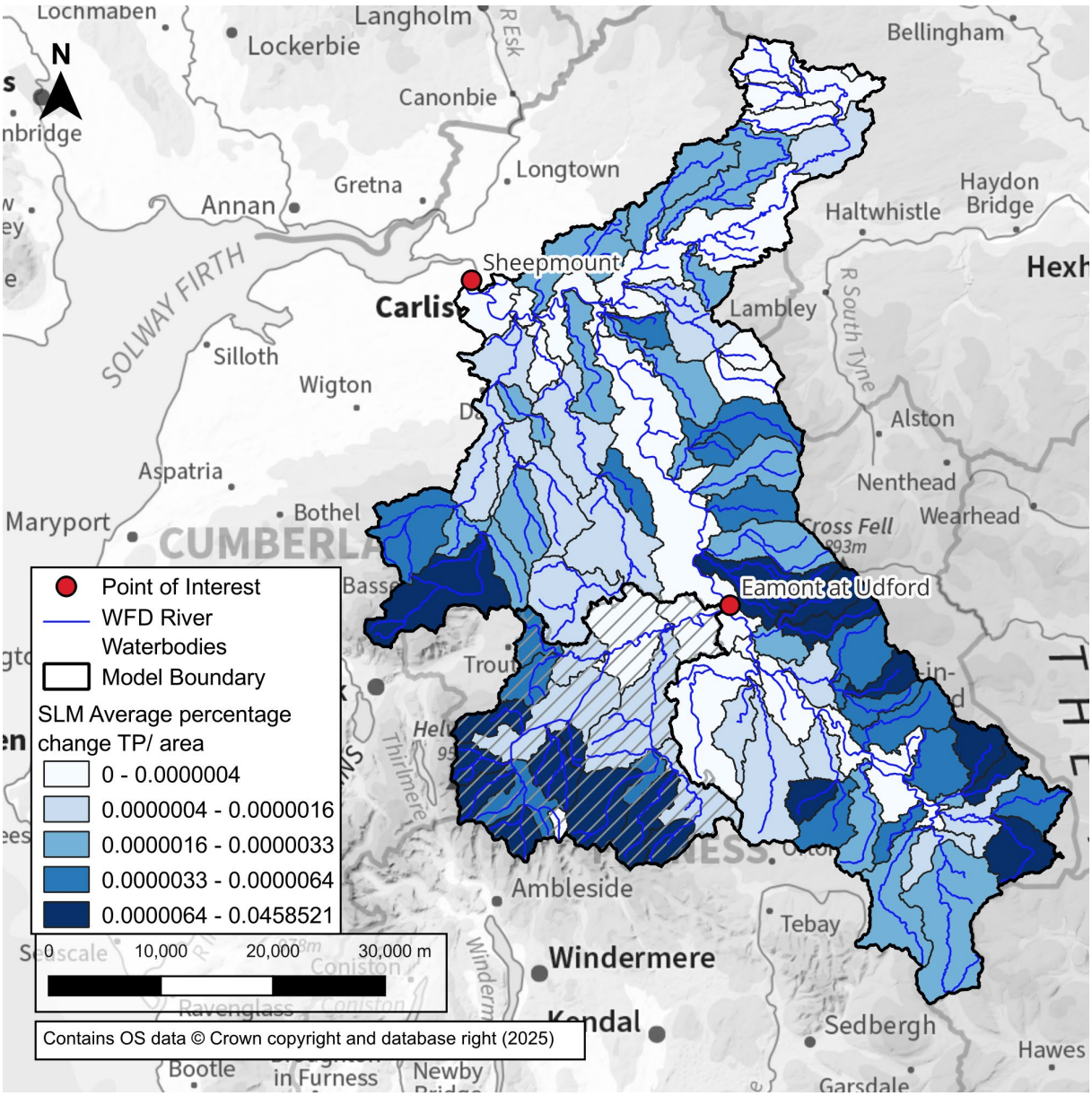


Figure 0-1: Average percentage change of total phosphorus load divided by the area (m^2) of SLM interventions, for the central results. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

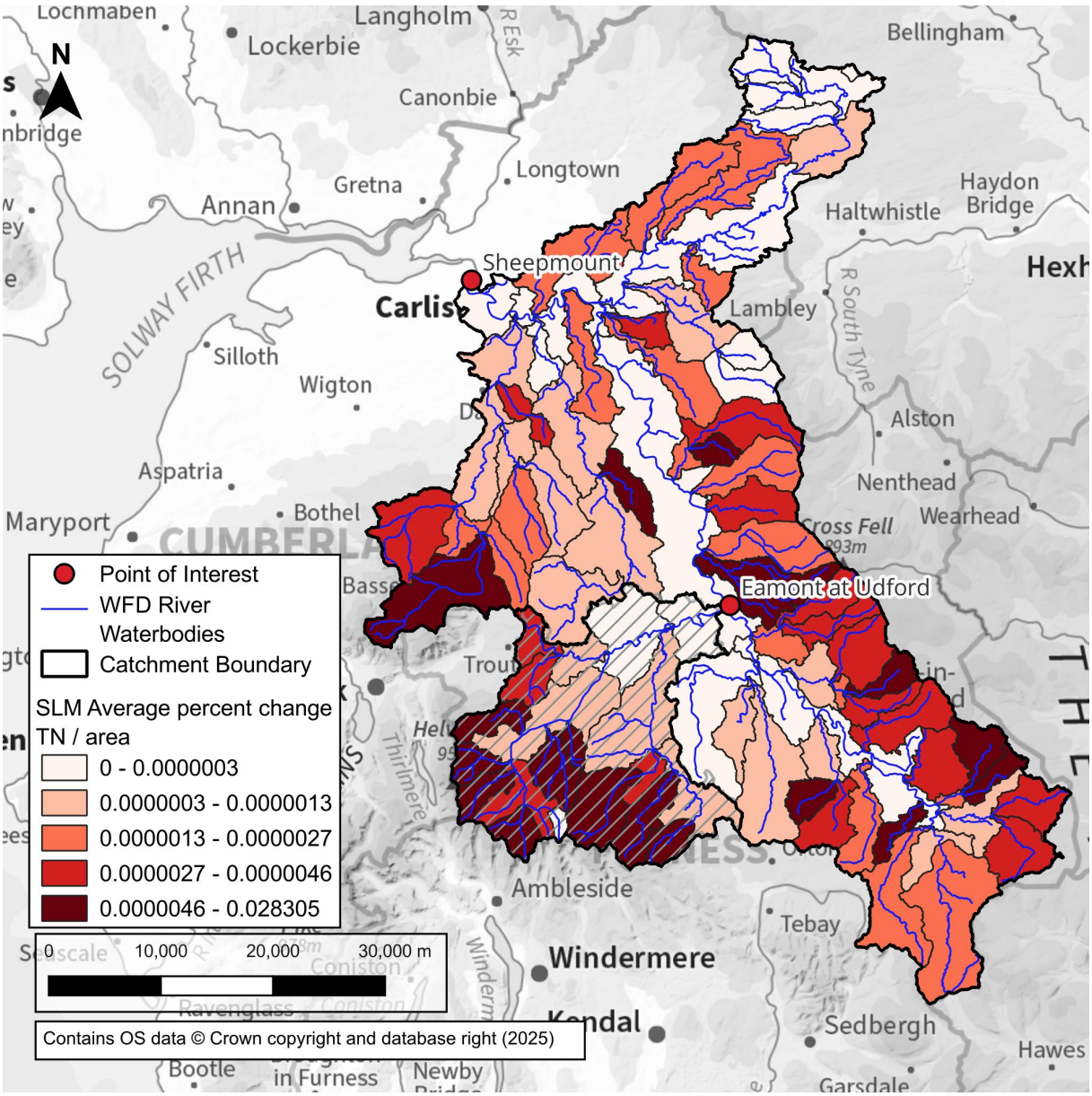


Figure 0-2: Average percentage change of total nitrogen scaled by the area of SLM interventions, for the central results. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

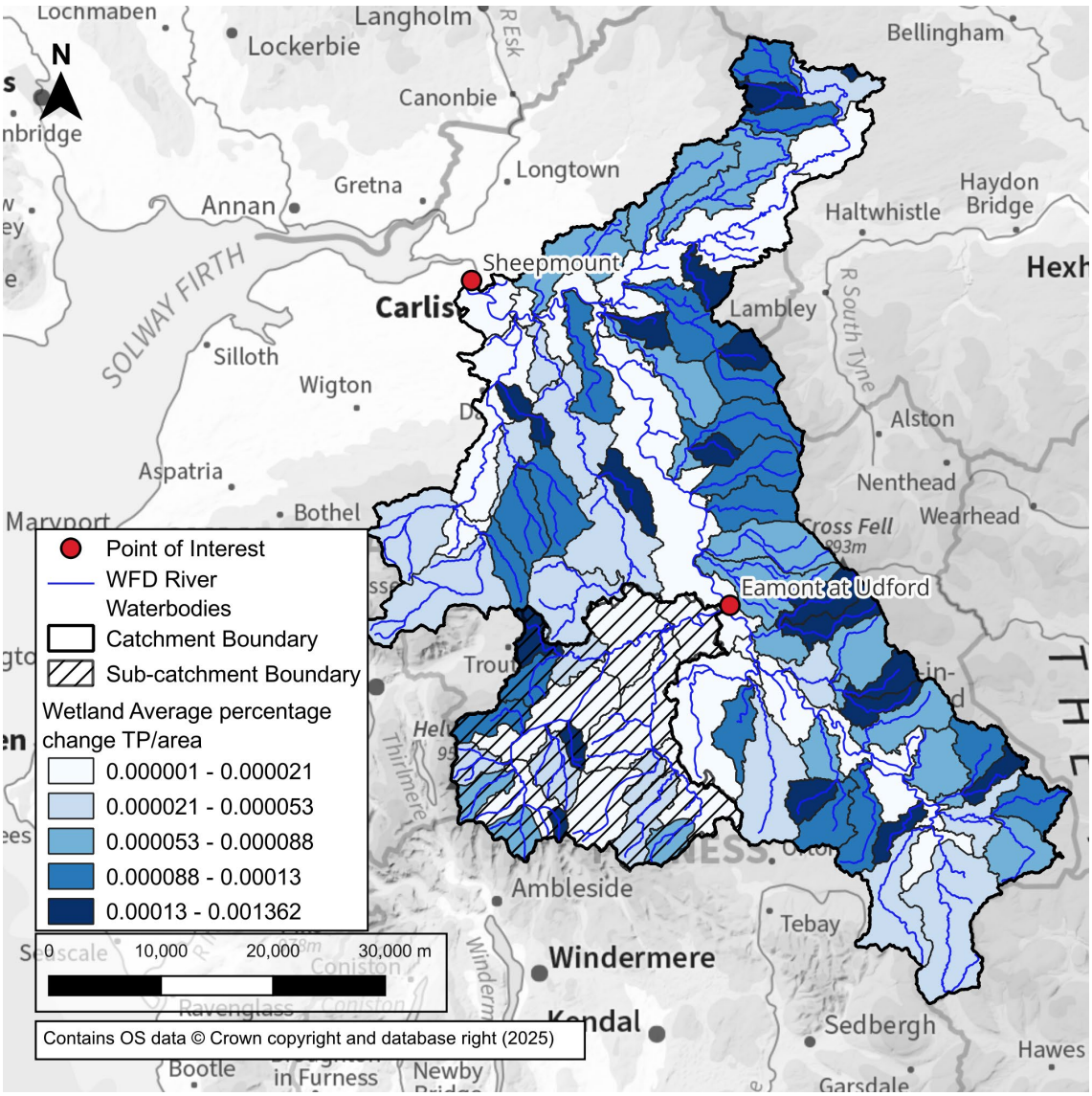


Figure 0-3: Average percentage change of total phosphorus divided by the area of in-field wetlands. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

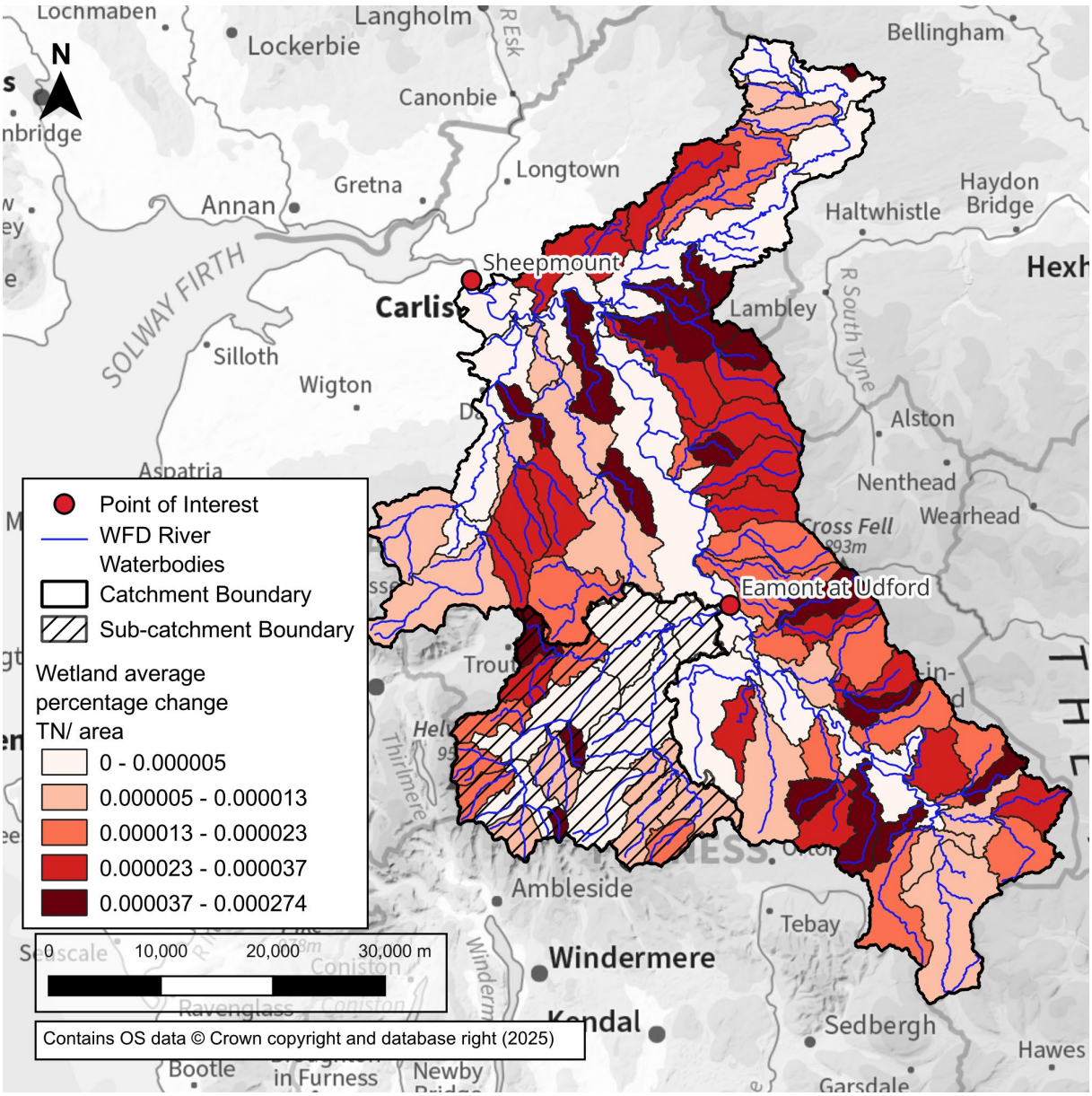


Figure 0-4: Average percentage change of total nitrogen divided by the area of in-field wetlands for the central results. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

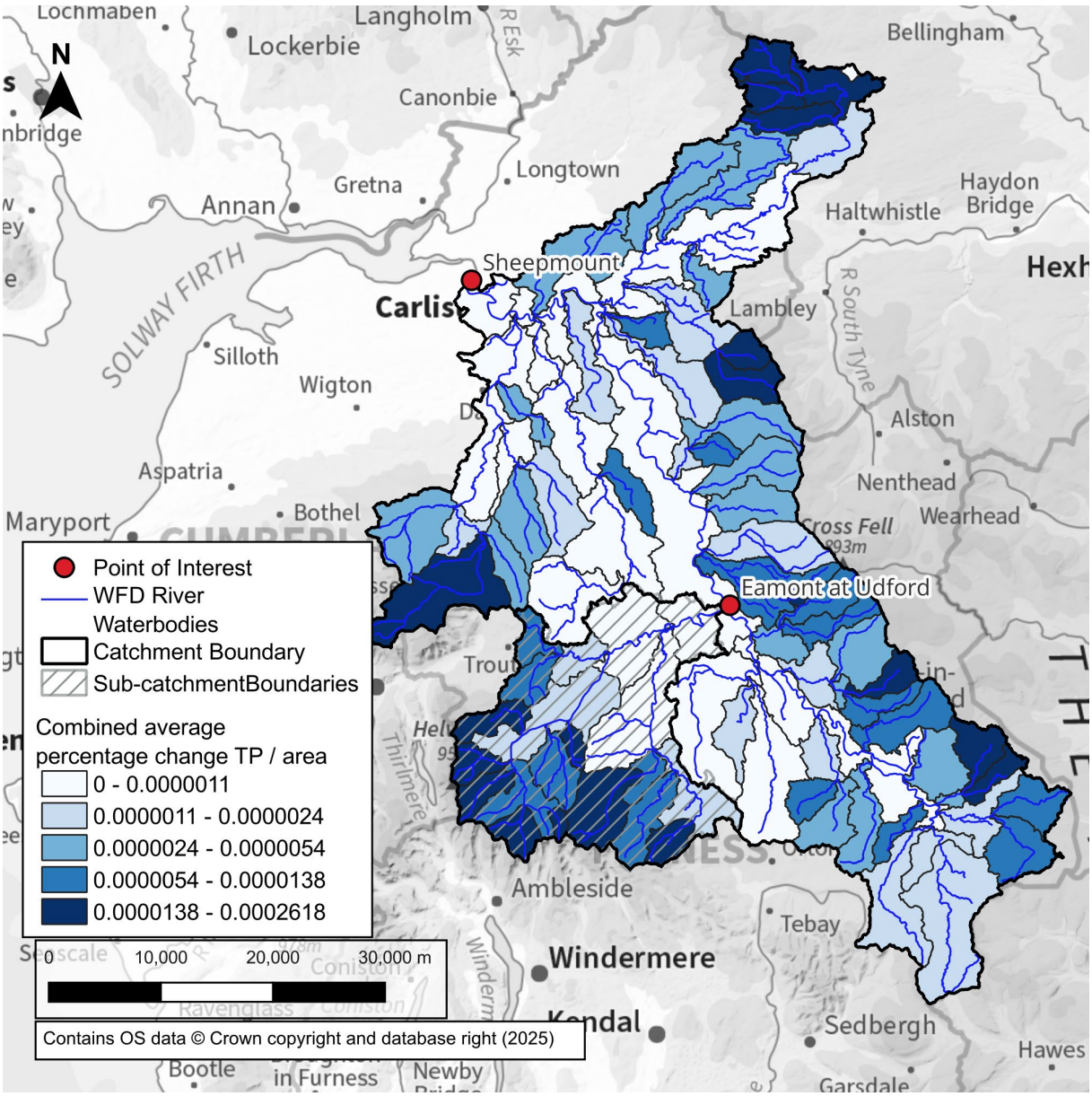


Figure 0-5: Average percentage change of total phosphorus divided by the area of combined scenario. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

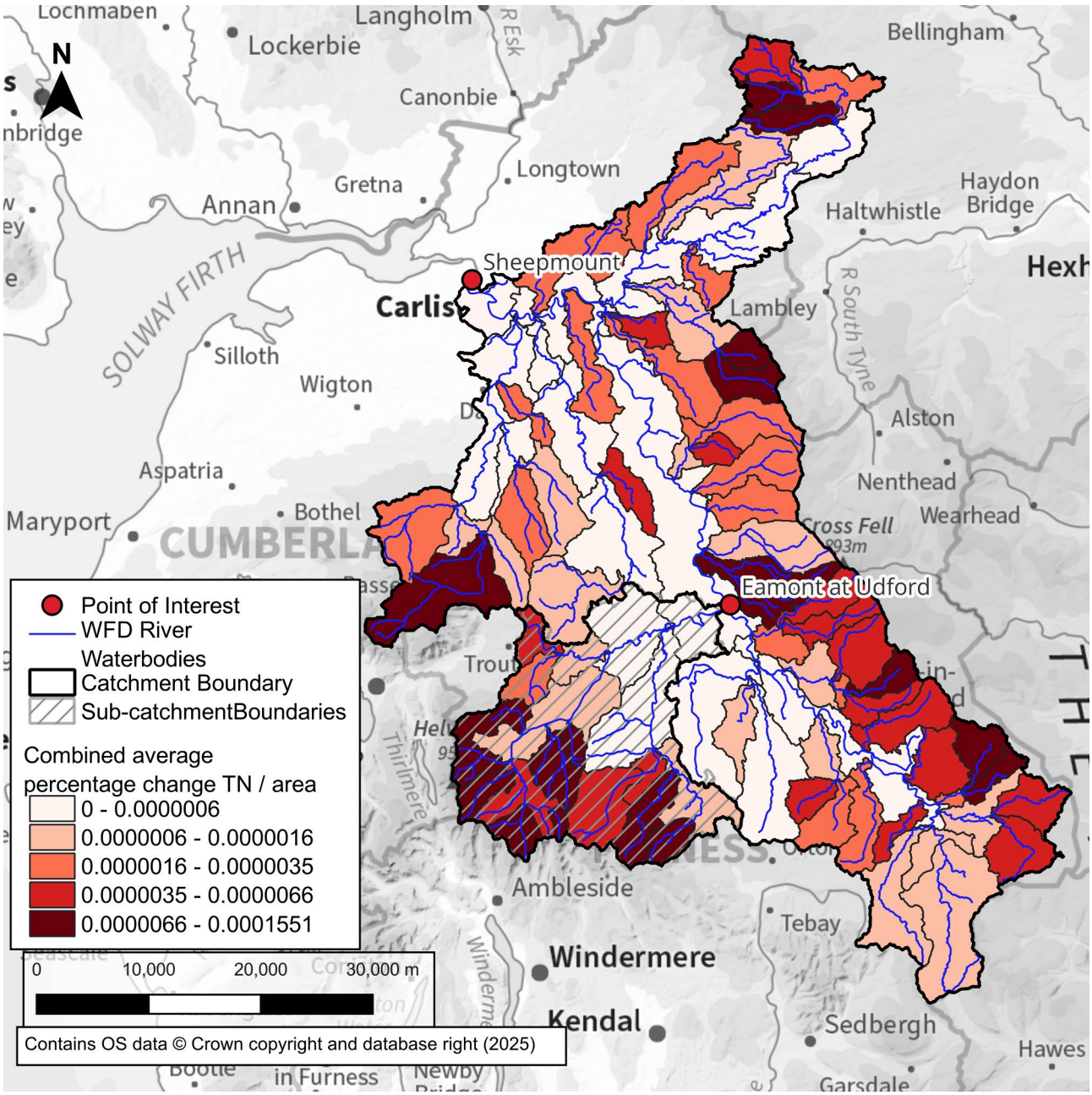


Figure 0-6: Average percentage change of total nitrogen divided by the area of combined scenario. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

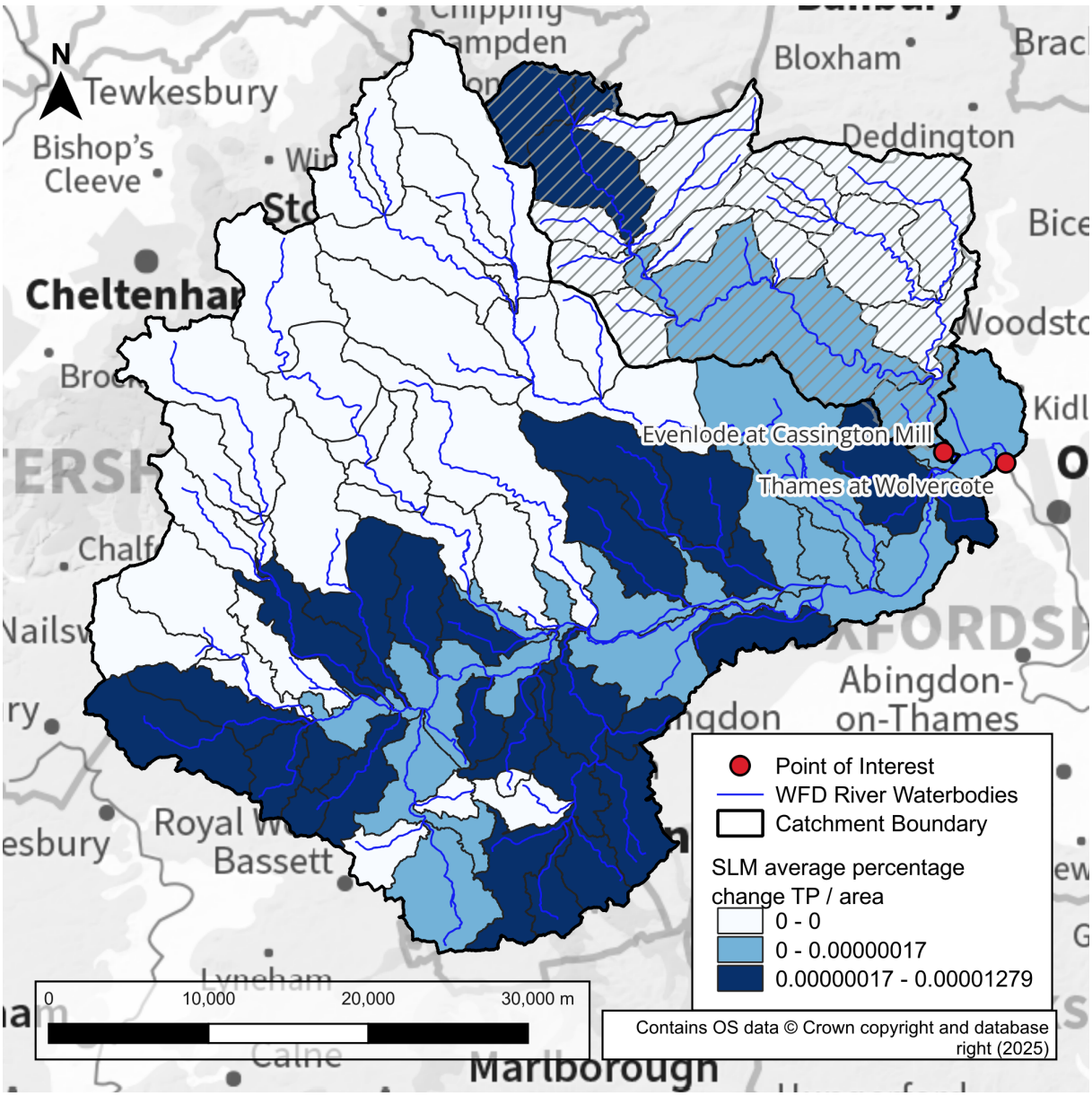


Figure 0-7: Average percentage change of total phosphorus divided by the area of SLM. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

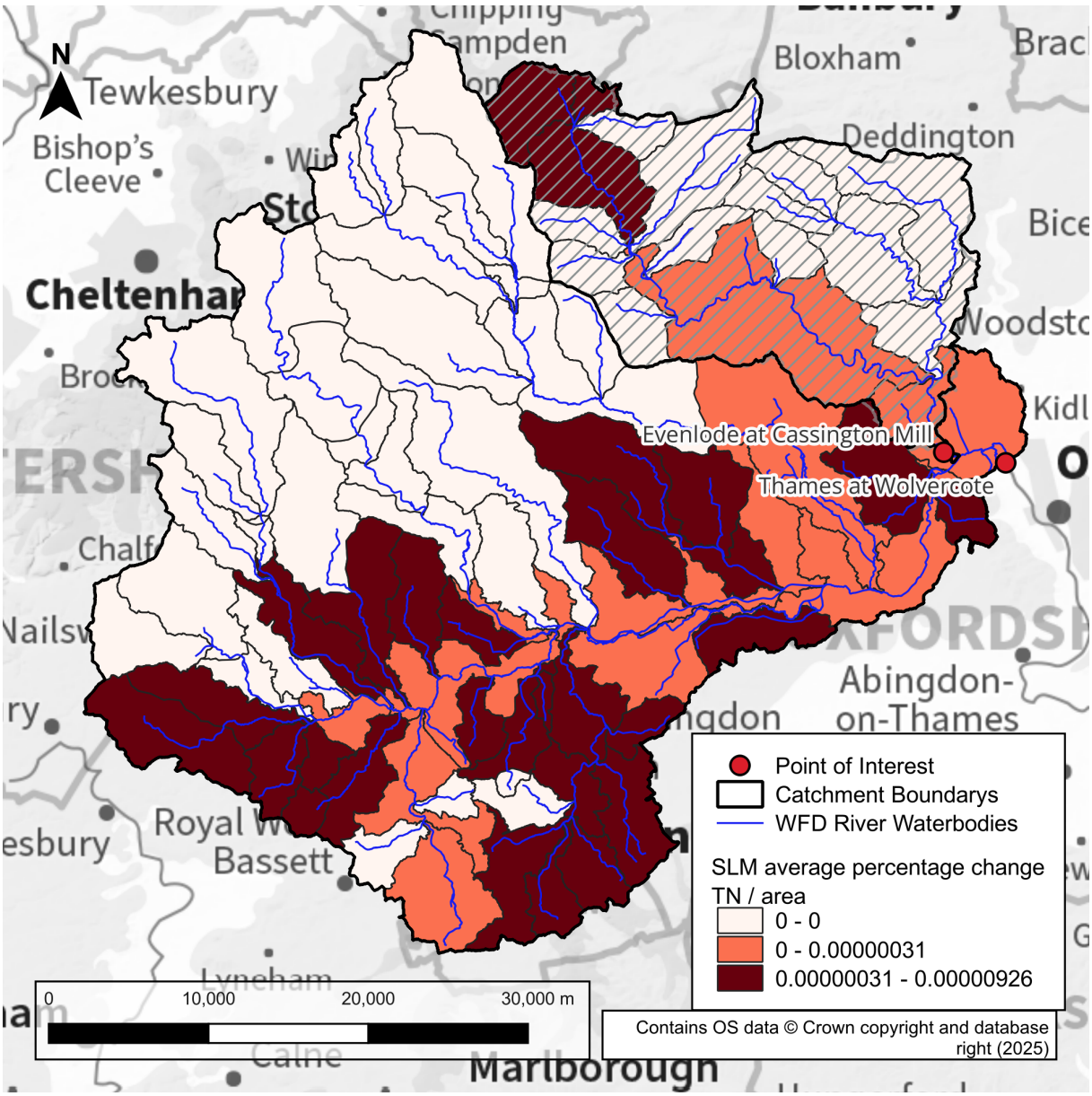


Figure 0-8: Average percentage change of total nitrogen divided by the area of SLM. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

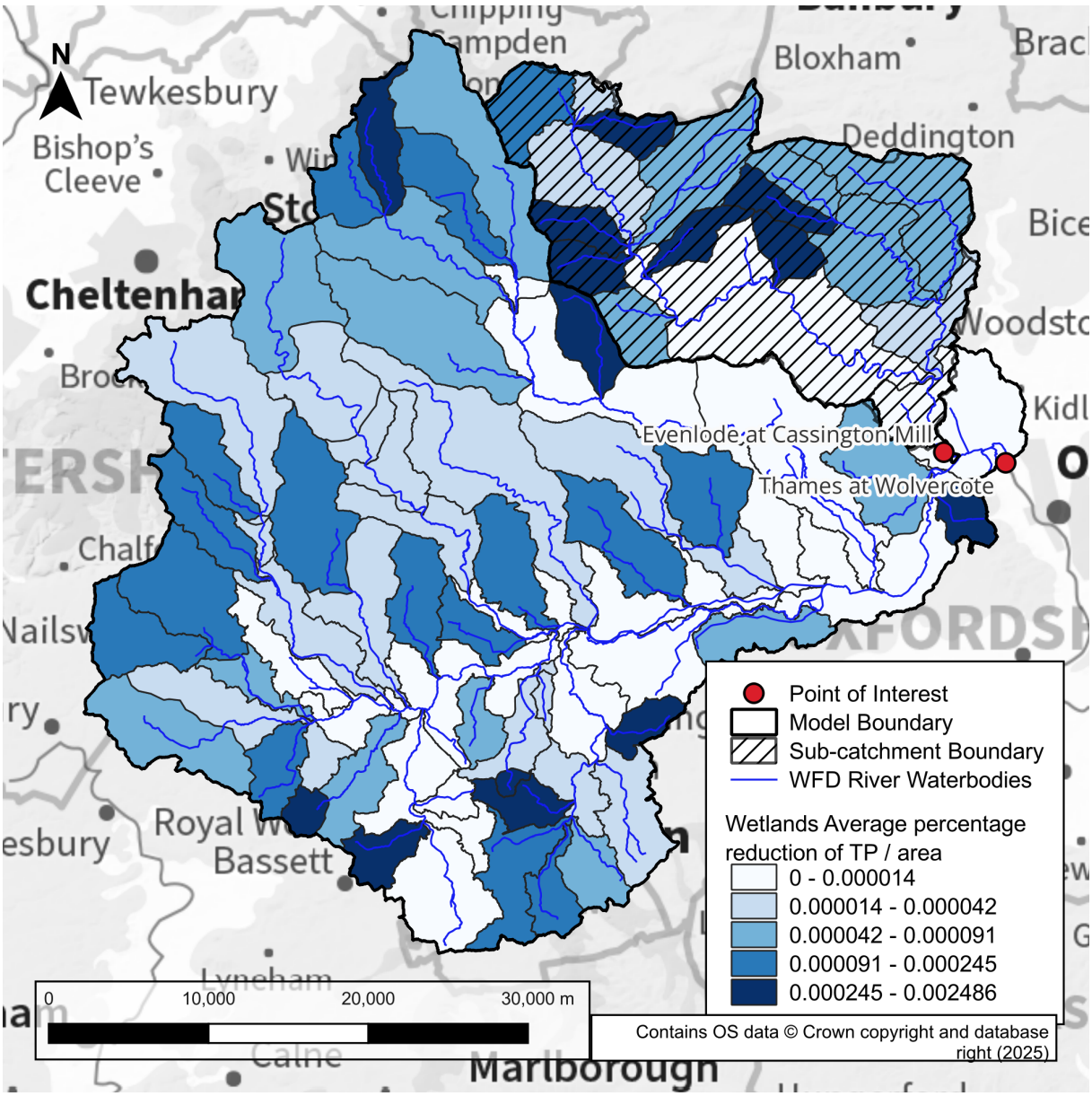


Figure 0-9: Average percentage change of total phosphorus divided by the area of in-field wetlands. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

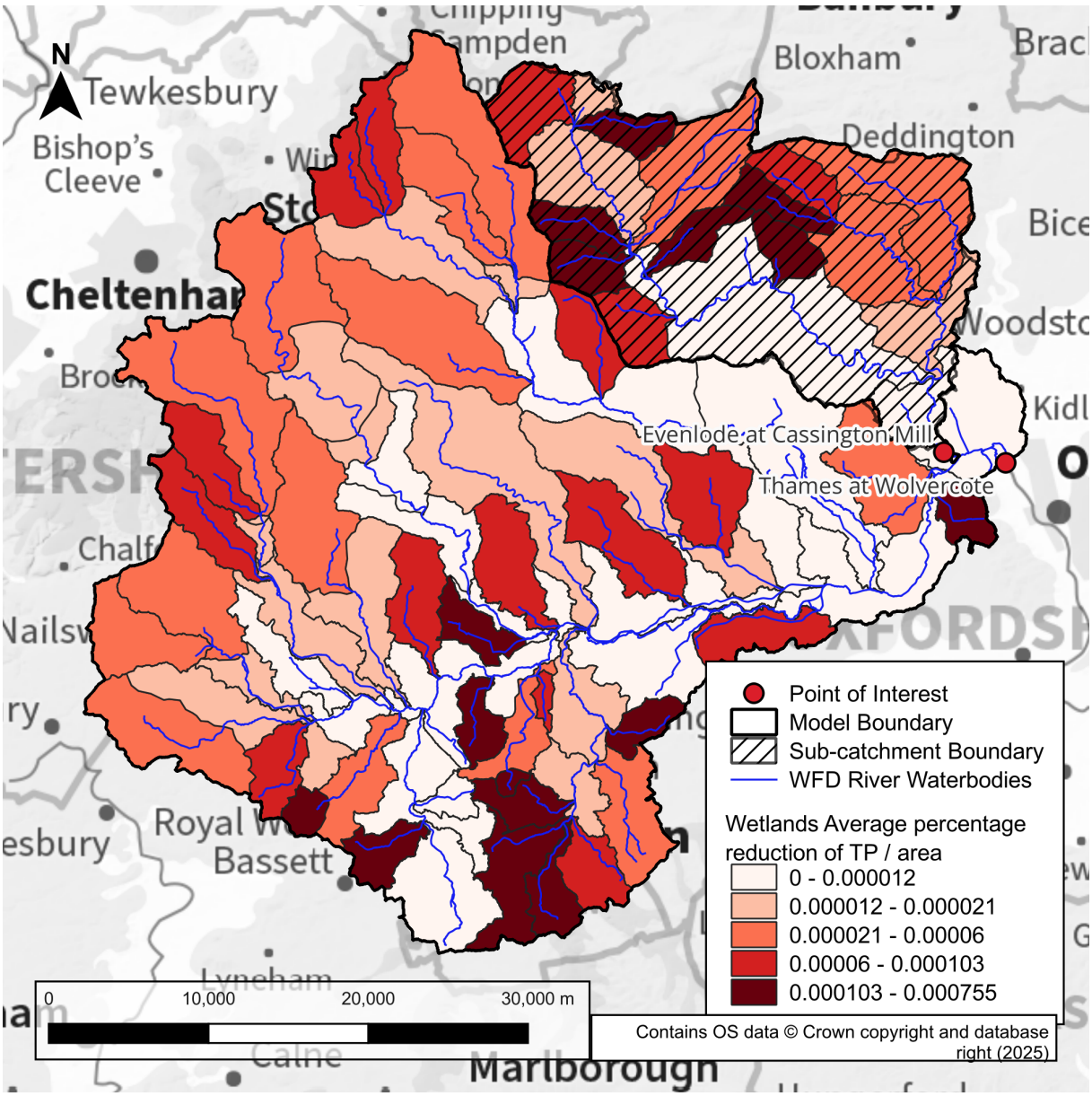


Figure 0-10: Average percentage change of total nitrogen divided by the area of in-field wetlands. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

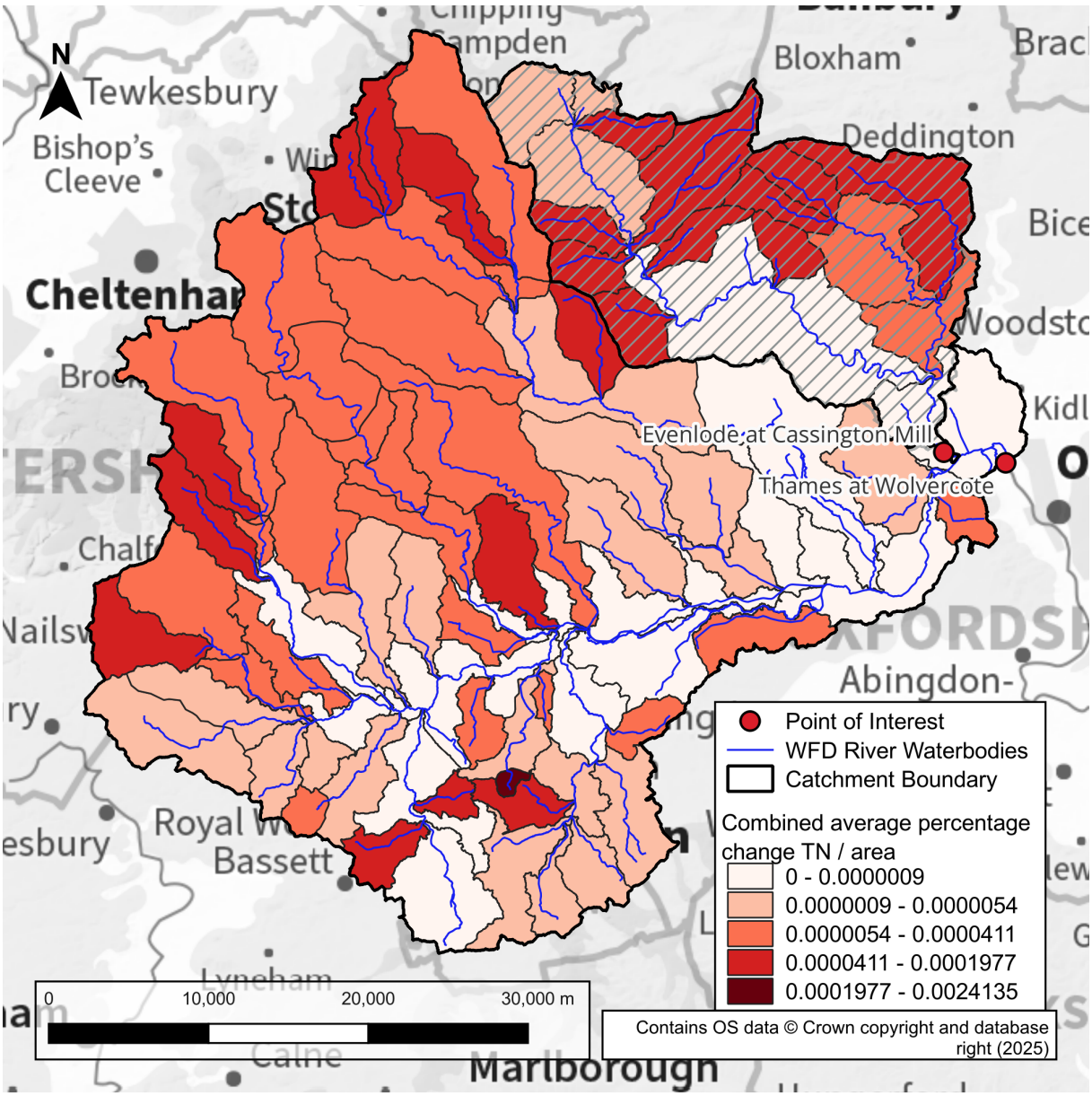


Figure 0-11: Average percentage change of total phosphorus divided by the combined scenarios. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

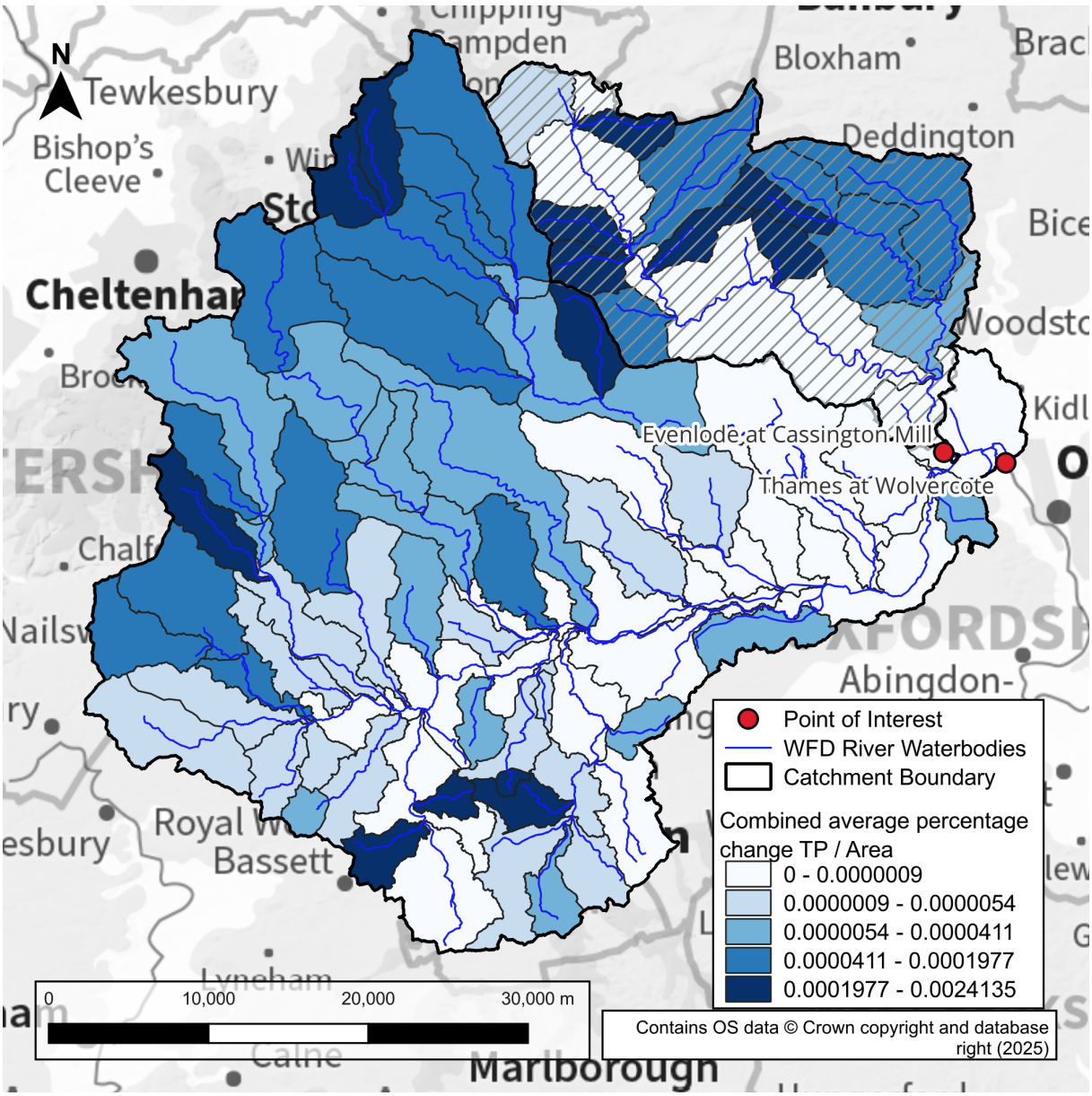


Figure 0-12: Average percentage change of total nitrogen divided by the combined scenarios. Non-headwaters will have the upstream catchment areas and wetland areas included in the calculations.

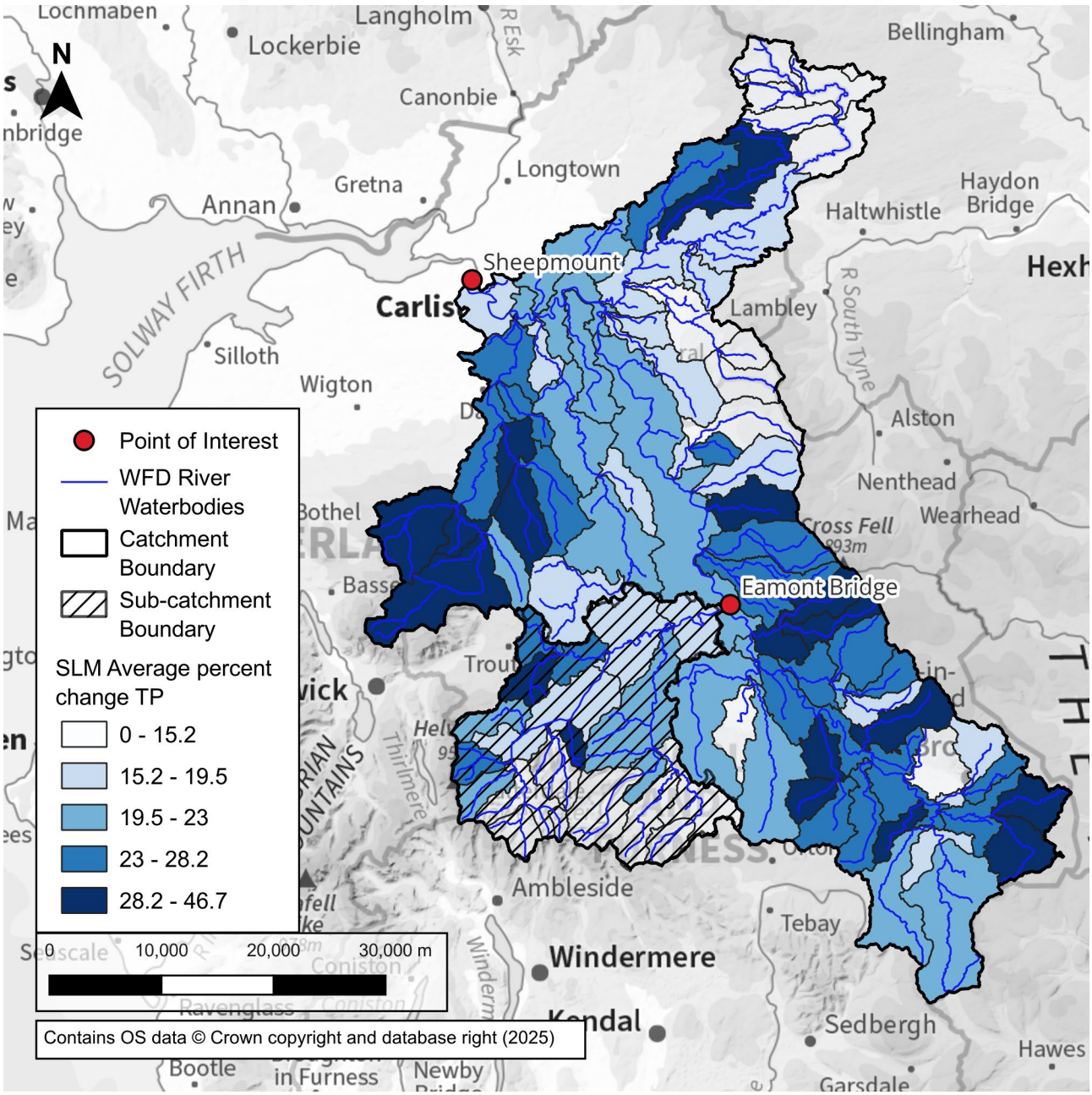


Figure 0-13: Average percentage change of total phosphorus load for SLM interventions, for the central results.

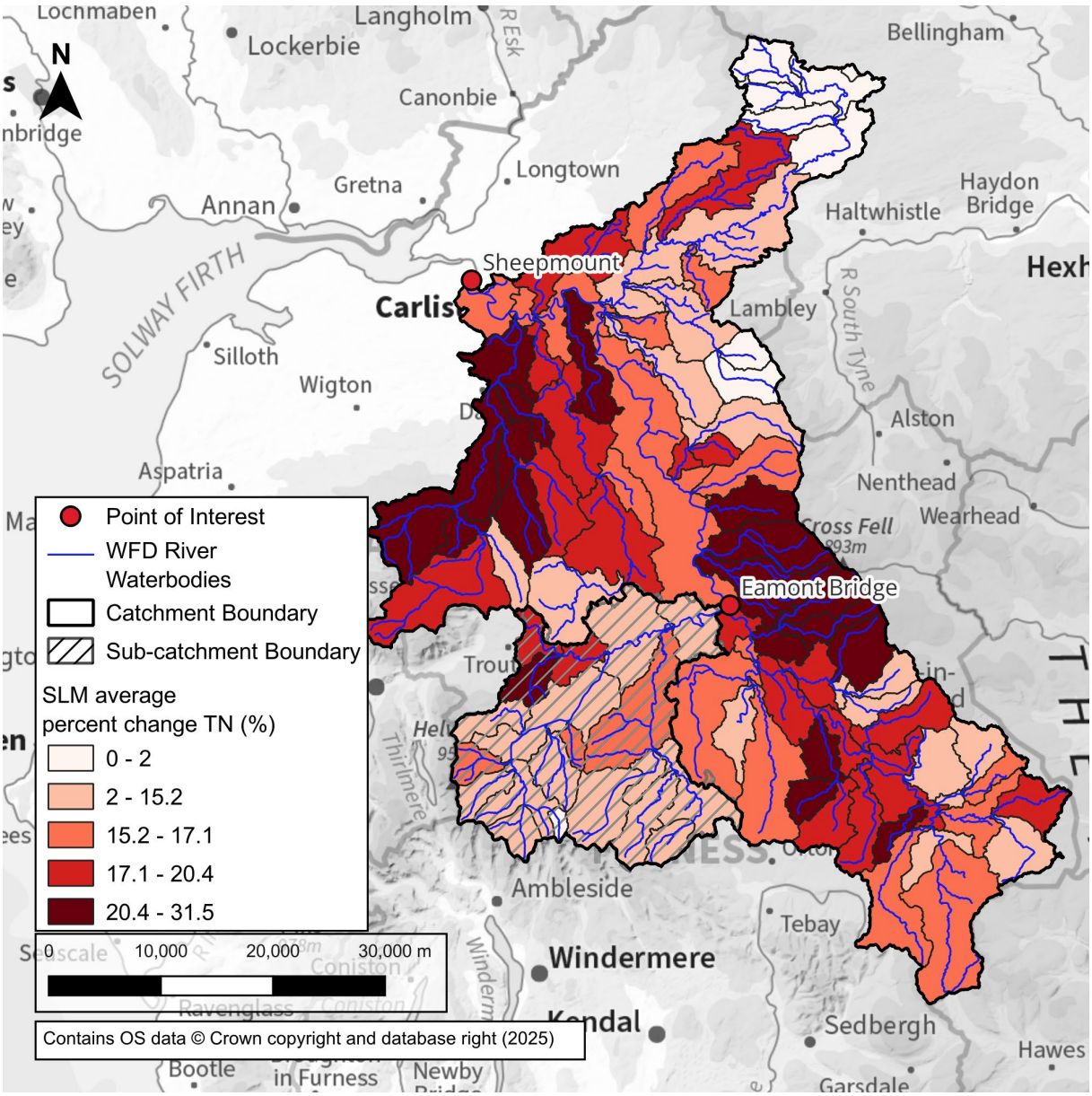


Figure 0-14: Average percentage change of total nitrogen for SLM.

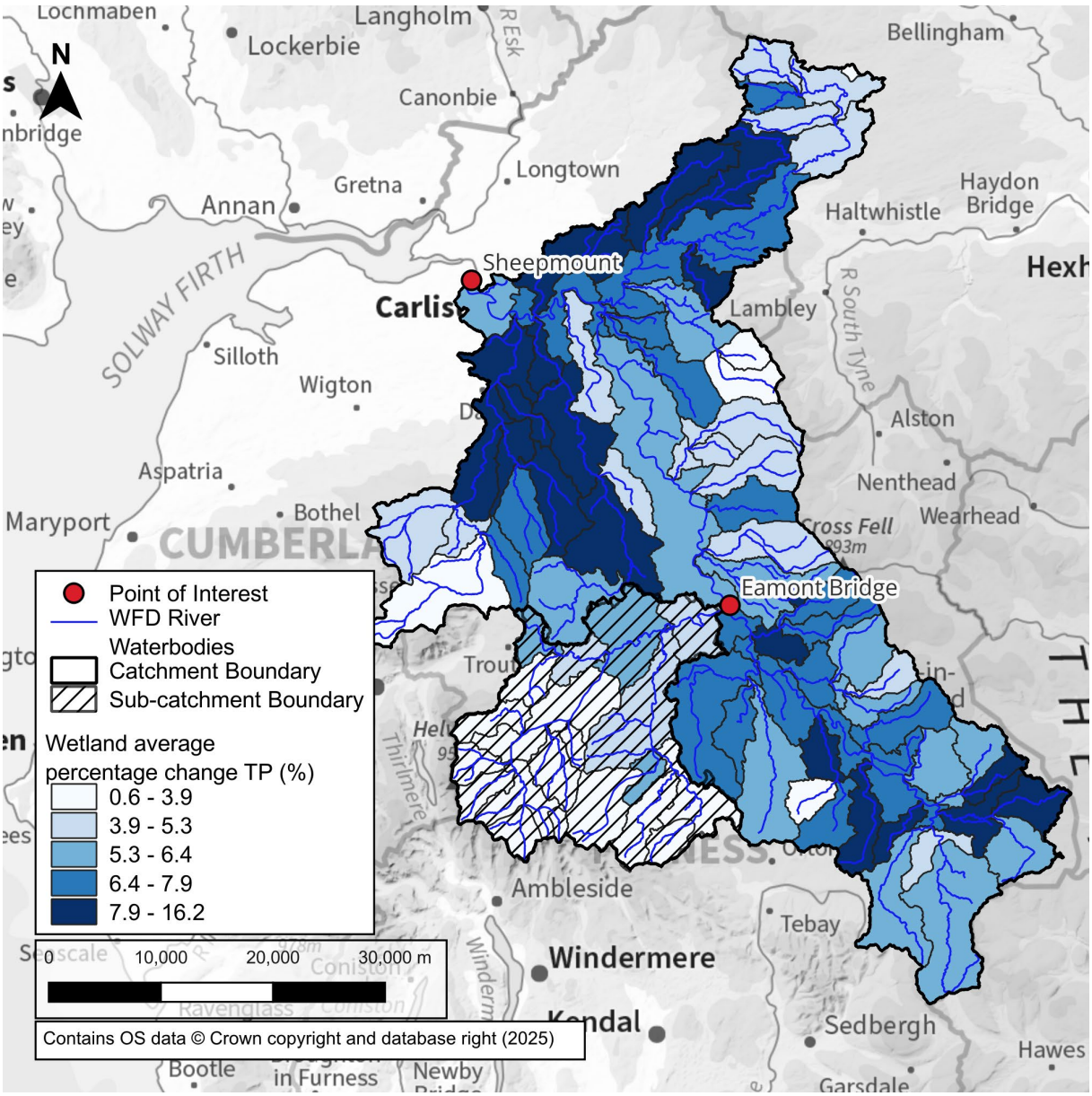


Figure 0-15: Average percentage change of total phosphorus for in-field wetlands, for the central results.

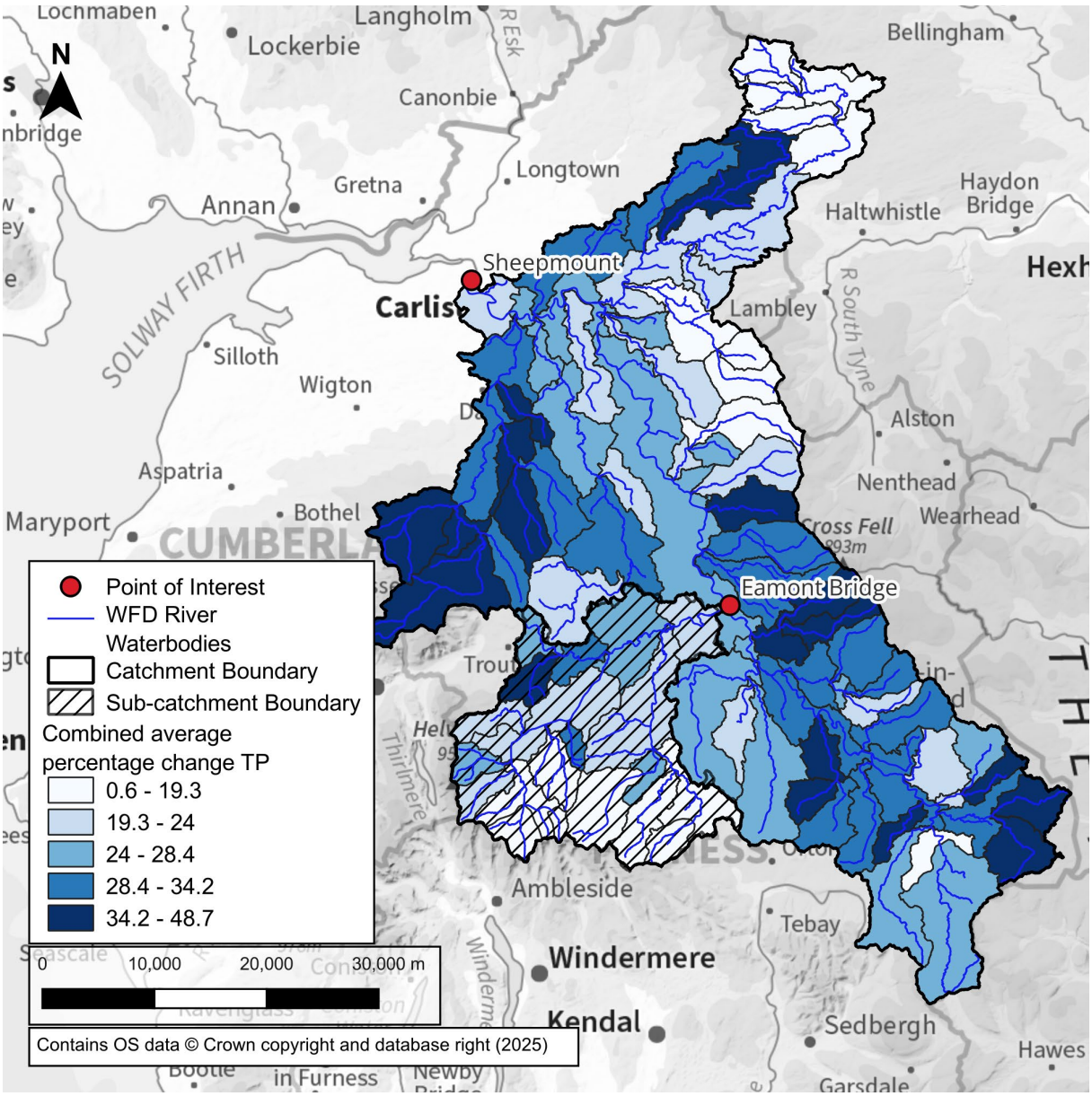


Figure 0-16: Average percentage change of total phosphorus divided by the area of combined scenario. The cumulative effects are non-headwater areas accounted for

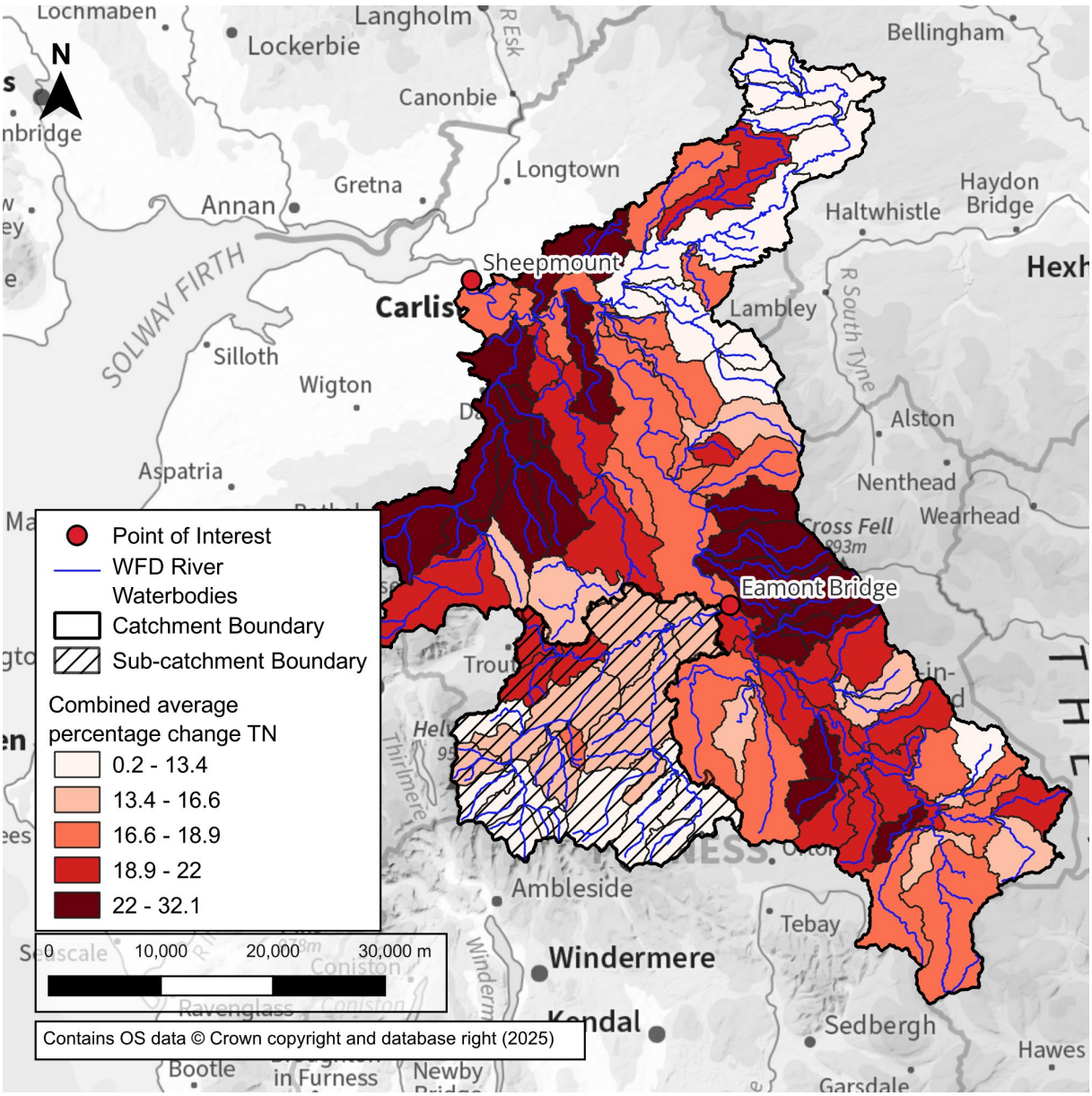


Figure 0-17: Average percentage change of total nitrogen for the combined scenario.

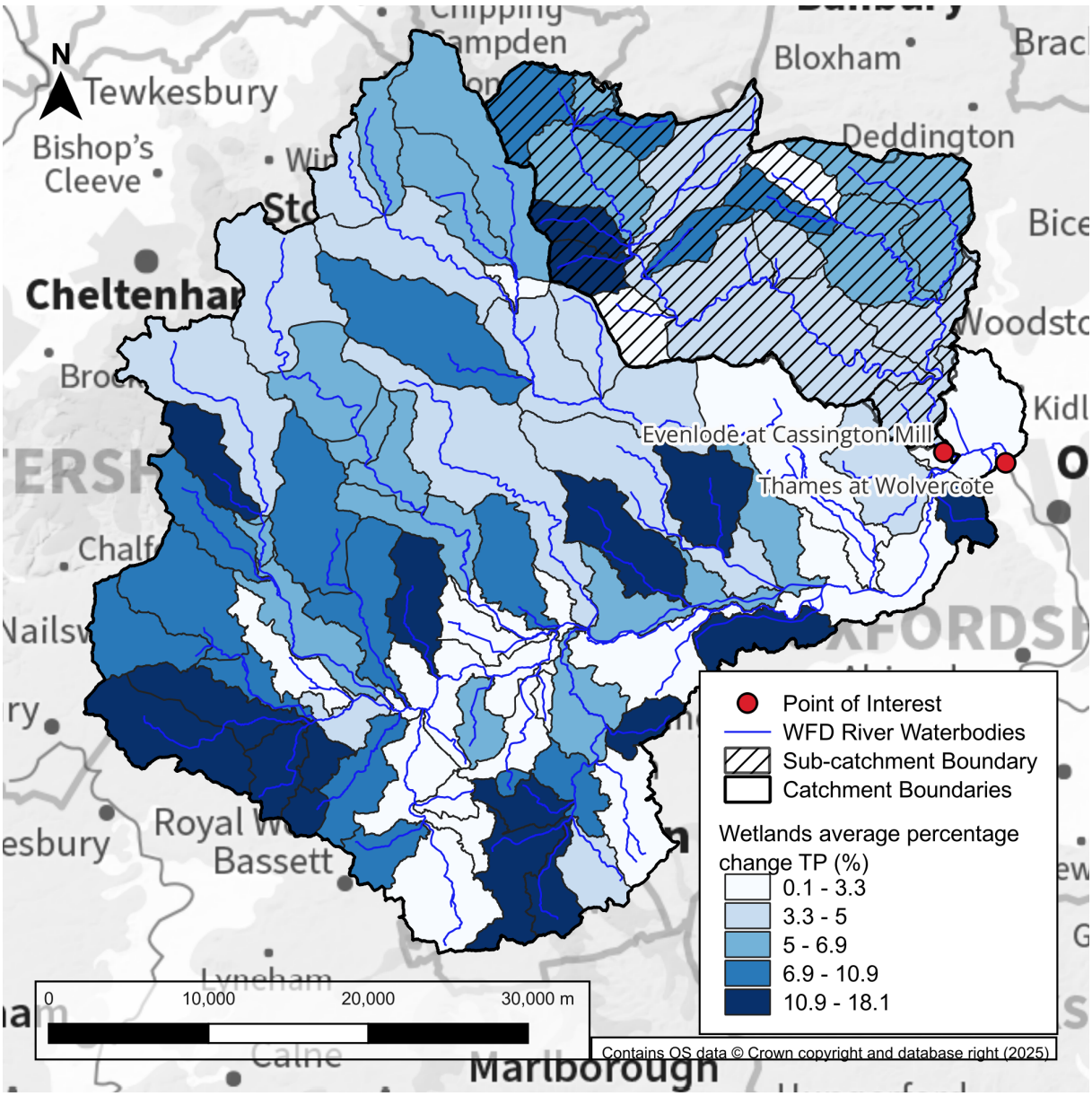


Figure 0-18: Average percentage change of total phosphorus load, for wetland central results.

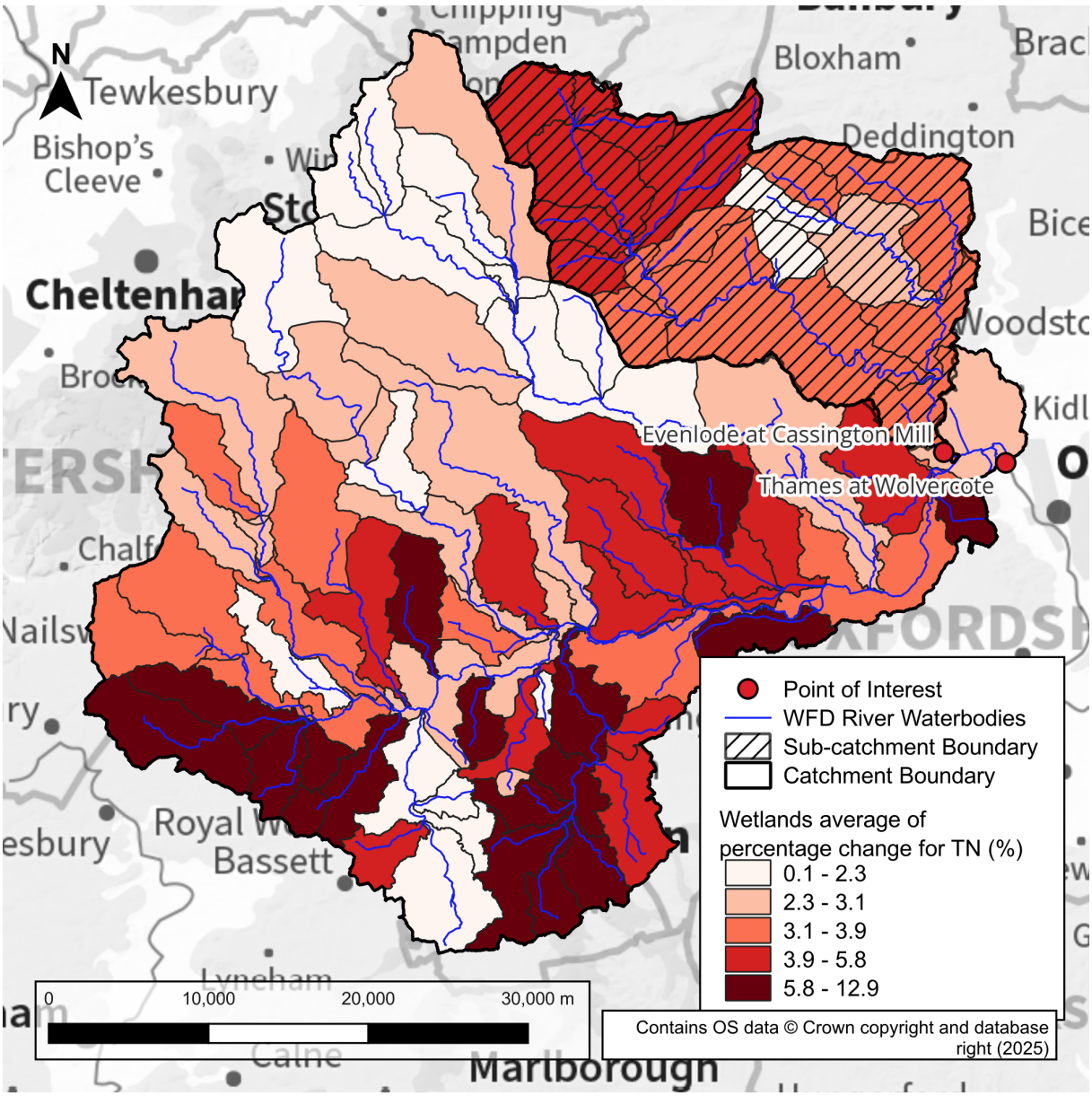


Figure 0-19: Average percentage change of total nitrogen for in-field wetlands central results. The cumulative effects are non-headwater areas accounted for.

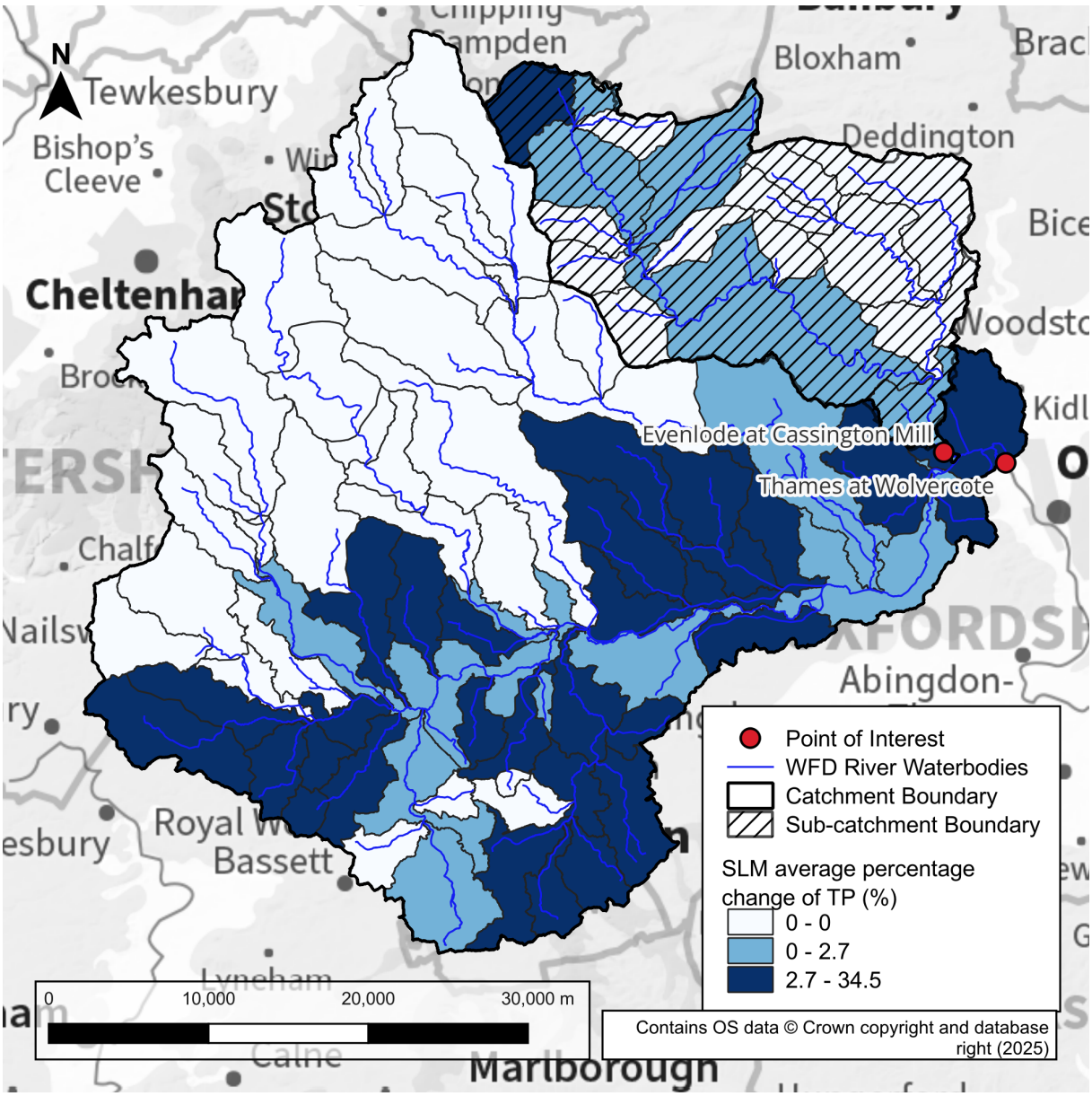


Figure 0-20: Average percentage change of total phosphorus divided by the area of soil and land management (SLM) for the central results. The cumulative effects are non-headwater areas accounted for.

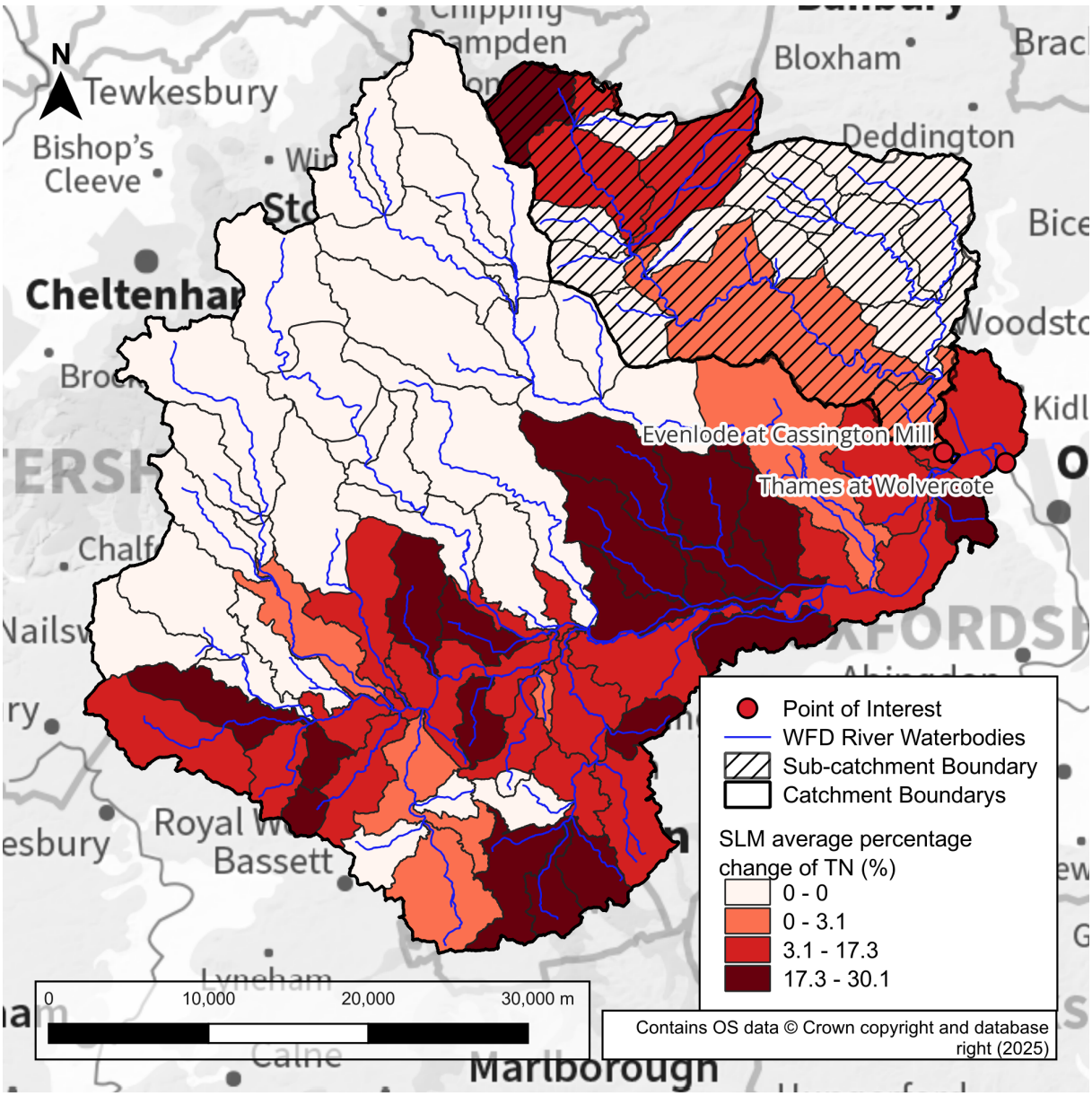


Figure 0-21: Average percentage change of total nitrogen for soil and land management (SLM) central results.

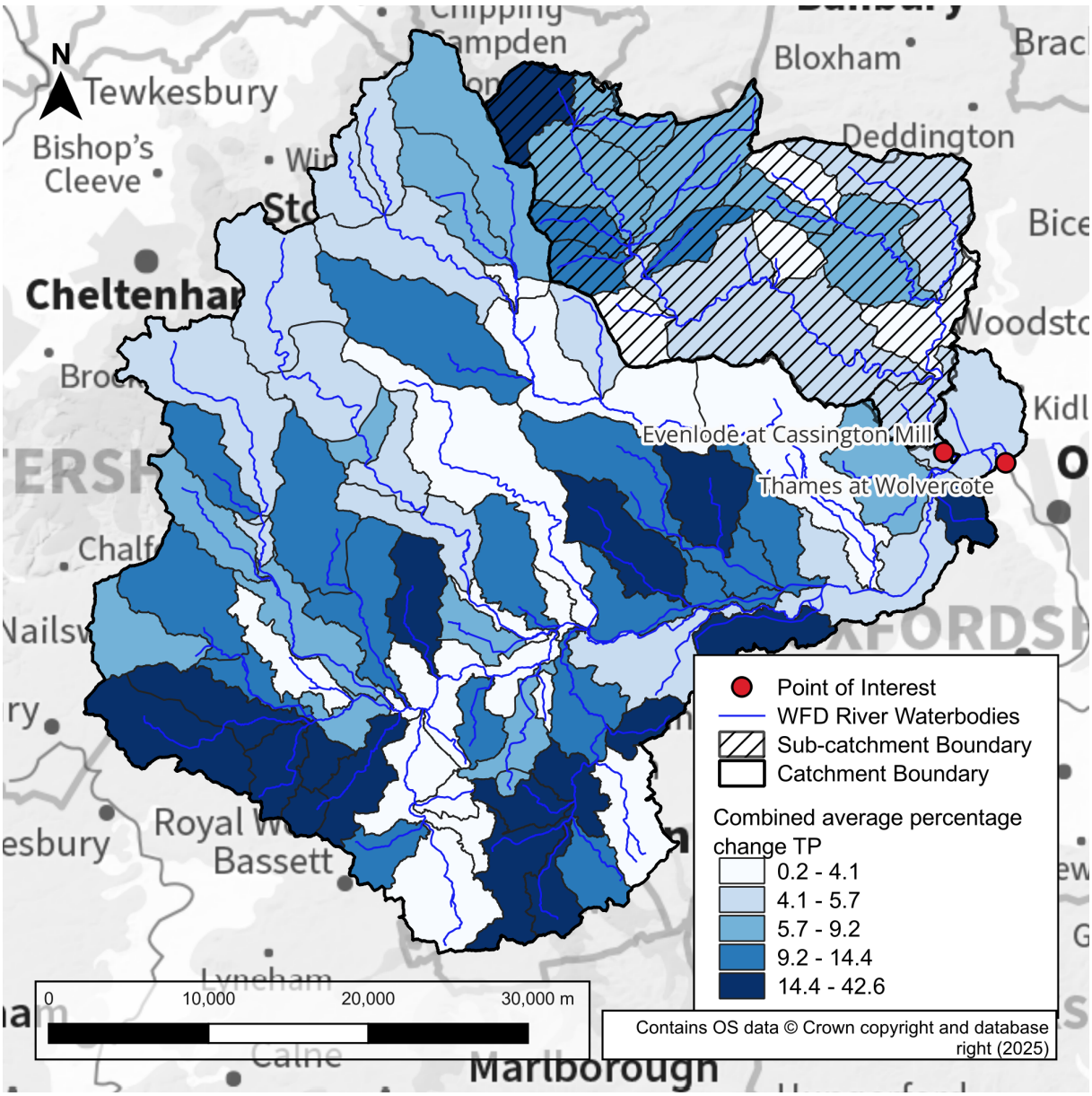


Figure 0-22: Average percentage change of total phosphorus divided by the combined scenarios. The cumulative effects are non-headwater areas accounted for.

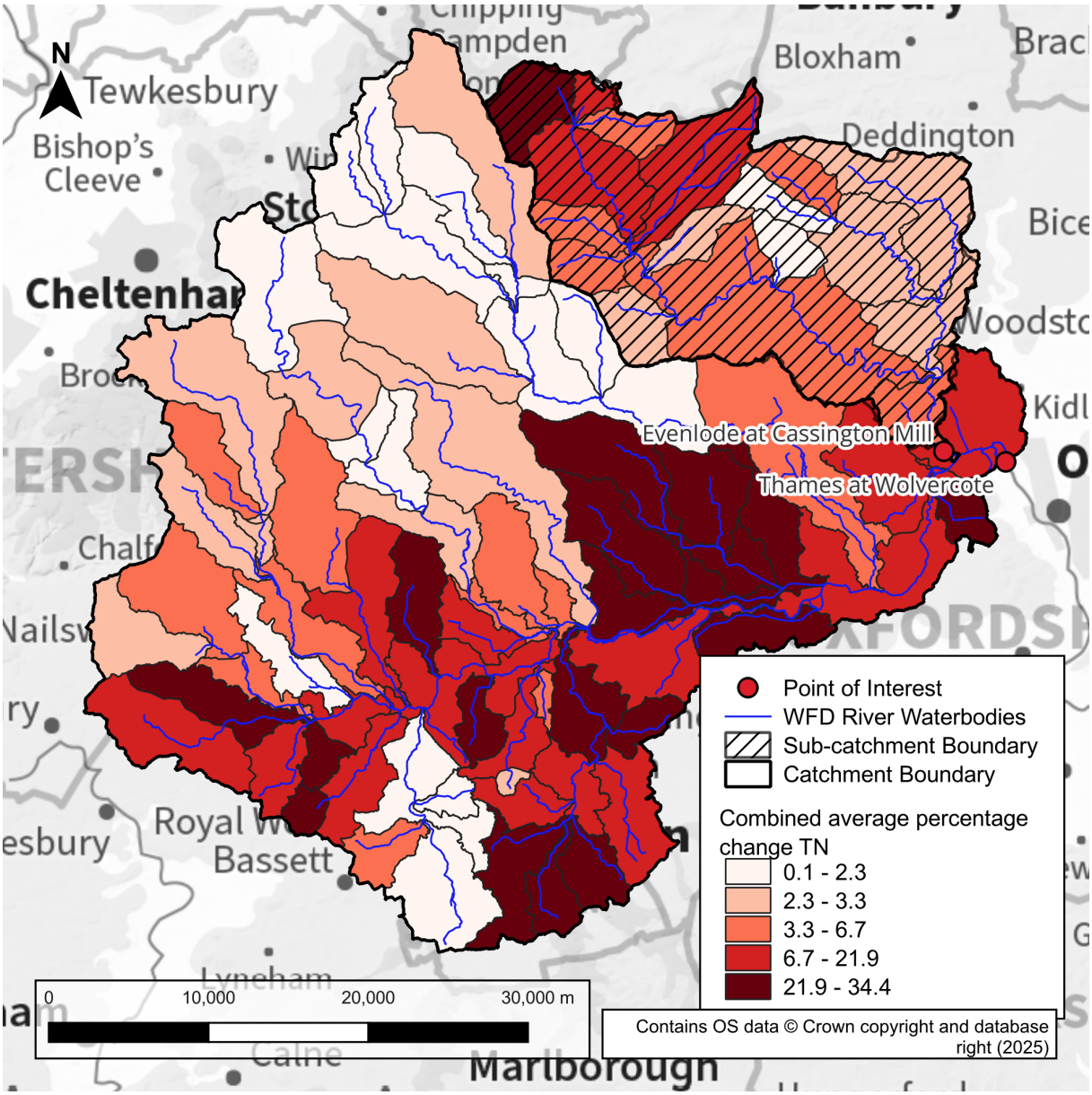


Figure 0-23: Average percentage change of total nitrogen for the combined results.

Appendix B – ‘Recent past’ load tables

Table 0-1 presents the absolute values for cumulative loads for the SLM scenario, including the sensitivity analysis, in the Eden at Sheepmount, Eamont at Udford, Thames at Wolvercote, and Evenlode at Cassington Mill.

Table 0-2 presents the absolute values for cumulative loads for the in-field wetland scenario, including the sensitivity analysis, in the Eden at Sheepmount, Eamont at Udford, Thames at Wolvercote, and Evenlode at Cassington Mill.

Table 0-3 presents the absolute values for cumulative loads for the combined intervention scenario, including the sensitivity analysis, in the Eden at Sheepmount, Eamont at Udford, Thames at Wolvercote, and Evenlode at Cassington Mill.

Table 0-4, Table 0-5, and Table 0-6 present the kg differences between the baseline results (i.e. no NbS) and the SLM, in-field wetland, and combined scenarios.

All results in Tables 0-1 to 0-6 are from the recent past scenarios.

Table 0-1: Average cumulative loads (kg/km^2/y) for all years (2000-2020) for the baseline, and soil and land management scenarios, including the sensitivity analysis

Location	Nutrient	Average cumulative loads (kg/km2/y) across all years		
		Baseline	With Farming Rules for Water (lower efficacy)	Without Farming Rules for Water (central efficacy)
Eden at Sheepmount	TN	4,356,973	4,170,601	3,685,044
	IN	3,771,636	3,585,443	3,100,719
	TP	167,183	160,940	137,632
	SP	122,079	118,634	103,629
Eamont at Udford	TN	662,340	641,316	575,965
	IN	569,757	548,904	484,359
	TP	25,633	24,788	21,331
	SP	17,571	17,083	14,877
Thames at Wolvercote	TN	4,032,202	3,925,393	3,789,238
	IN	3,628,852	3,522,046	3,385,899
	TP	129,237	128,124	125,666
	SP	109,324	108,872	107,530
Evenlode at Cassington Mill	TN	1,036,135	1,028,772	1,018,730
	IN	933,487	926,125	916,083
	TP	25,426	25,335	25,144
	SP	20,256	20,221	20,122

Table 0-2: Average cumulative loads (kg/km^2/y) for all years (2000-2020) for the baseline, and in-field wetland scenarios, including the sensitivity analysis

Location	Nutrient	Average cumulative loads (kg/km2/y) across all years			
		Baseline	Lower	Central	Upper
Eden at Sheepmount	TN	4,356,973	4,292,917	4,265,416	4,189,982
	IN	3,771,636	3,707,820	3,680,390	3,605,133
	TP	167,183	160,448	157,721	150,560
	SP	122,079	117,508	115,723	111,011
Eamont at Udford	TN	662,340	655,566	652,563	644,082
	IN	569,757	563,120	560,177	551,858
	TP	25,633	24,828	24,462	23,482
	SP	17,571	17,035	16,797	16,159
Thames at Wolvercote	TN	4,032,202	3,948,551	3,917,484	3,835,499
	IN	3,628,852	3,545,356	3,514,295	3,432,320
	TP	129,237	126,223	125,248	122,642
	SP	109,324	107,765	107,296	106,041
Evenlode at Cassington Mill	TN	1,036,135	1,010,754	1,000,968	975,421
	IN	933,487	908,103	898,318	872,776
	TP	25,426	24,693	24,444	23,788
	SP	20,256	19,903	19,790	19,491

Table 0-3: Average cumulative loads (kg/km^2/y) for all years (2000-2020) for the baseline, and combined scenarios.

Location	Nutrient	Average cumulative loads (kg/km2/y) across all years	
		Baseline	Combined
Eden at Sheepmount	TN	4,356,973	3,610,490
	IN	3,771,636	3,026,554
	TP	167,183	130,405
	SP	122,079	98,730
Eamont at Udford	TN	662,340	567,730
	IN	569,757	476,303
	TP	25,633	20,400
	SP	17,571	14,257
Thames at Wolvercote	TN	4,032,202	3,689,768
	IN	3,628,852	3,286,589
	TP	129,237	122,177
	SP	109,324	105,762
Evenlode at Cassington Mill	TN	1,036,135	984,669
	IN	933,487	882,021
	TP	25,426	24,197
	SP	20,256	19,674

Table 0-4: Average cumulative loads (kg) difference for the soil and land management scenario compared to the baseline scenarios for all years (2000-2020).

Location	Nutrient	Average cumulative load difference (kg) across all years	
		With Farming Rules for Water (lower efficacy)	Without Farming Rules for Water (central efficacy)
Sheepmount	TN	186,372	671,928
	IN	186,193	670,916
	TP	6,244	29,551
	SP	3,446	18,450
Udford	TN	21,025	86,375
	IN	20,853	85,398
	TP	845	4,302
	SP	487	2,694
Thames at Wolvercote	TN	106,809	242,964
	IN	106,806	242,953
	TP	1,113	3,572
	SP	452	1,794
Evenlode at Eamont	TN	7,363	17,405
	IN	7,362	17,404
	TP	91	283
	SP	35	134

Table 0-5: Average cumulative loads (kg) difference for the in-field wetland scenario compared to the baseline scenarios for all years (2000-2020).

Location	Nutrient	Average cumulative load difference (kg) across all years		
		Lower	Central	Upper
Sheepmount	TN	64,056	91,557	16,6991
	IN	63,816	91,246	16,6503
	TP	6,735	9,463	16,623
	SP	4,571	6,356	11,068
Udford	TN	6,775	9,778	18,258
	IN	6,637	9,580	17,898
	TP	805	1,171	2,152
	SP	536	773	1,411
Thames at Wolvercote	TN	83,652	114,718	196,703
	IN	83,496	114,557	196,532
	TP	3,014	3,989	6,595
	SP	1,559	2,028	3,284
Evenlode at Eamont	TN	25,381	35,167	60,714
	IN	25,384	35,169	60,712
	TP	733	982	1,638
	SP	353	466	765

Table 0-6: Average cumulative loads (kg) difference for the combined scenario to the baseline scenarios for all years (2000-2020).

Location	Nutrient	Average cumulative load difference (kg) across all years
Sheepmount	TN	746,483
	IN	745,082
	TP	36,779
	SP	23,349
Udford	TN	94,611
	IN	93,454
	TP	5233
	SP	3314
Thames at Wolvercote	TN	6,848,680
	IN	6,845,261
	TP	141,207
	SP	71,238
Evenlode at Eamont	TN	1,029,317
	IN	1,029,321
	TP	24,575
	SP	11,639

Appendix C – Climate change 2020-2040 results

Figure 0-1 to Figure 0-8 show the TN and TP concentrations across the 12 ensemble members for each month at the Eden at Sheepmount and Eamont at Udford catchments for the near future baseline (i.e. no NbS) and the SLM and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenario (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

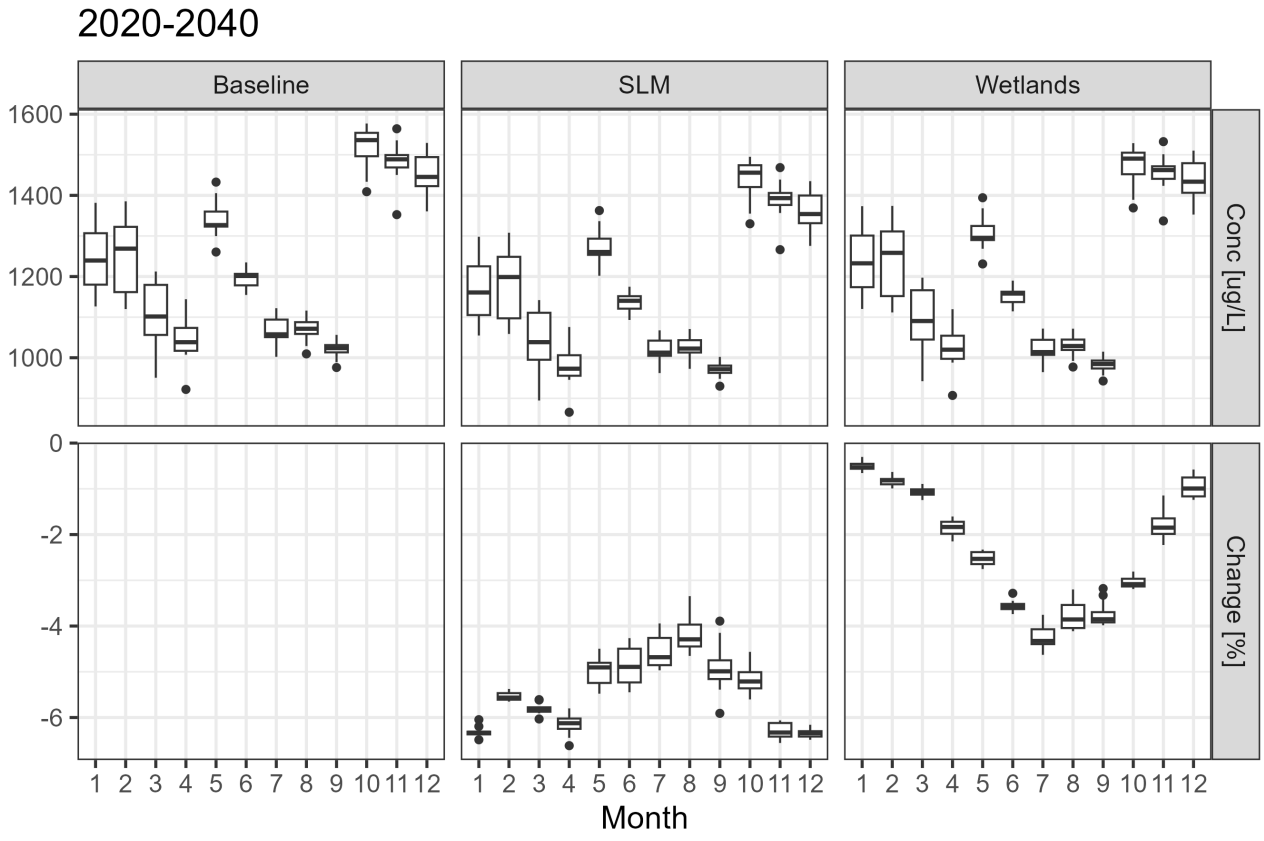


Figure 0-1: Total nitrogen concentrations across the 12 ensemble members for each month at Udford for the future baseline (baseline) and the soil and land management (SLM) and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenario (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

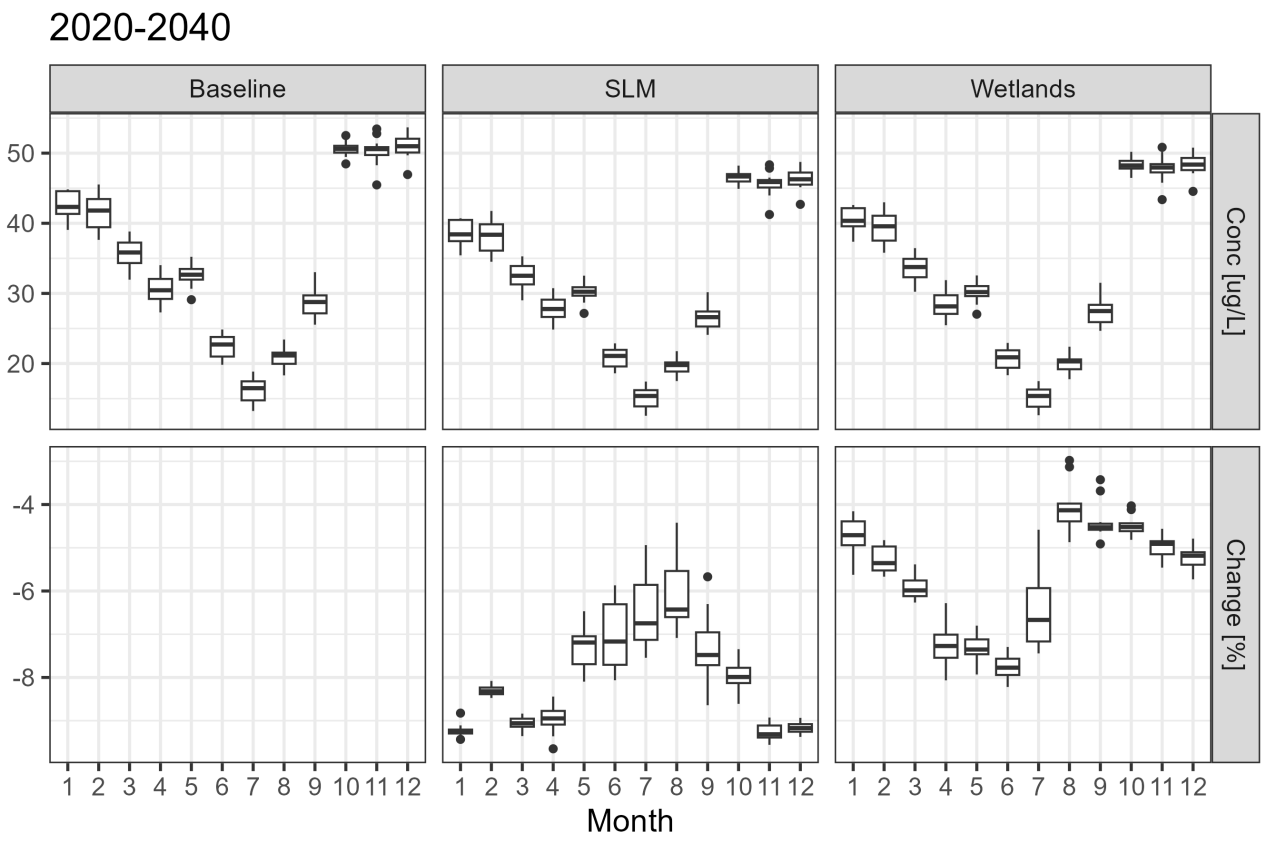


Figure 0-2: Total phosphorus concentrations across the 12 ensemble members for each month at Udford for the future baseline (baseline) and the soil and land management (SLM) and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenario (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

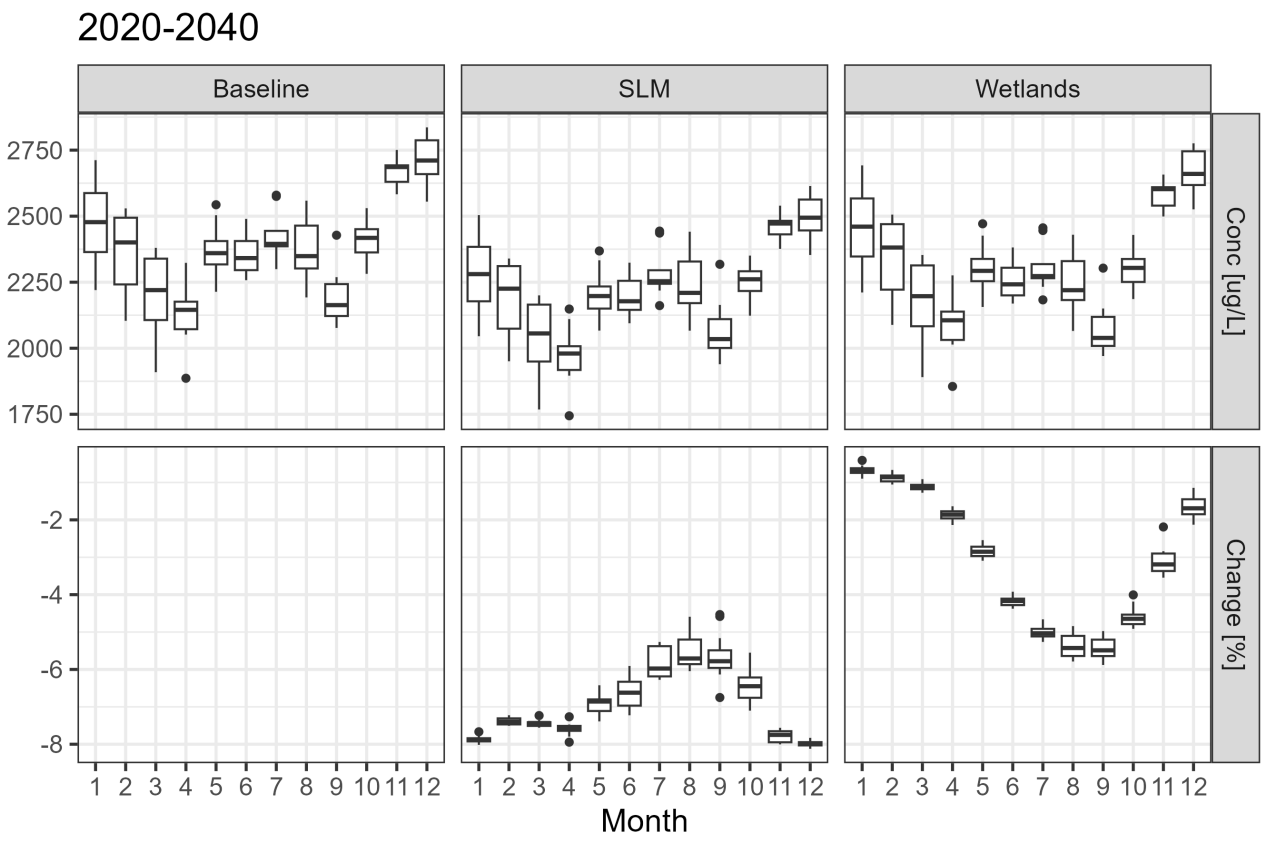


Figure 0-3: Total nitrogen concentrations across the 12 ensemble members for each month at Sheepmount for the future baseline (baseline) and the soil and land management (SLM) and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenario (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

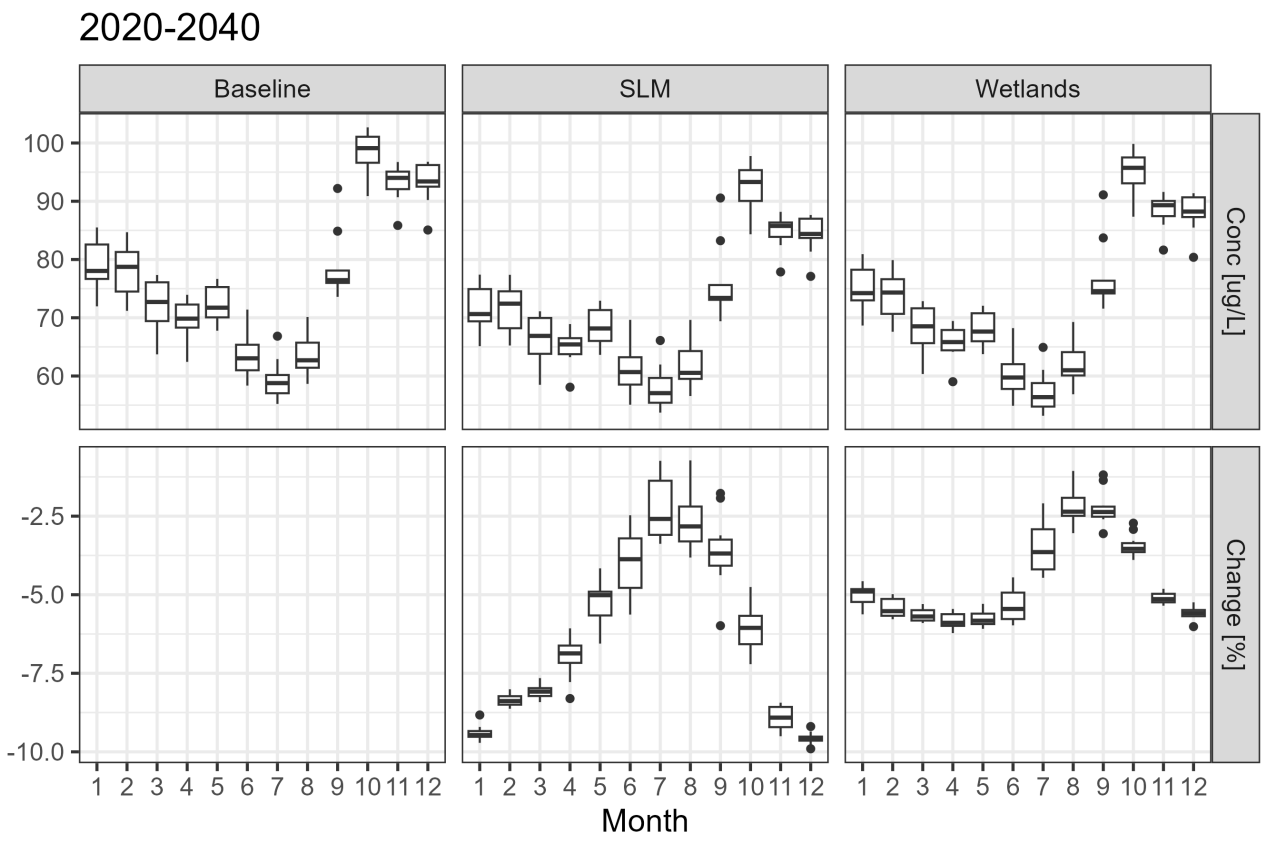


Figure 0-4: Total phosphorus concentrations across the 12 ensemble members for each month at Sheepmount for the future baseline (baseline) and the soil and land management (SLM) and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenario (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

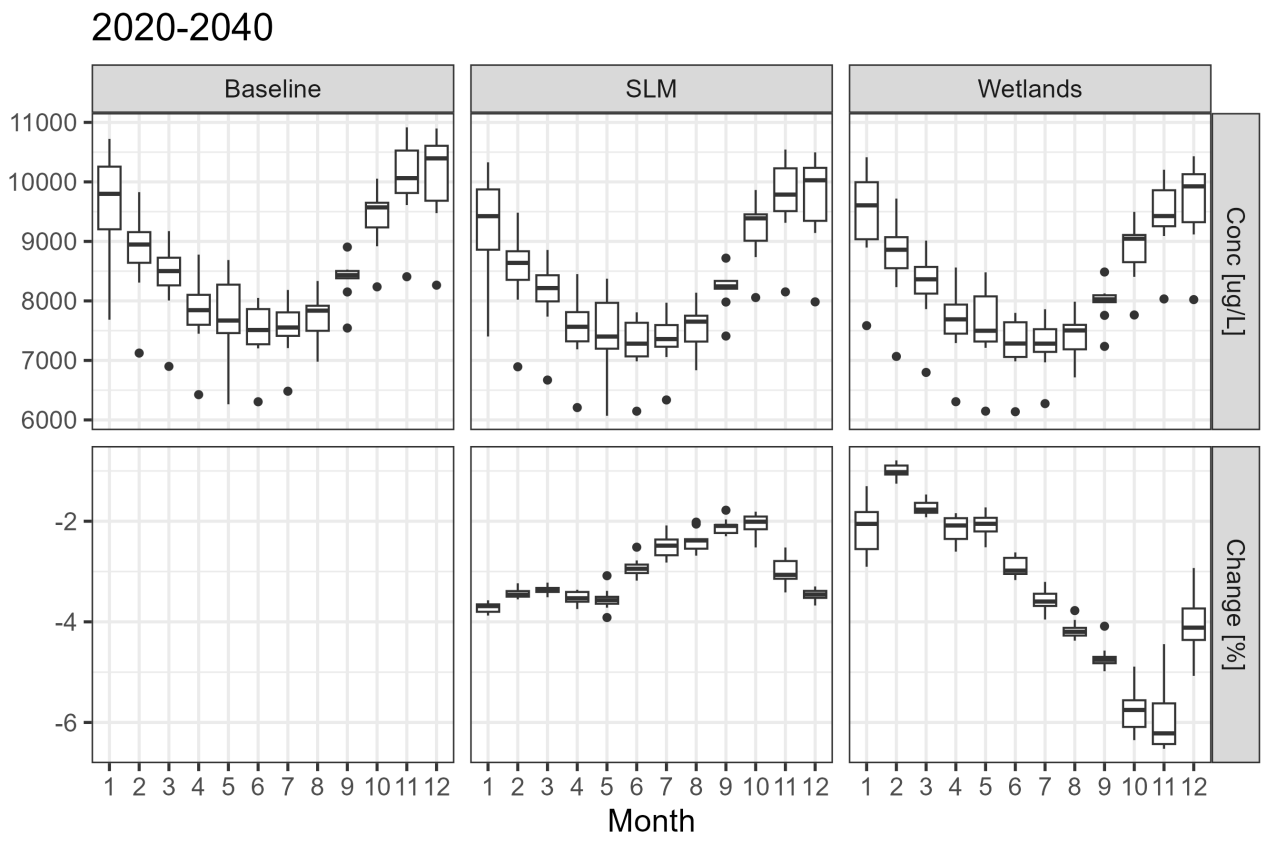


Figure 0-5: Total nitrogen concentrations across the 12 ensemble members for each month for the Thames at Wolvercote for the future baseline (baseline) and the soil and land management (SLM) and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenarios (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

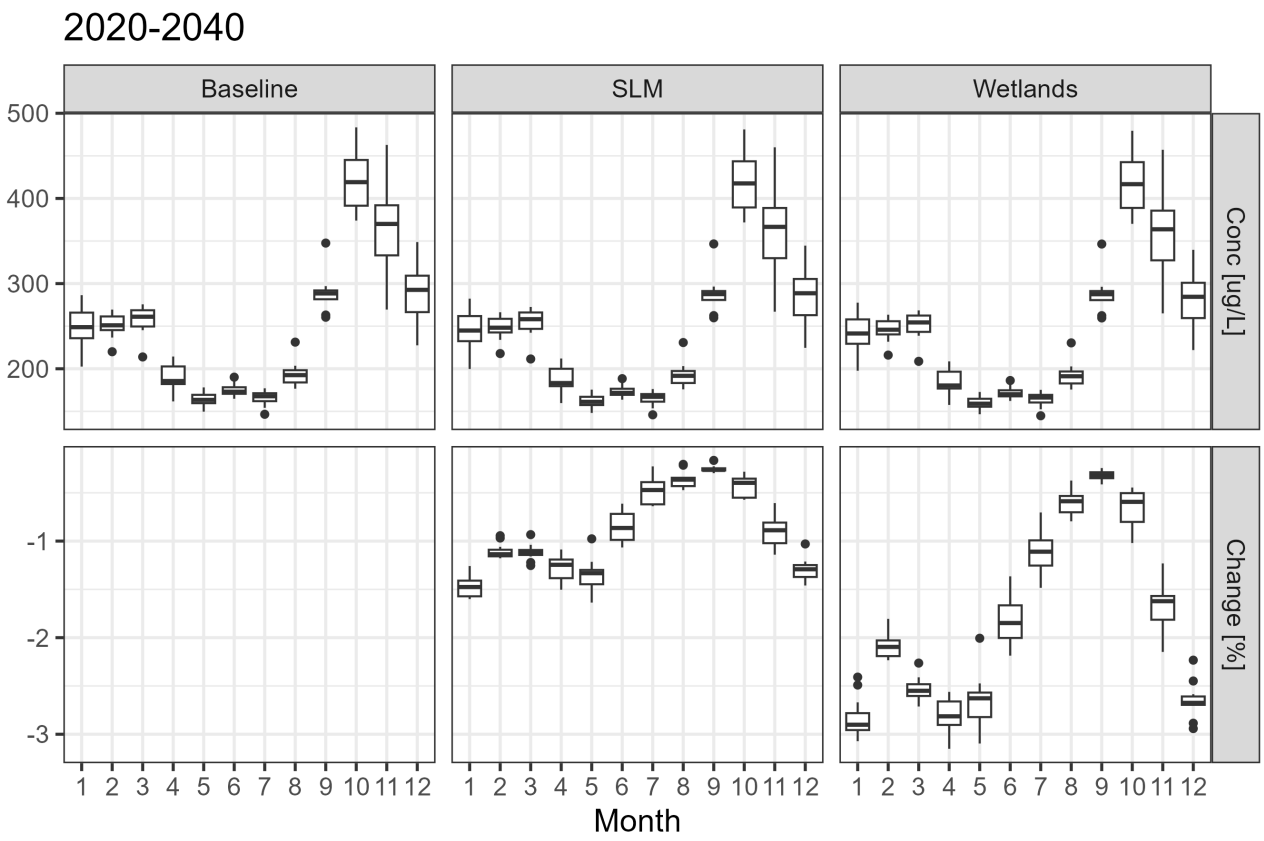


Figure 0-6: Total phosphorus concentrations across the 12 ensemble members for each month for the Thames at Wolvercote for the future baseline (baseline) and the soil and land management (SLM) and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenarios (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

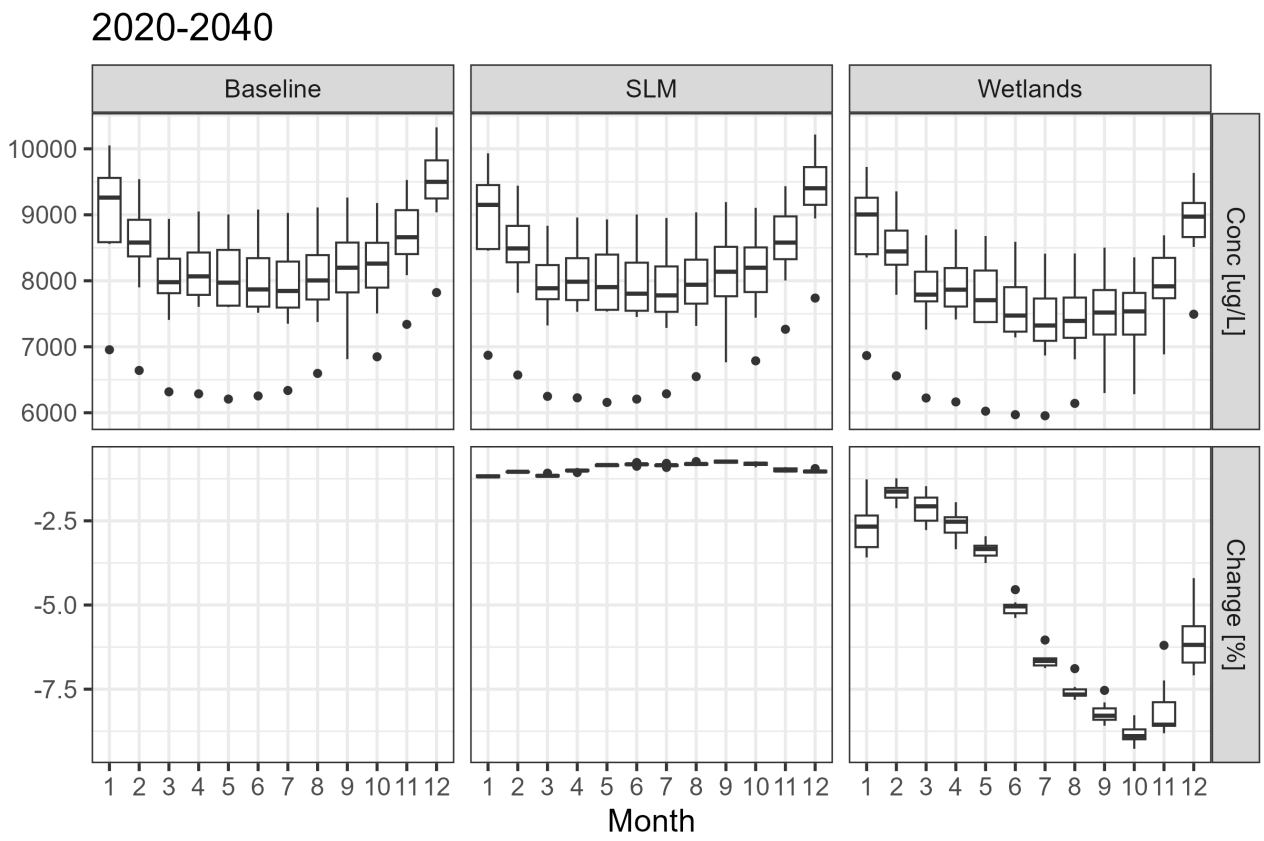


Figure 0-7: Total nitrogen concentrations across the 12 ensemble members for each month for the Evenlode at Cassington Mill for the future baseline (baseline) and the soil and land management (SLM) and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenarios (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

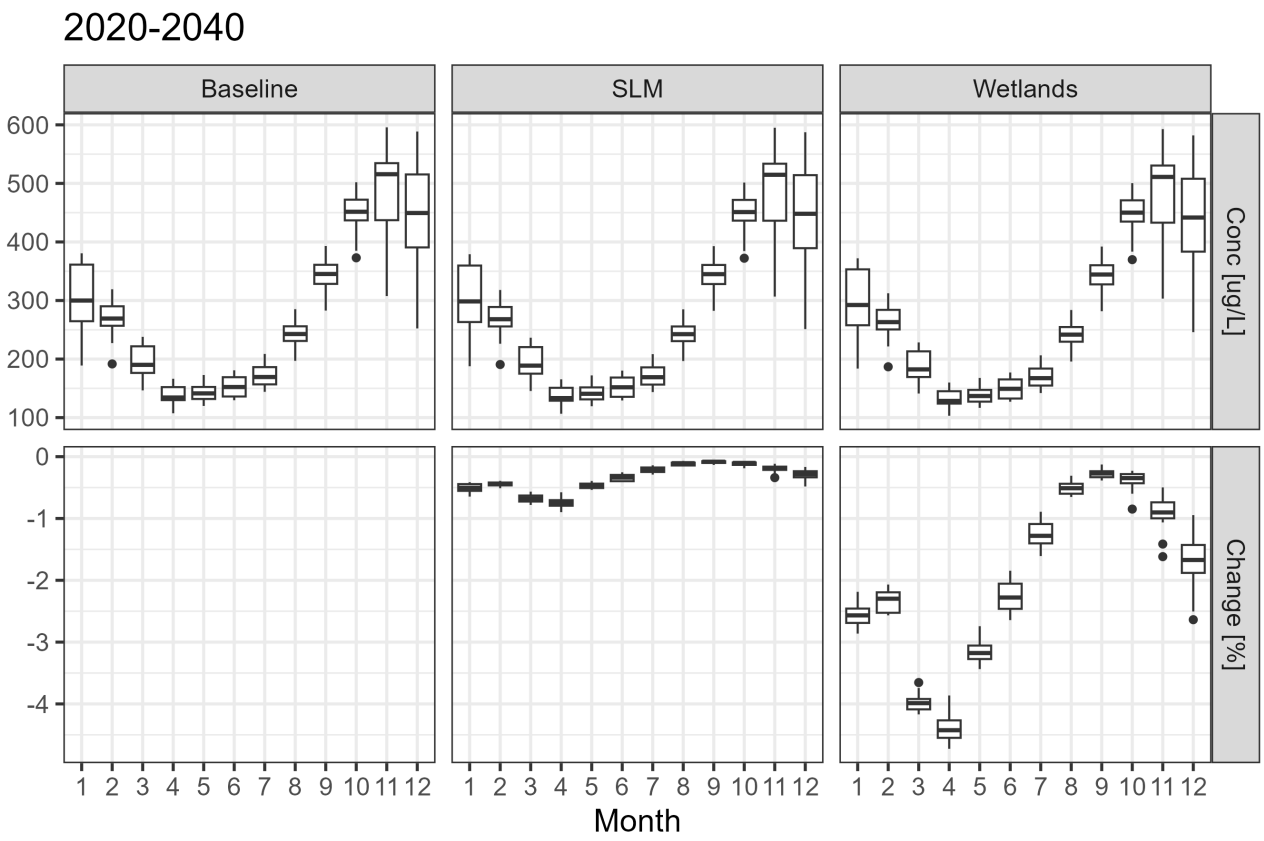


Figure 0-8: Total phosphorus concentrations across the 12 ensemble members for each month for the Evenlode at Cassington Mill for the future baseline (baseline) and the soil and land management (SLM) and in-field wetland scenarios for 2020-2040. This includes absolute concentrations and percentage reductions from the baseline to the NbS scenarios (%). The box and whisker plots illustrate the upper range, 75% quantile, median, 25% quantile, lower range, and outliers across the 12 climate change ensemble members.

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