

When does nitrate peak in rivers and why? Catchment traits and climate drive synchrony with discharge

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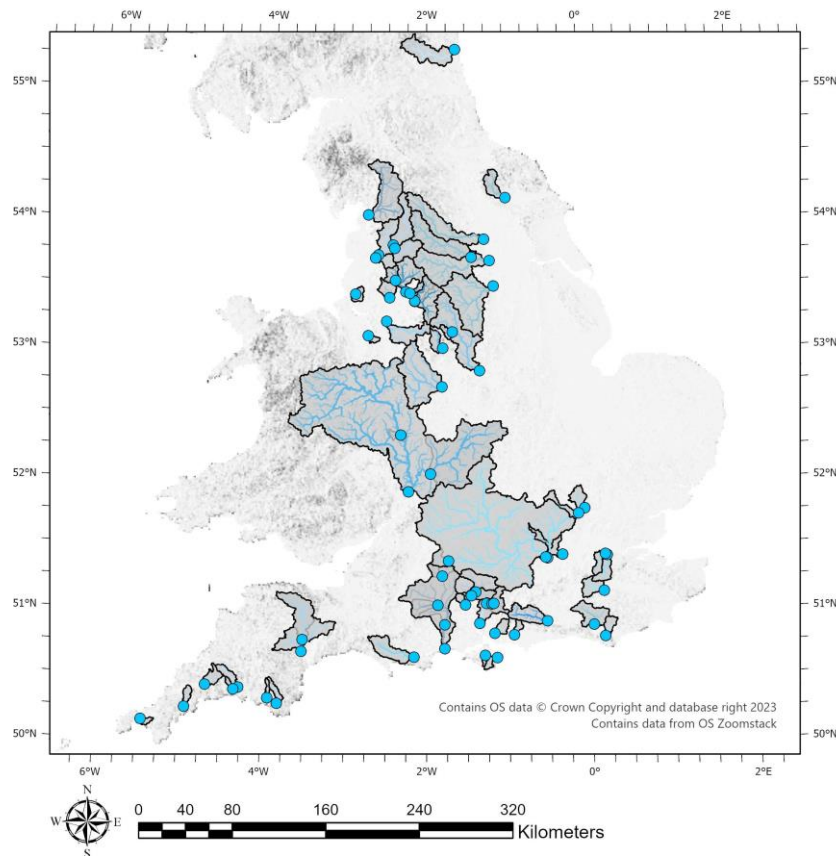


Figure S1: Map of the sampling stations (blue points) and study catchments. River networks (blue lines) were obtained from the UK Atlas Rivers (ECRINS) dataset (Esri ArcGIS FeatureServer, ArcGIS Online)

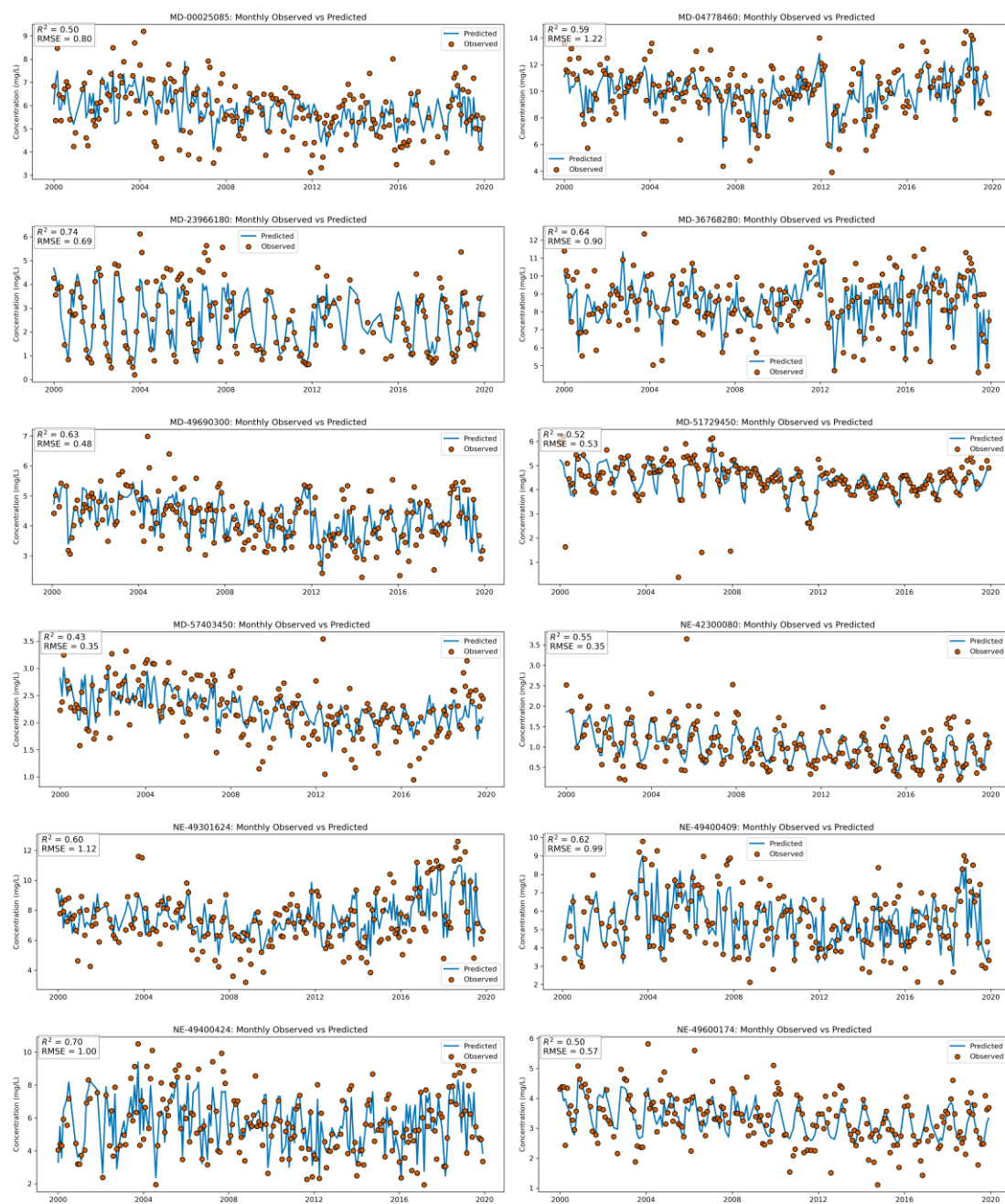


Figure S2: Monthly observed and predicted nitrate concentration (Sites 1-12). Predicted values were derived from daily WRTDS outputs and aggregated to monthly averages for comparison with observed monitoring data.

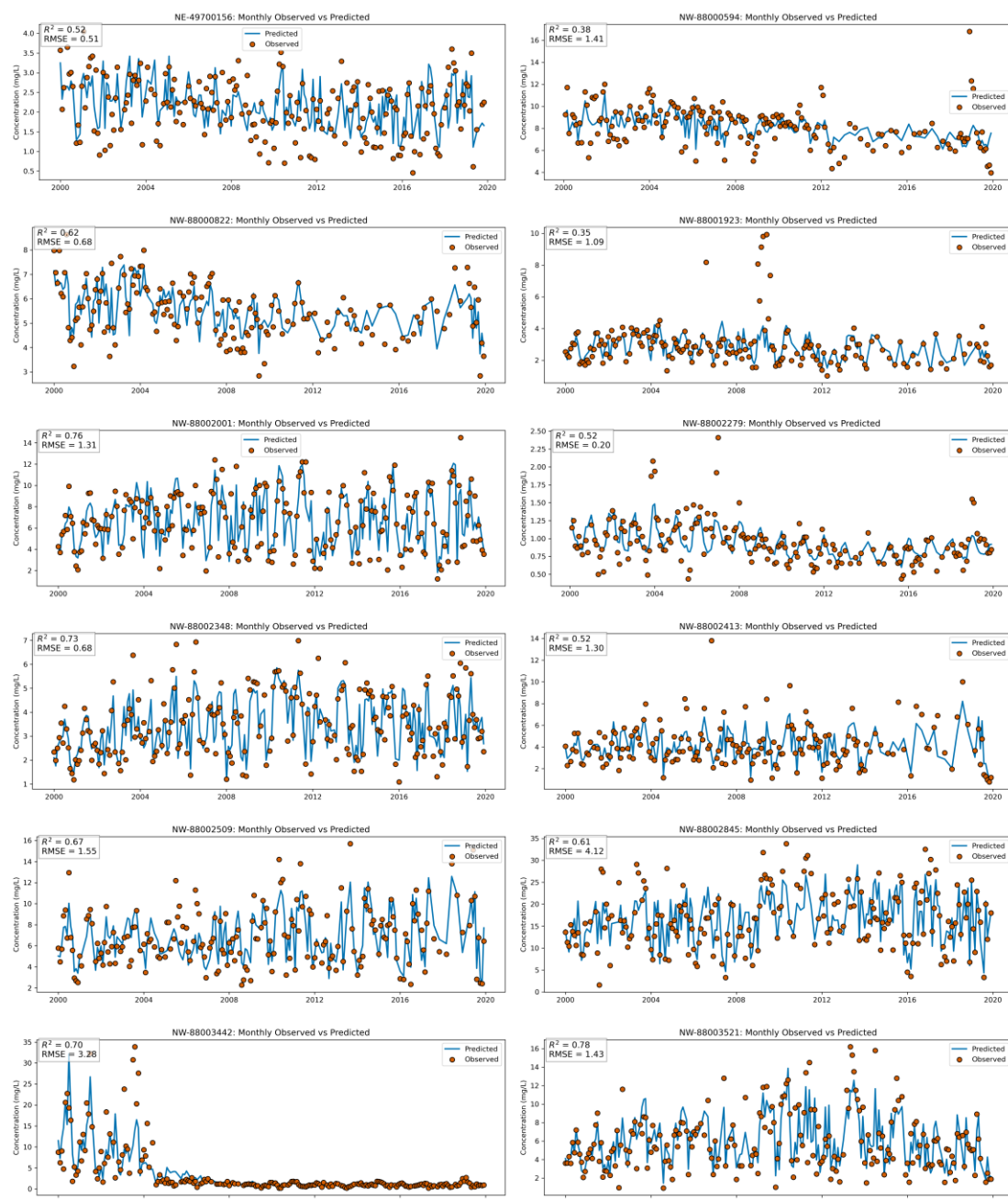


Figure S3: Monthly observed and predicted nitrate concentration (Sites 13-24). Predicted values were derived from daily WRTDS outputs and aggregated to monthly averages for comparison with observed monitoring data.

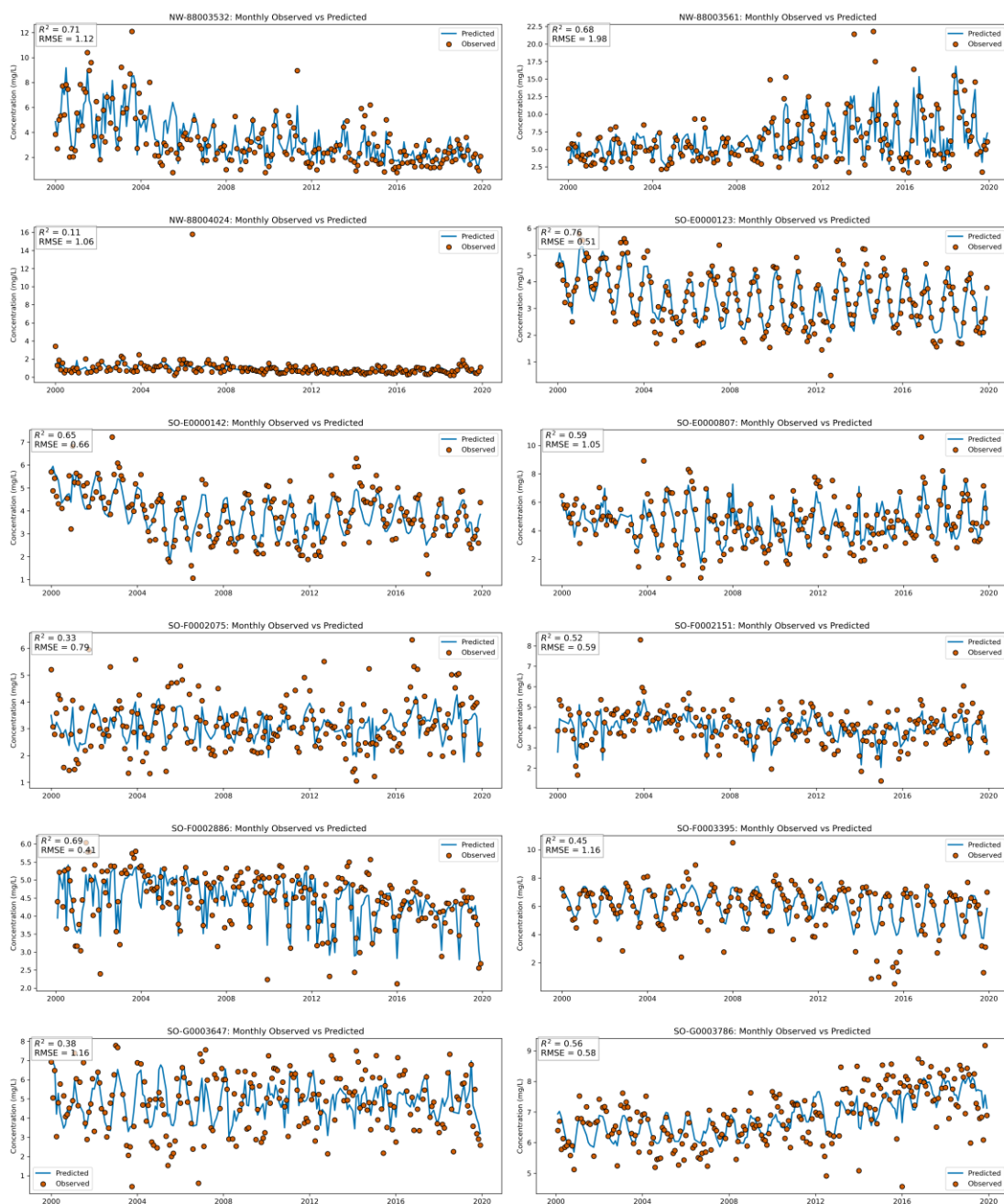


Figure S4: Monthly observed and predicted nitrate concentration (Sites 25-36). Predicted values were derived from daily WRTDS outputs and aggregated to monthly averages for comparison with observed monitoring data.

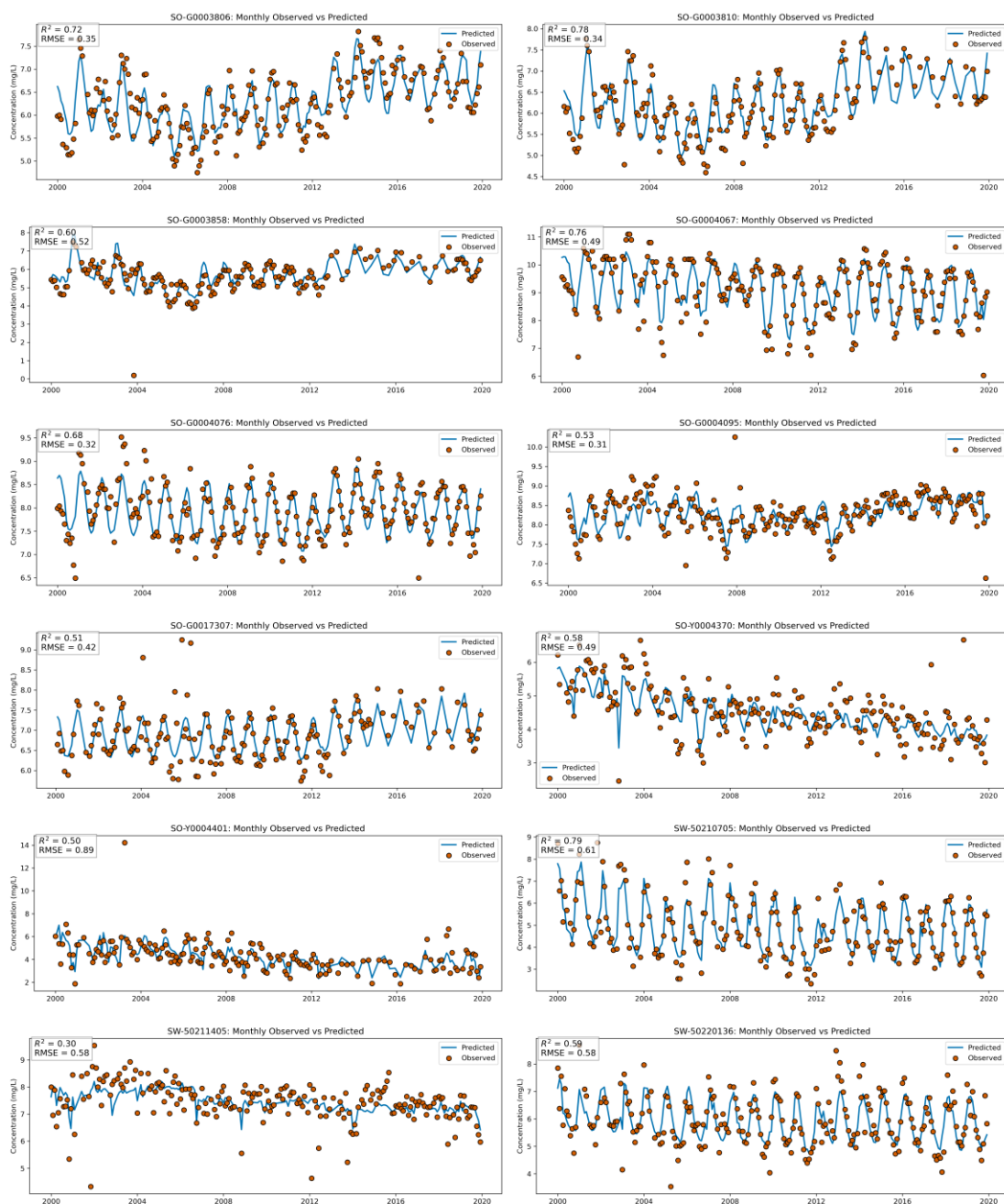


Figure S5: Monthly observed and predicted nitrate concentration (Sites 37-48). Predicted values were derived from daily WRTDS outputs and aggregated to monthly averages for comparison with observed monitoring data.

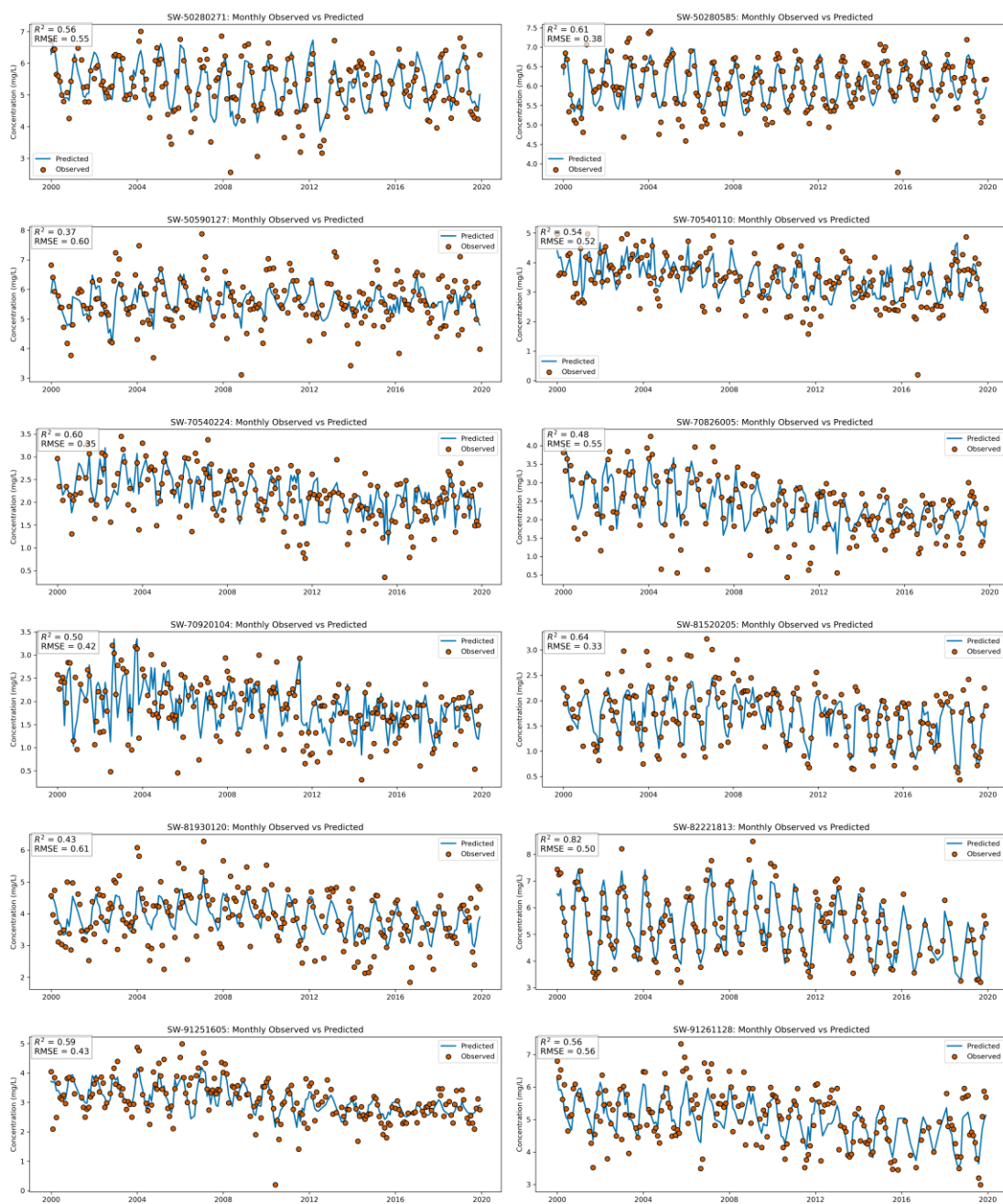


Figure S6: Monthly observed and predicted nitrate concentration (Sites 49-60). Predicted values were derived from daily WRTDS outputs and aggregated to monthly averages for comparison with observed monitoring data.

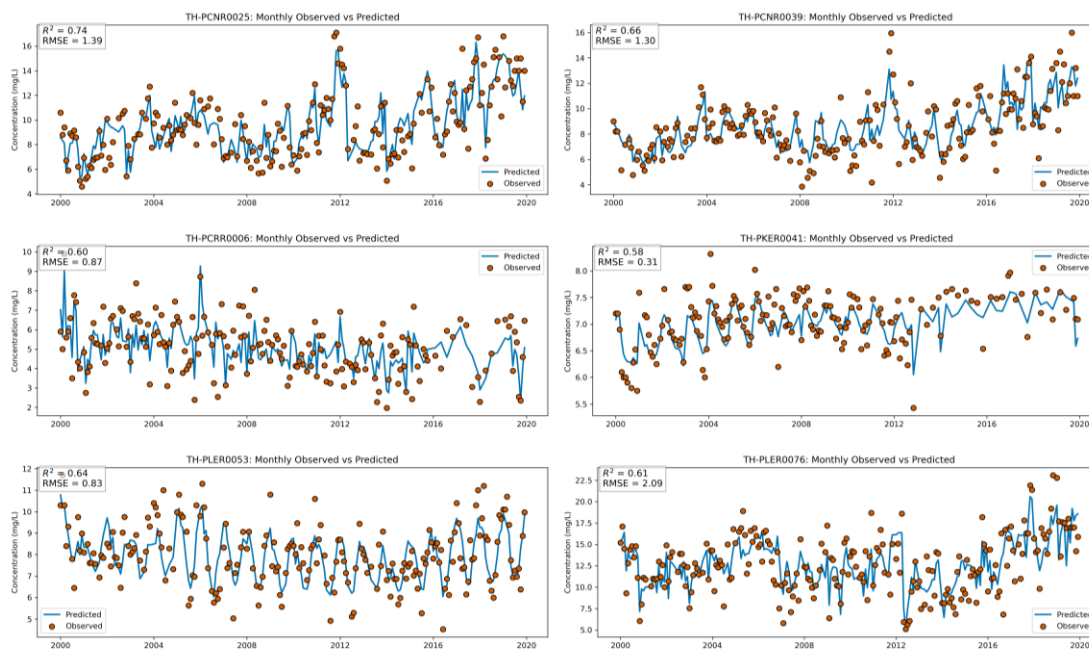


Figure S7: Monthly observed and predicted nitrate concentration (Sites 61-66). Predicted values were derived from daily WRTDS outputs and aggregated to monthly averages for comparison with observed monitoring data.

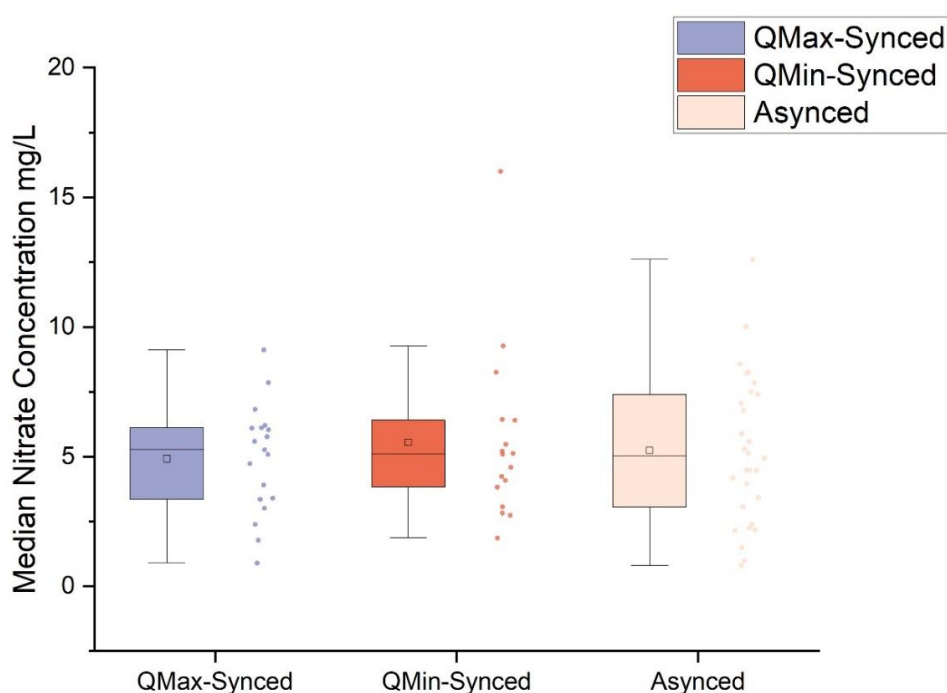


Figure S8: Boxplots of concentrations in synchronous patterns; Note: The central line in each box indicates the median nitrate concentration; the square marker represents the mean. Boxes span the interquartile range (IQR, 25th-75th percentiles), and whiskers show the range excluding outliers (beyond 1.5IQR). No statistically significant differences in median nitrate concentrations were observed among the synchrony groups (Kruskal-Wallis test, $p > 0.05$).

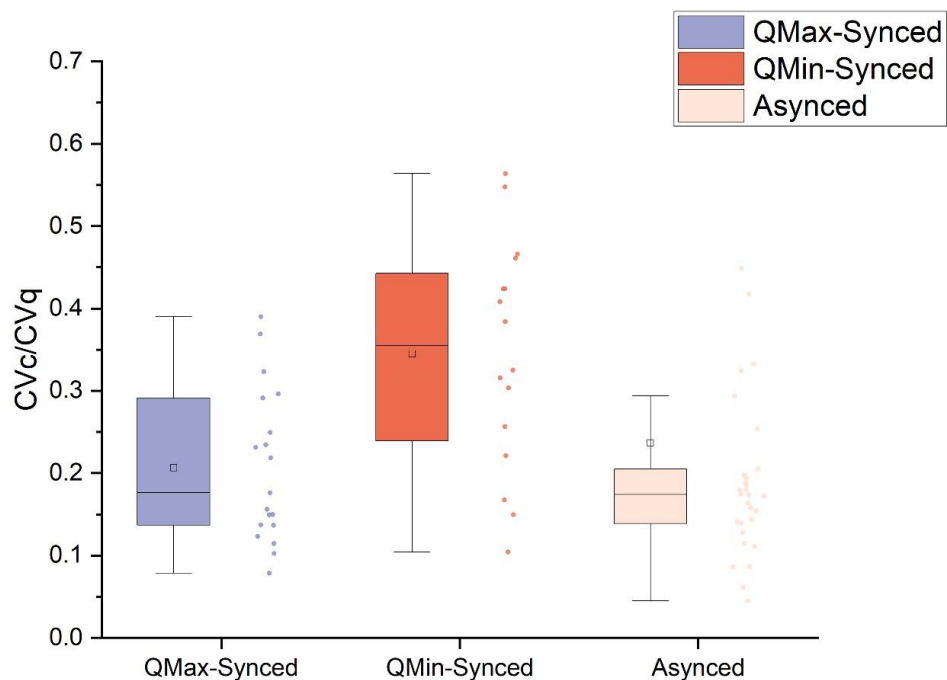


Figure S9: CVc/CVq in synchrony patterns; Note: The central line in each box indicates the median CVc/CVq Values; the square marker represents the mean. Boxes span the interquartile range (IQR, 25th-75th percentiles), and whiskers show the range excluding outliers (beyond 1.5IQR). The QMin-Synced group exhibits significantly higher CVc/CVq values than both the QMax-Synced and Asynced groups (Wilcoxon rank-sum test, $p < 0.05$).

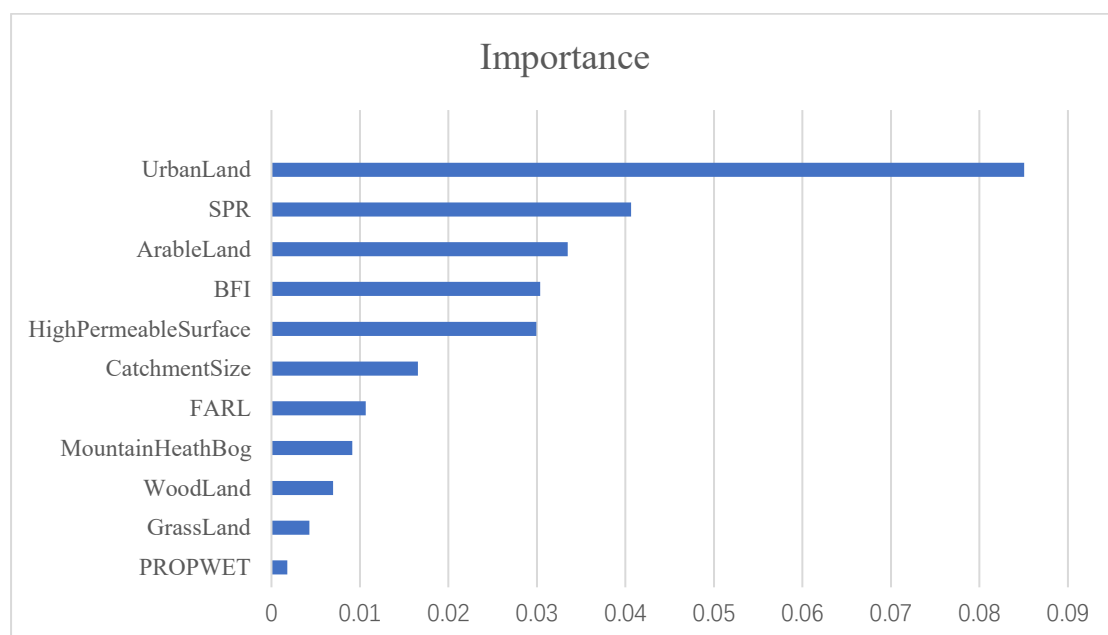


Figure S10: Feature importance from random forest classification model for QMax-Synced and QMin-Synced catchment

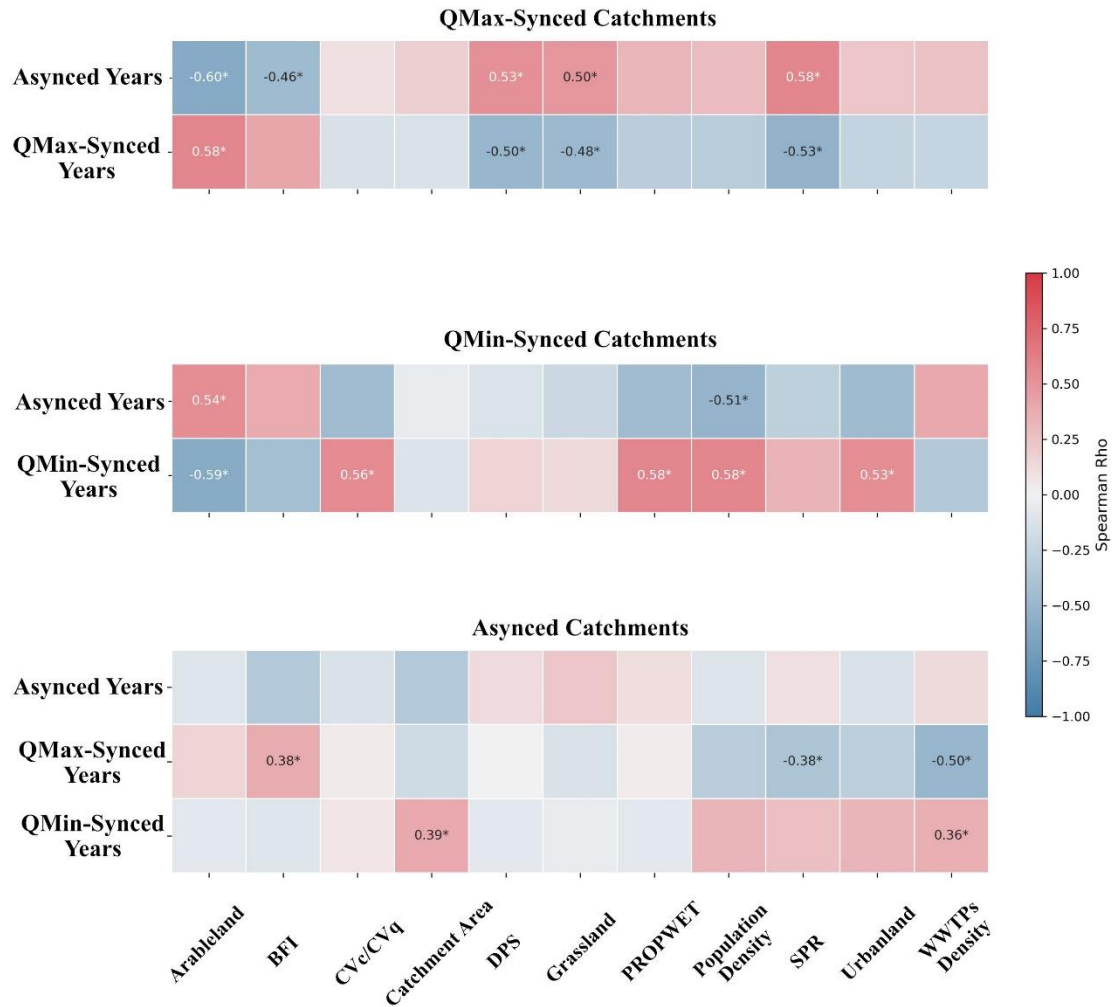


Figure S11: Spearman Correlation Results between Synchronous Years and Potential Drivers (* indicates $p < 0.05$)

Table S1. Summary Statistics of Calculated Metrics in All Catchments (n=66) from Observations and the WRTDS Models

	Mean Discharge m ³ /s	CVq	Mean NO ₃ -N mg/L	CVc	CVc/CVq	C-Q Coefficient β_2
Max	114.66	1.37	16.62	1.26	1.65	0.27
Min	0.36	0.33	0.89	0.04	0.04	-0.61
Median	3.52	0.71	5.11	0.15	0.19	-0.12
IQR (25%-75%)	11.6	0.20	3.48	0.10	0.18	0.27
Standard Deviation	17.04	0.21	2.75	0.16	0.21	0.19