Appendix 19. Weighted Regressions on Time, Discharge, and Season Model Evaluation and Trend Analysis Graphical Output for Total Suspended Solids during January 1, 1999, through December 31, 2019

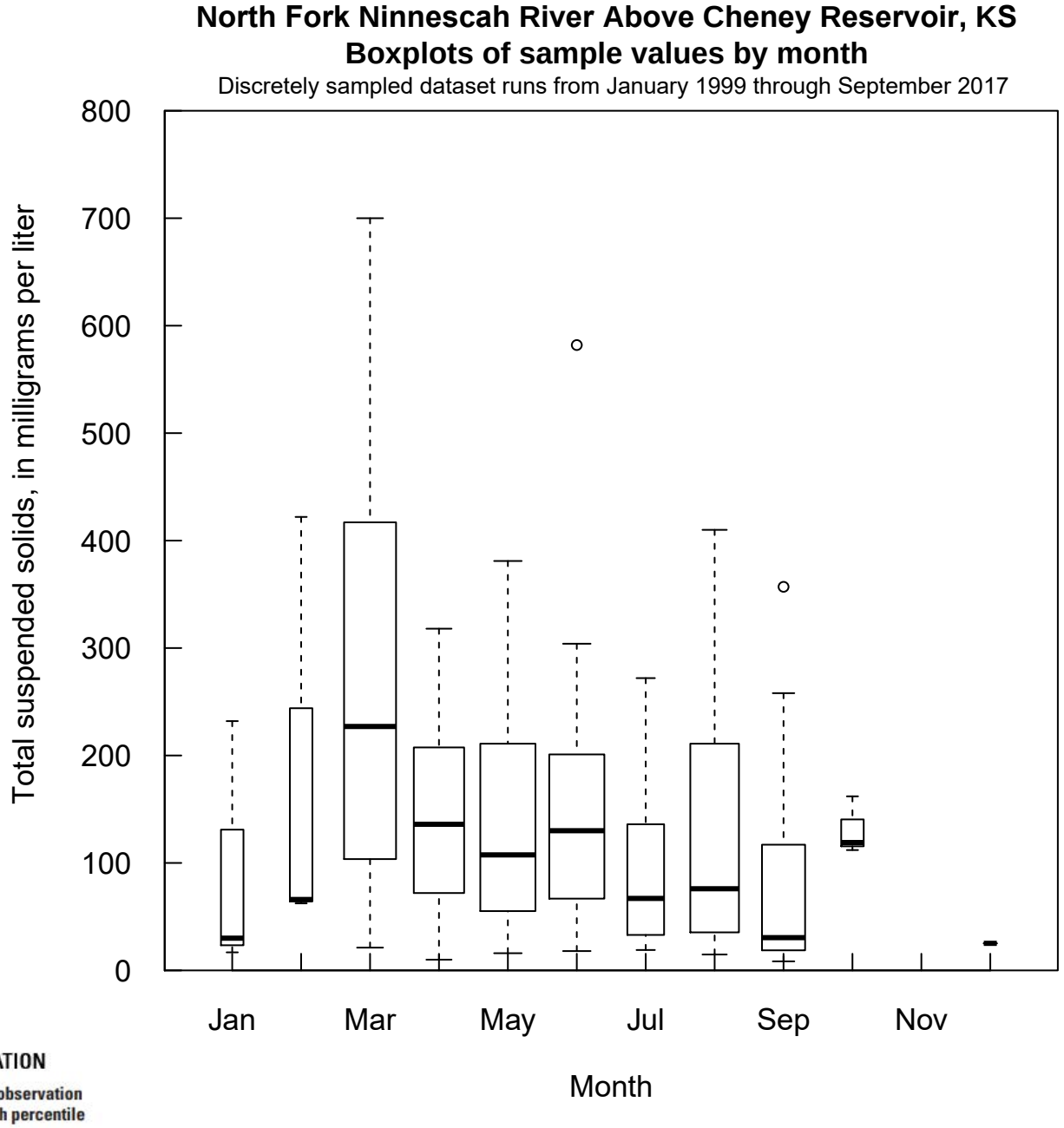
All graphics were produced using R programming language (R Core Team, 2019) and the Exploration and Graphics for RivEr Trends (EGRET) and EGRETci packages. More information on these packages and methods can be found in Hirsch and De Cicco (2015) and Hirsch and others (2015).

Functions used to produce the following outputs are included as text preceding the graphic.

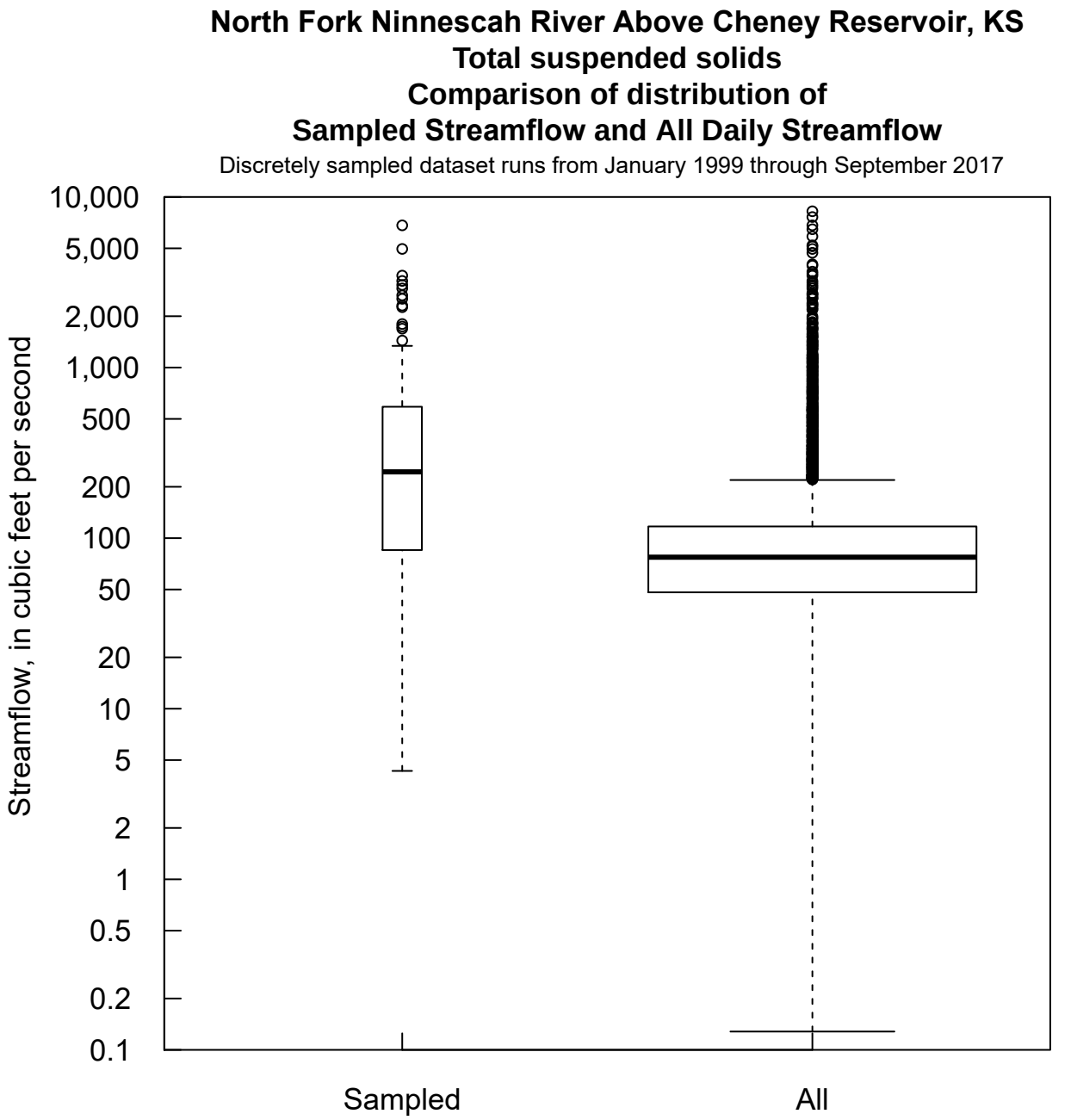
Suspended Solids (00530)

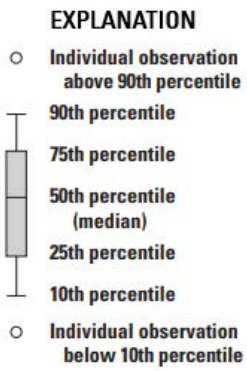
Sample Data

```
boxConcMonth(wrtds)
```

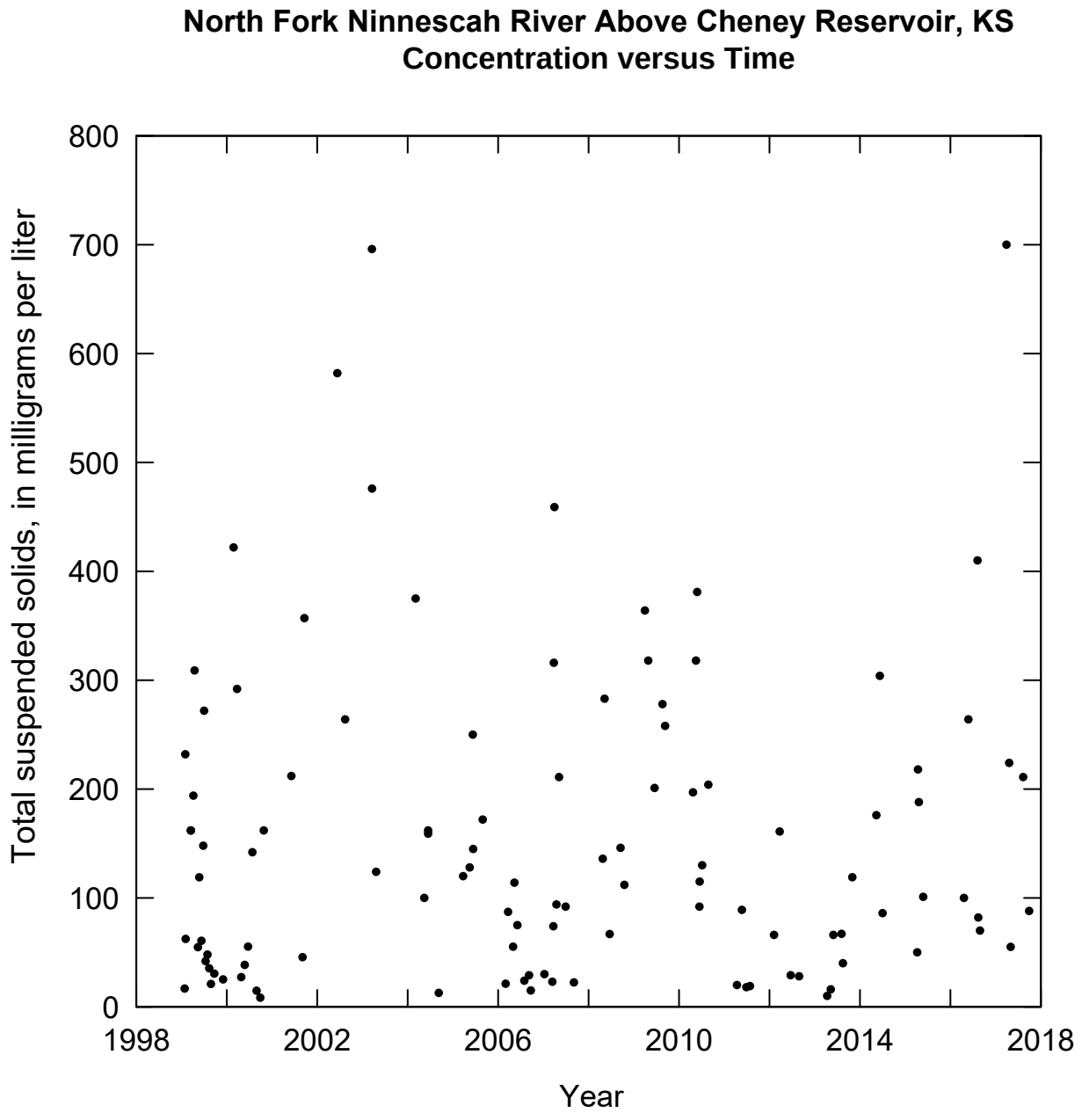


```
boxQTwice(wrtds, qUnit=1)
```

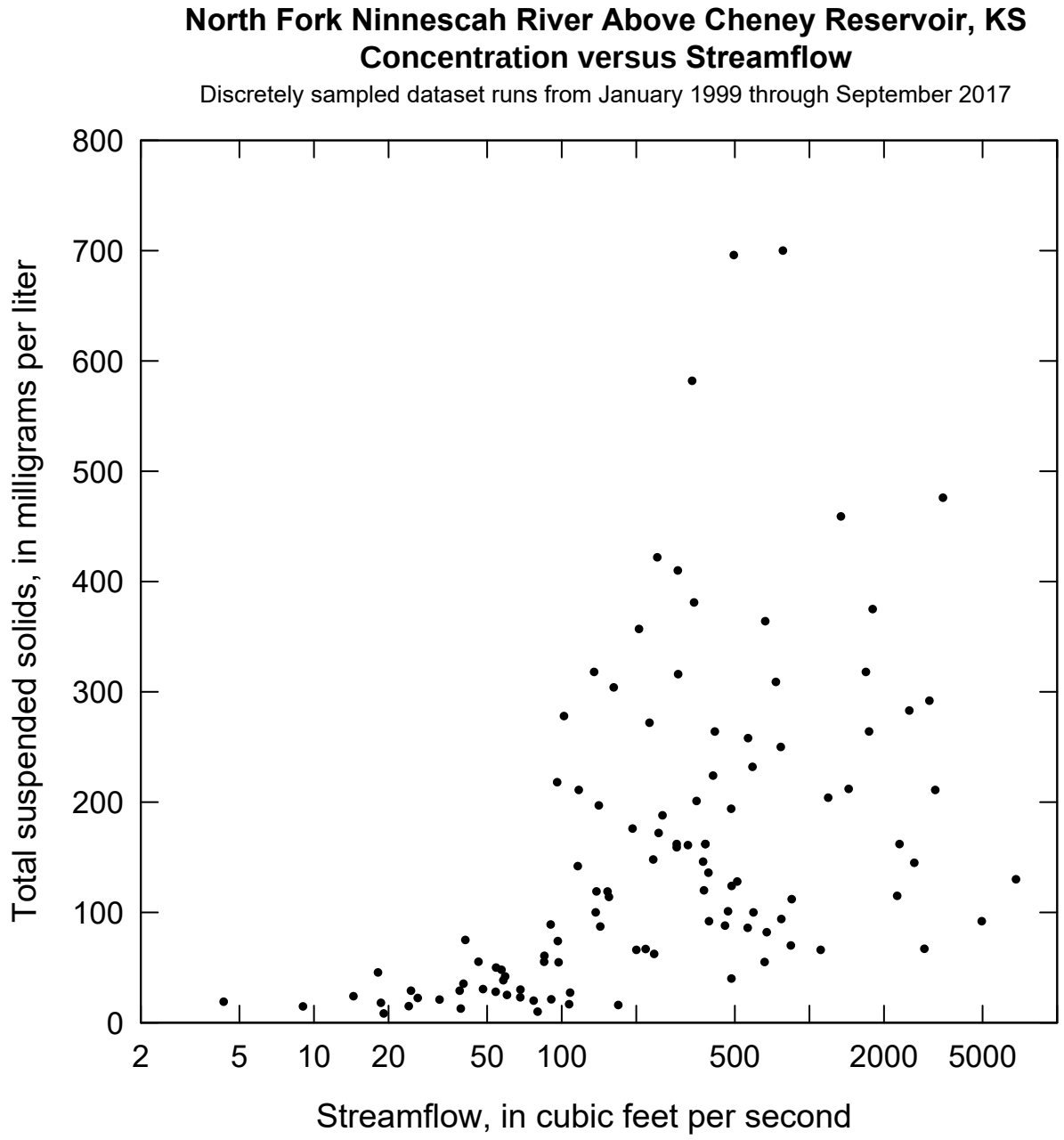




```
plotConcTime(wrtds)
```



```
plotConcQ(wrtds, qUnit=1)
```



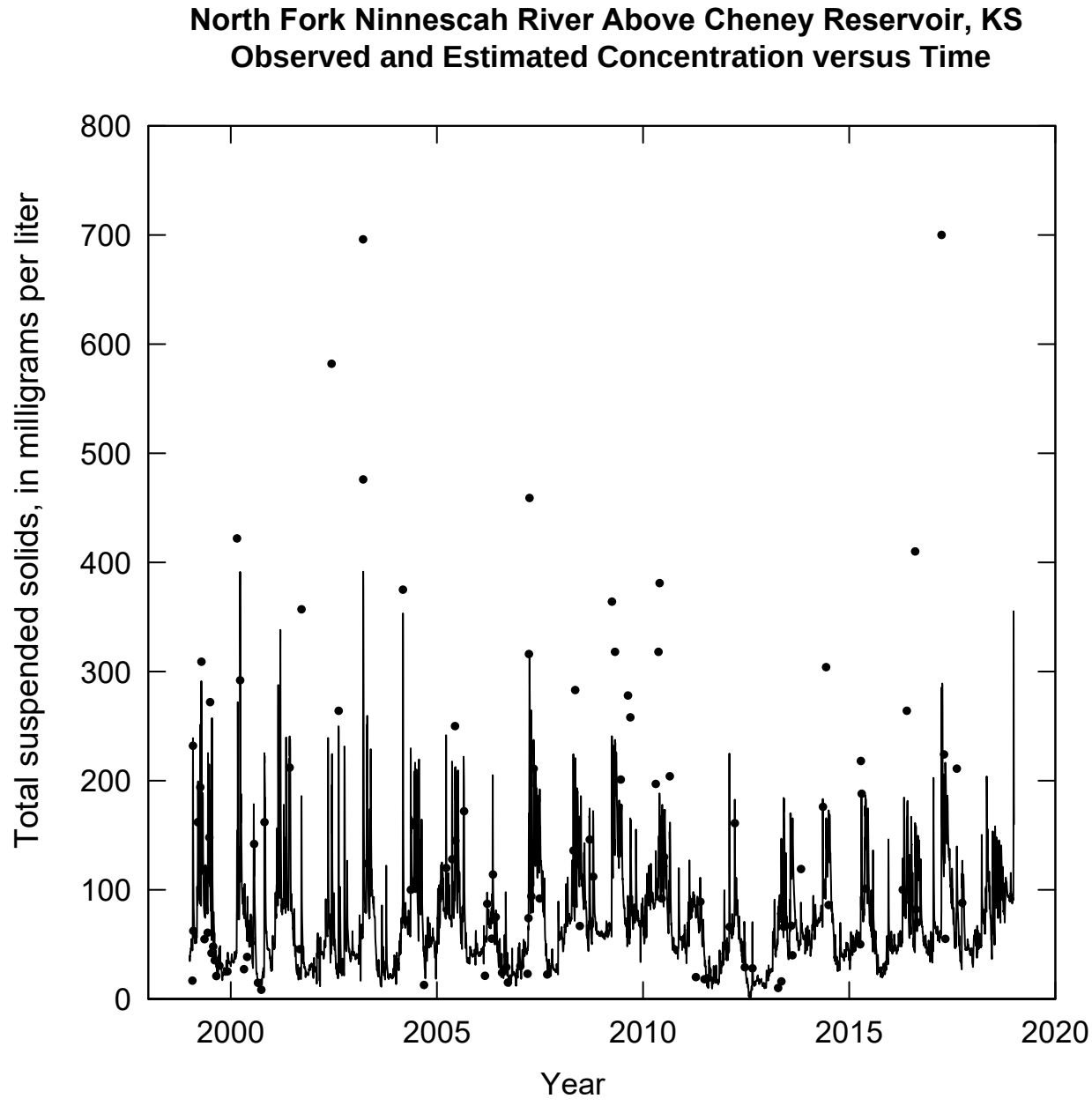
Weighted Regression on Time, Discharge, and Season Model Results

```
fluxBiasStat(wrtds$Sample)
```

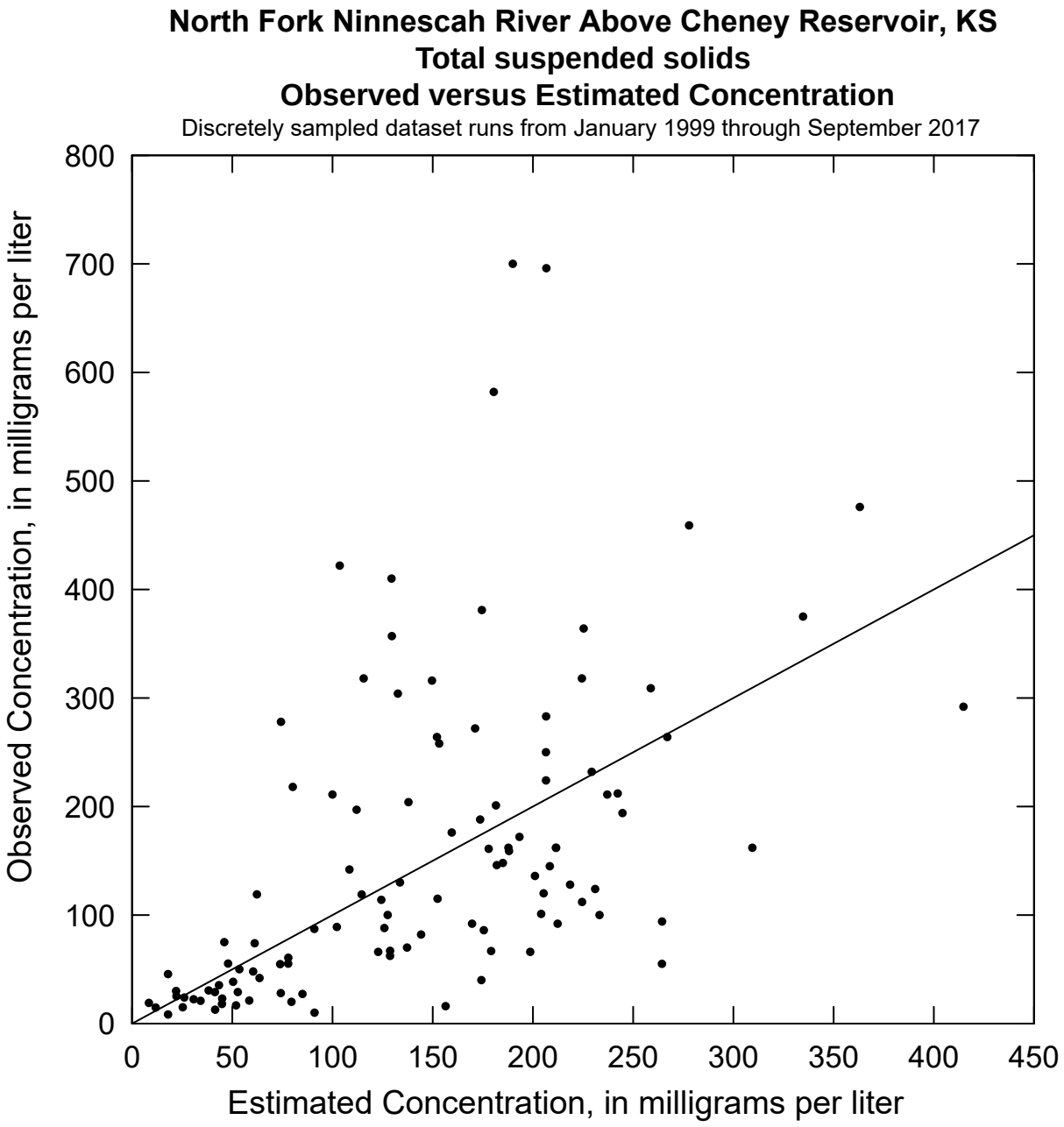
```
##             bias1
## 0.011508926993343
```

The flux bias statistic is (Mean Of Estimated Flux - Mean Of Observed Flux) / Mean Of Observed Flux. The statistic assumes all the censored values are the mean. In Hickman and Hirsch (2017) they used -0.20 to 0.20 as guidance for acceptability of the flux bias statistic.

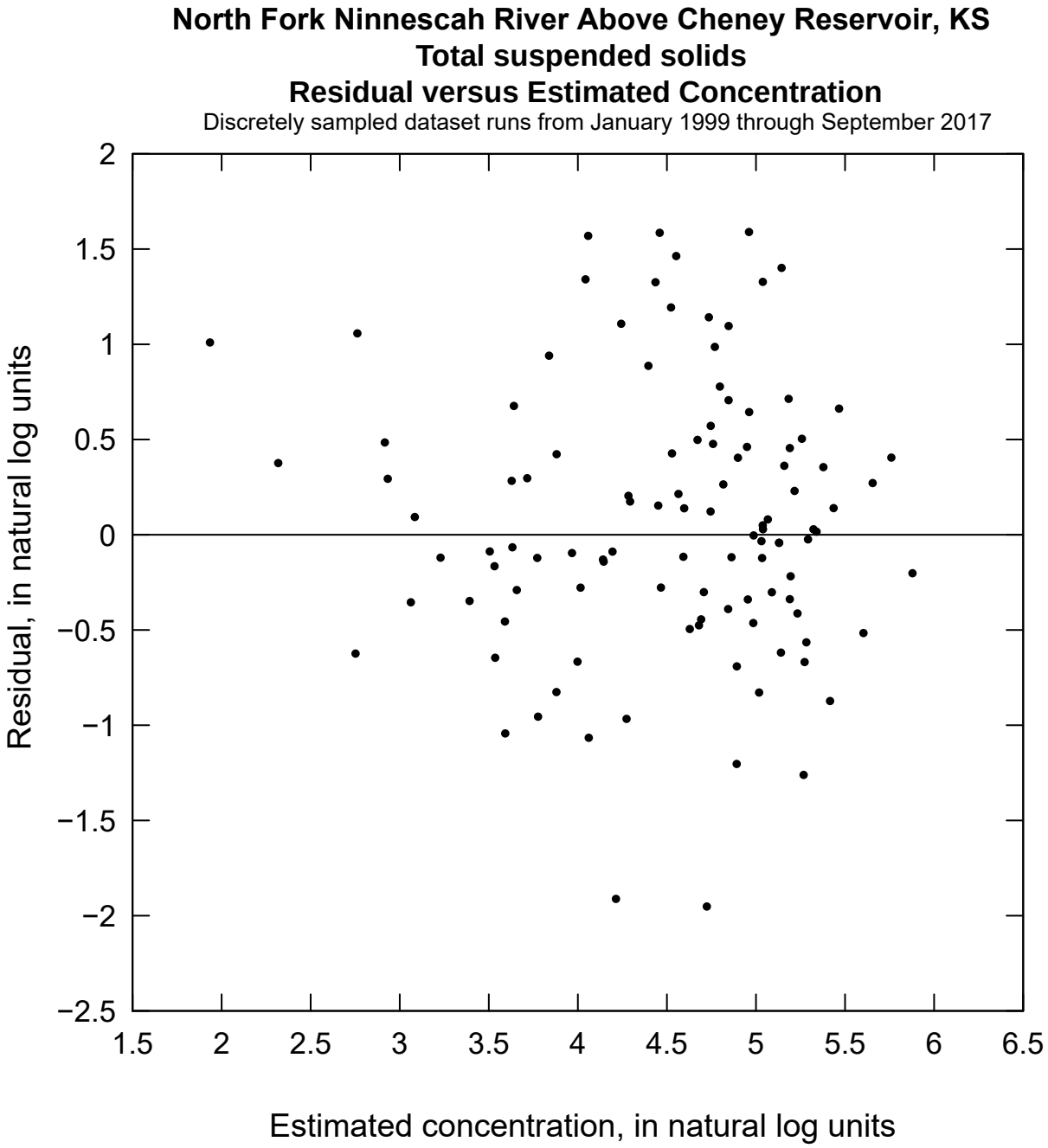
```
plotConcTimeDaily(wrtds)
```



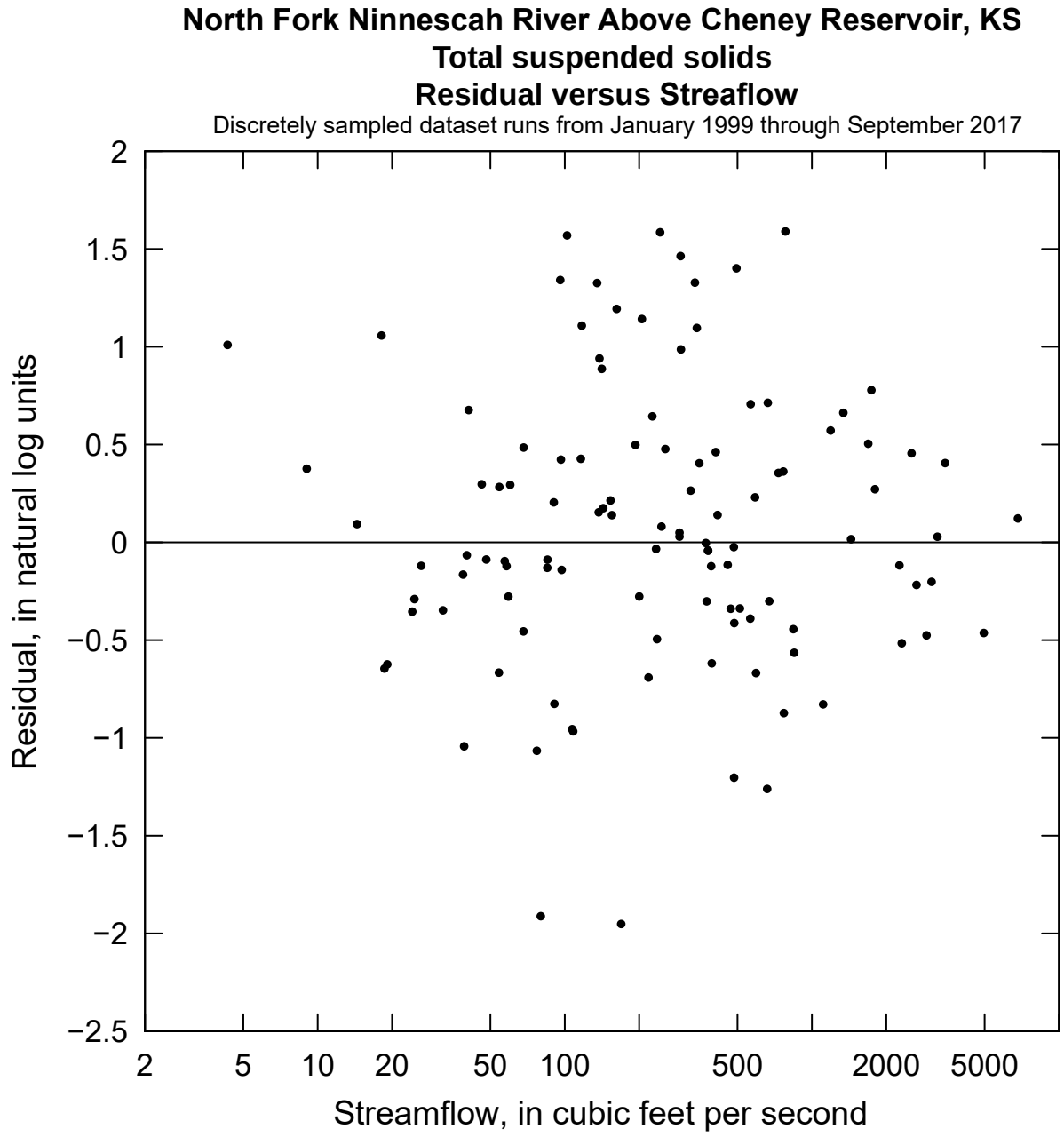
```
plotConcPred(wrtds)
```



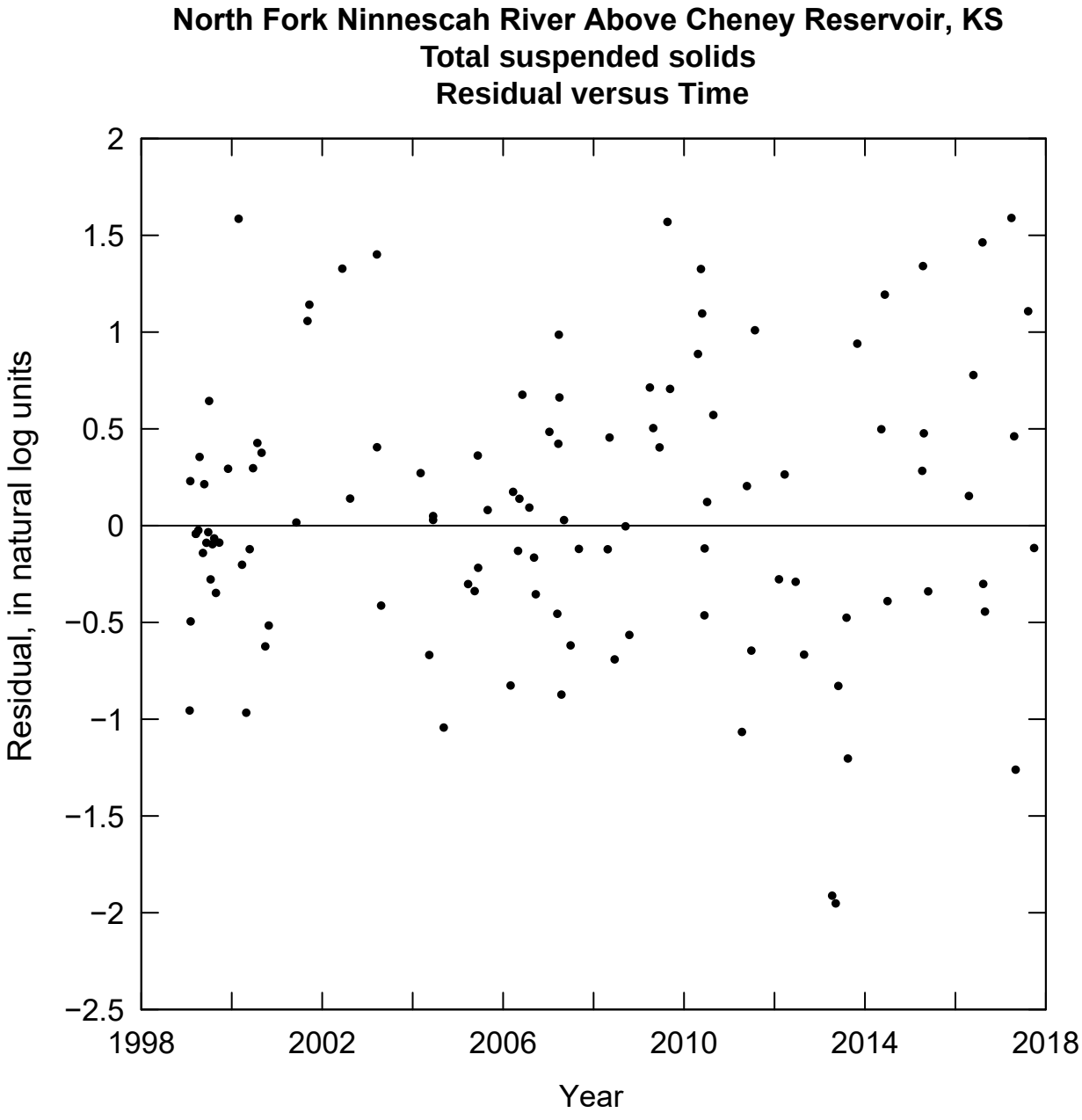
```
plotResidPred(wzrtds)
```



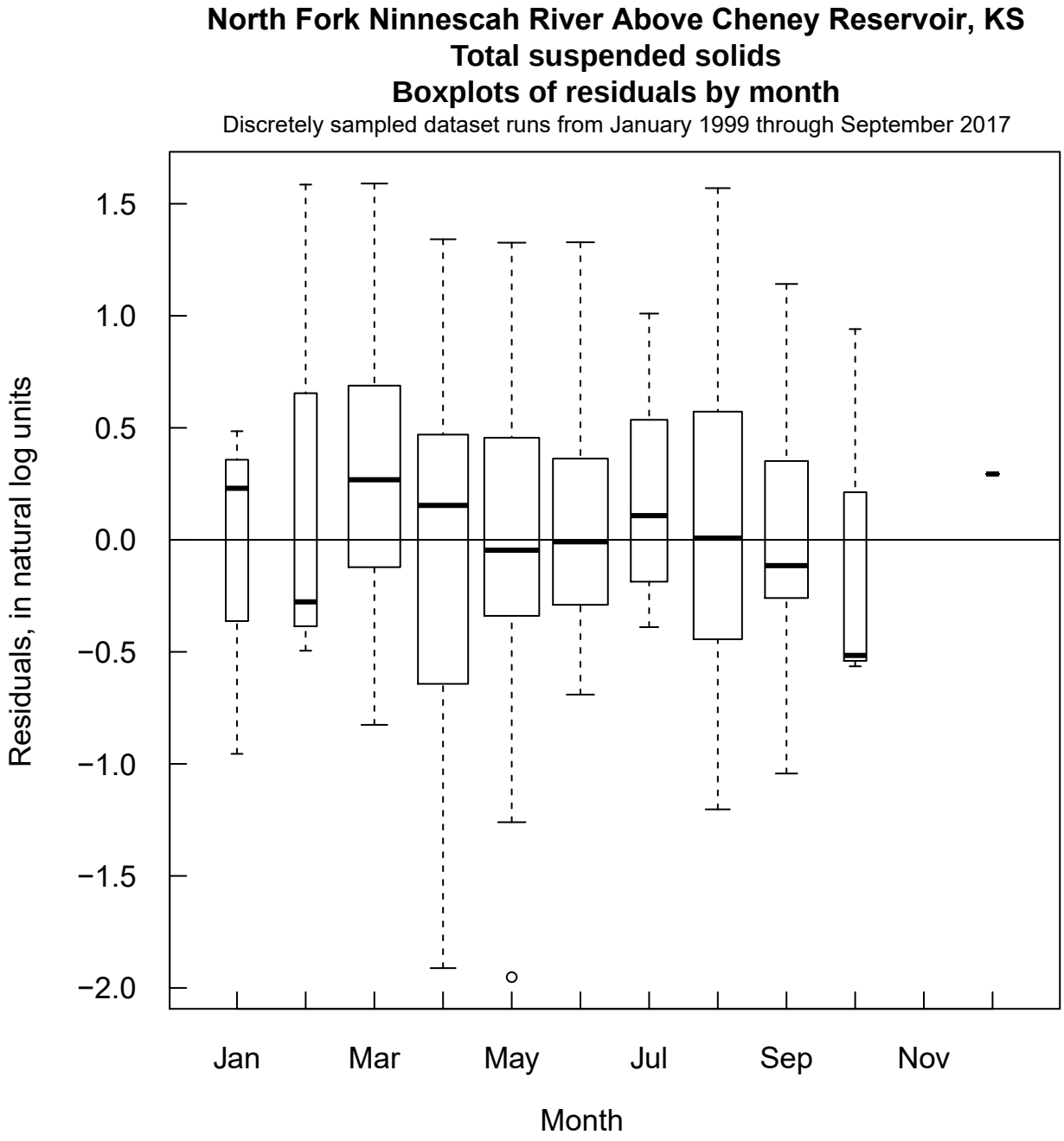
```
plotResidQ(wrtds, qUnit=1)
```

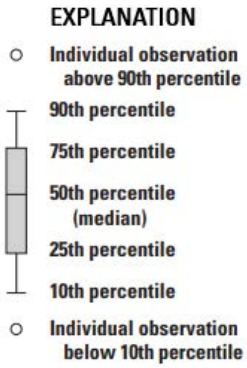


```
plotResidTime(wrtds)
```

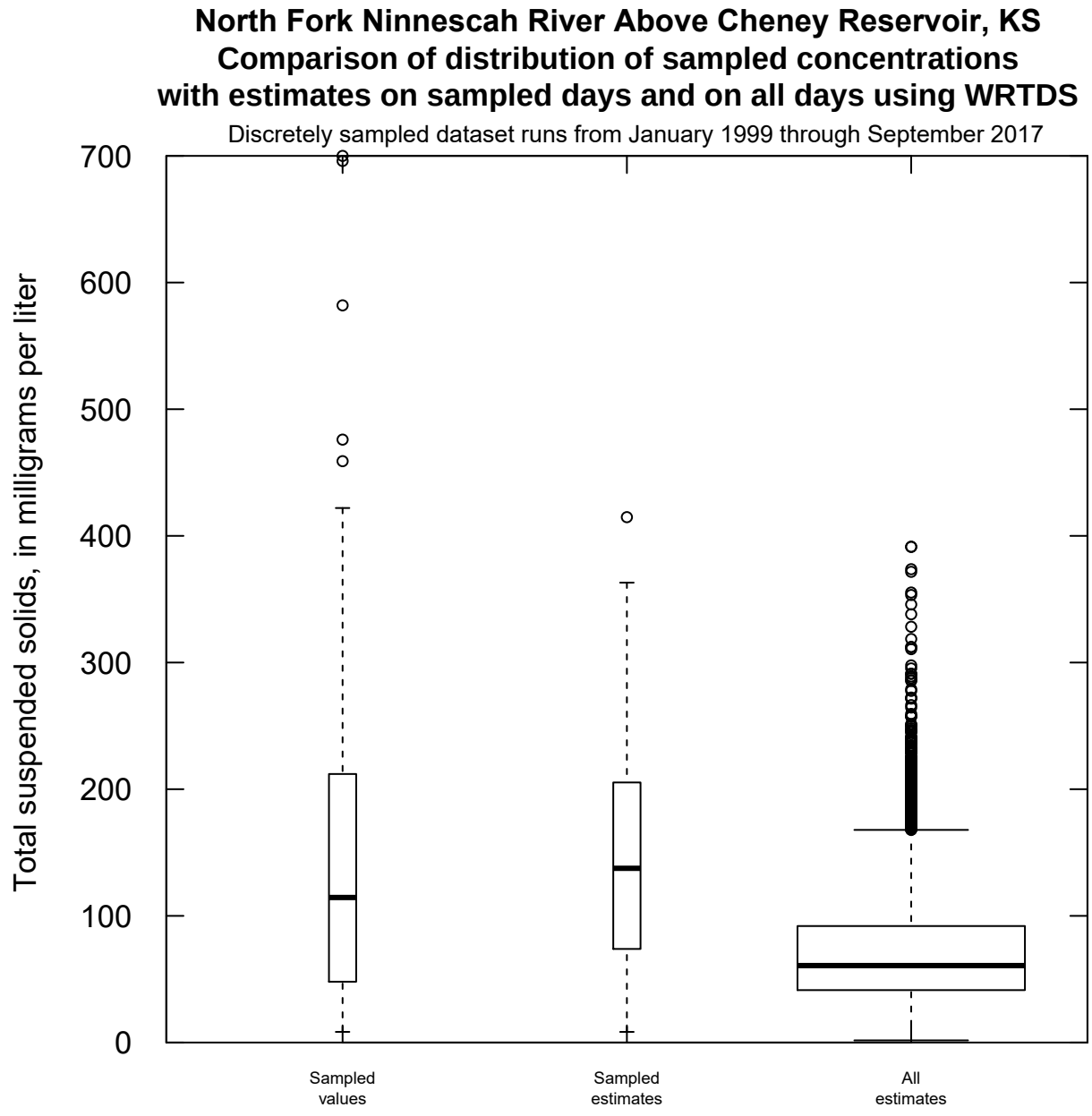


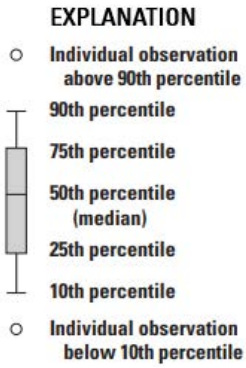
```
boxResidMonth(wrtds)
```



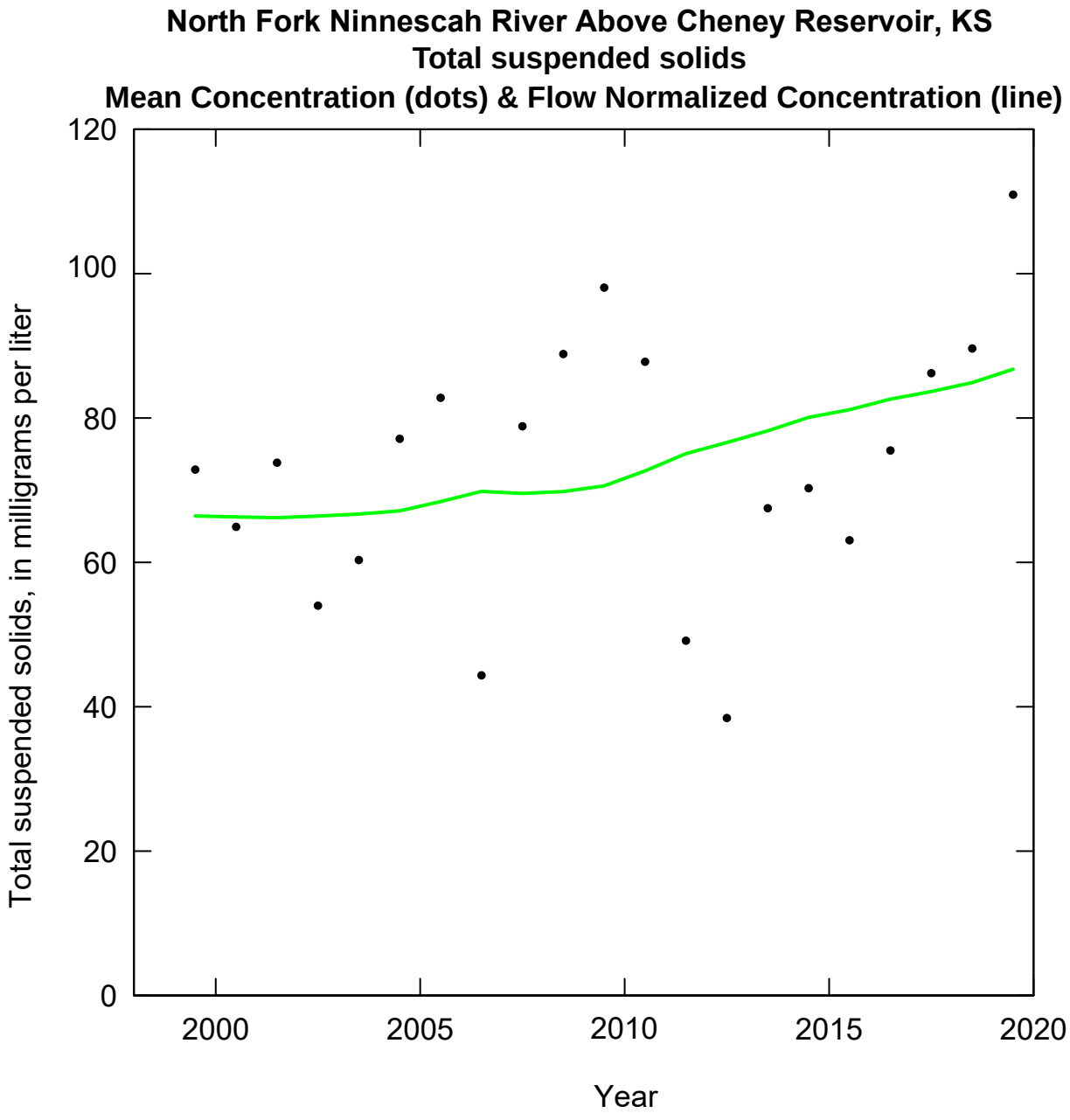


```
boxConcThree(wrtds)
```

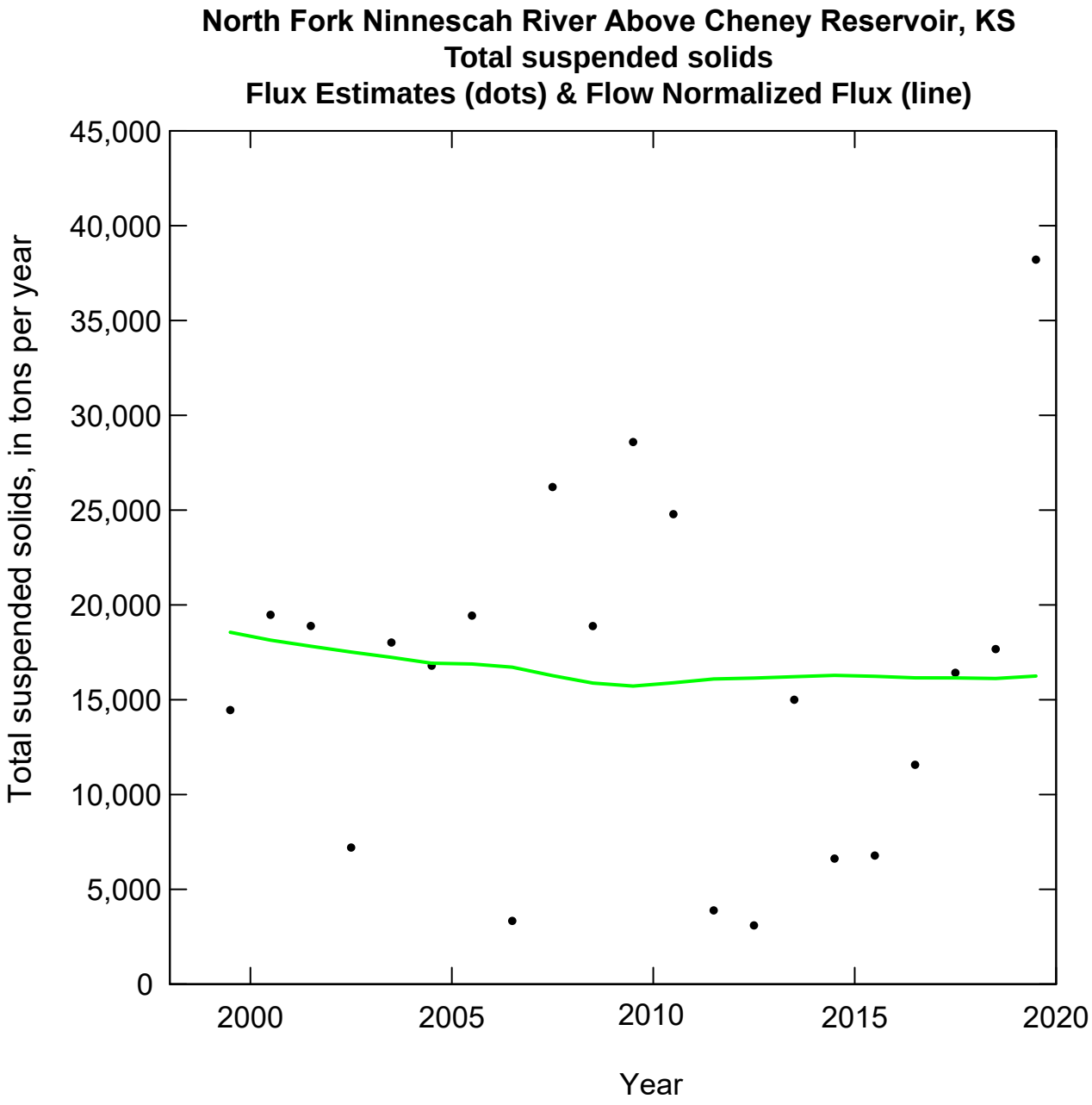




```
plotConcHist(wrtds)
```



```
plotFluxHist(wrtds)
```



Trend (using EGRETci)

North Fork Ninnescah River Above Cheney Reservoir, KS Total suspended solids

Calendar Year
Bootstrap process, for change from calendar Year 1999 to 2017 data set runs
from January 1999 to September 2017

Bootstrap block length in days 200
bootBreak is 39 confStop is 0.7

Weighted Regressions on Time, Discharge and Season (WRTDS) estimated
concentration change is 20.3 milligrams per year (mg/L)

WRTDS estimated flux change is -1.697 10^6 kilograms per year (kg/yr)

Should we reject Ho that Flow Normalized Concentration Trend = 0 ? Do Not Reject Ho
best estimate is 20.3 mg/L
Lower and Upper 90% CIs -7.08 80.93
also 95% CIs -8.40 89.97
and 50% CIs 8.62 35.15

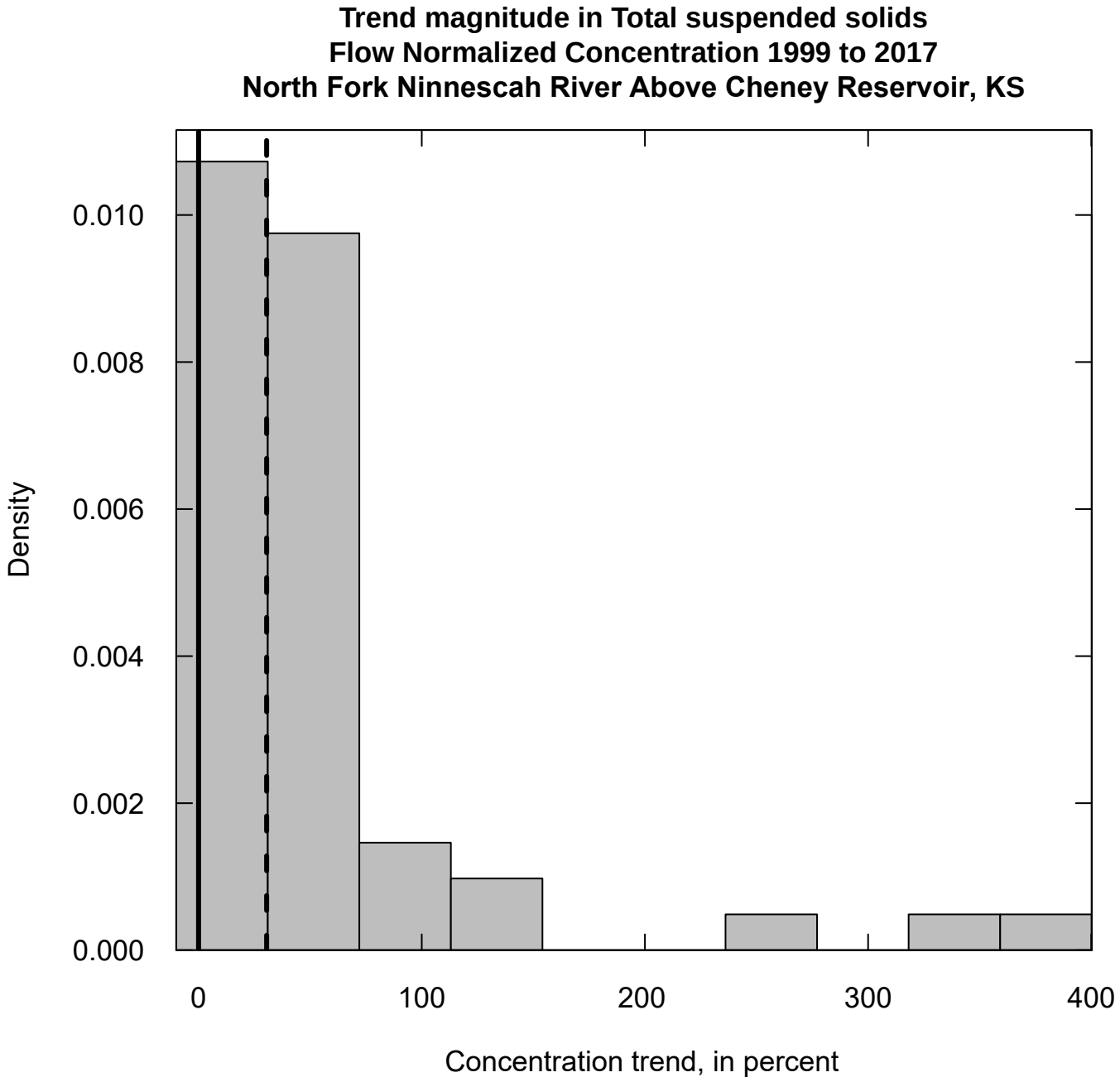
approximate two-sided p-value for Conc 0.17

Likelihood that Flow Normalized Concentration is trending up = 0.912 is trending down = 0.0882

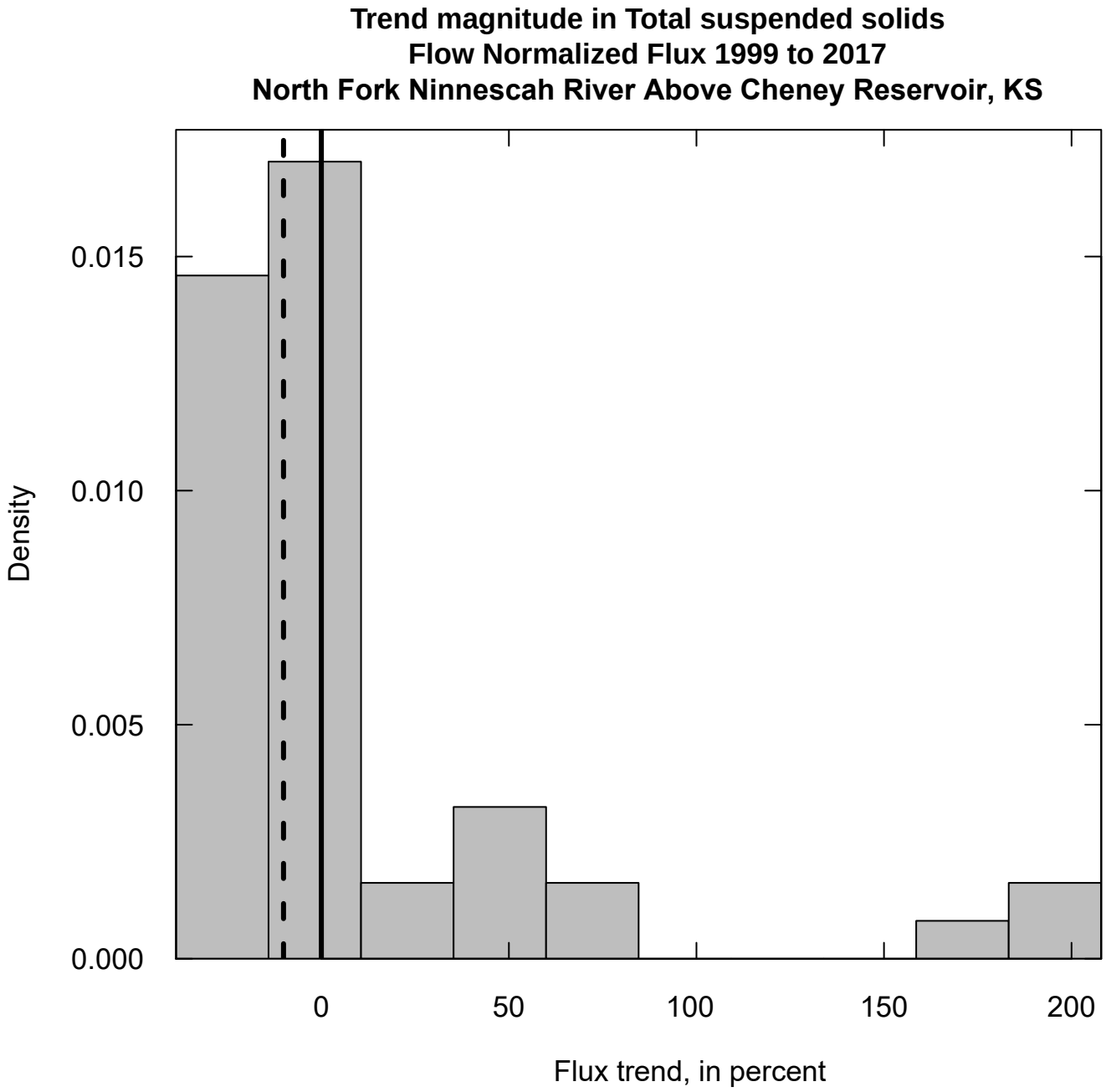
Should we reject Ho that Flow Normalized Flux Trend = 0 ? Do Not Reject Ho
best estimate is -1.697 10^6 kg/year
Lower and Upper 90% CIs -7.06 9.91
also 95% CIs -7.70 14.85
and 50% CIs -3.16 1.56
approximate two-sided p-value for Flux 0.73
Likelihood that Flow Normalized Flux is trending up = 0.363 is trending down= 0.637

Upward trend in concentration is very likely
Upward trend in flux is about as likely as not
Downward trend in concentration is very unlikely
Downward trend in flux is about as likely as not

```
par(mar=c(5,6,5,0))
par(mfrow=c(2,1))
plotHistogramTrend(wrtds, eBoot, caseSetUp, flux=FALSE)
plotHistogramTrend(wrtds, eBoot, caseSetUp, flux=TRUE)
```

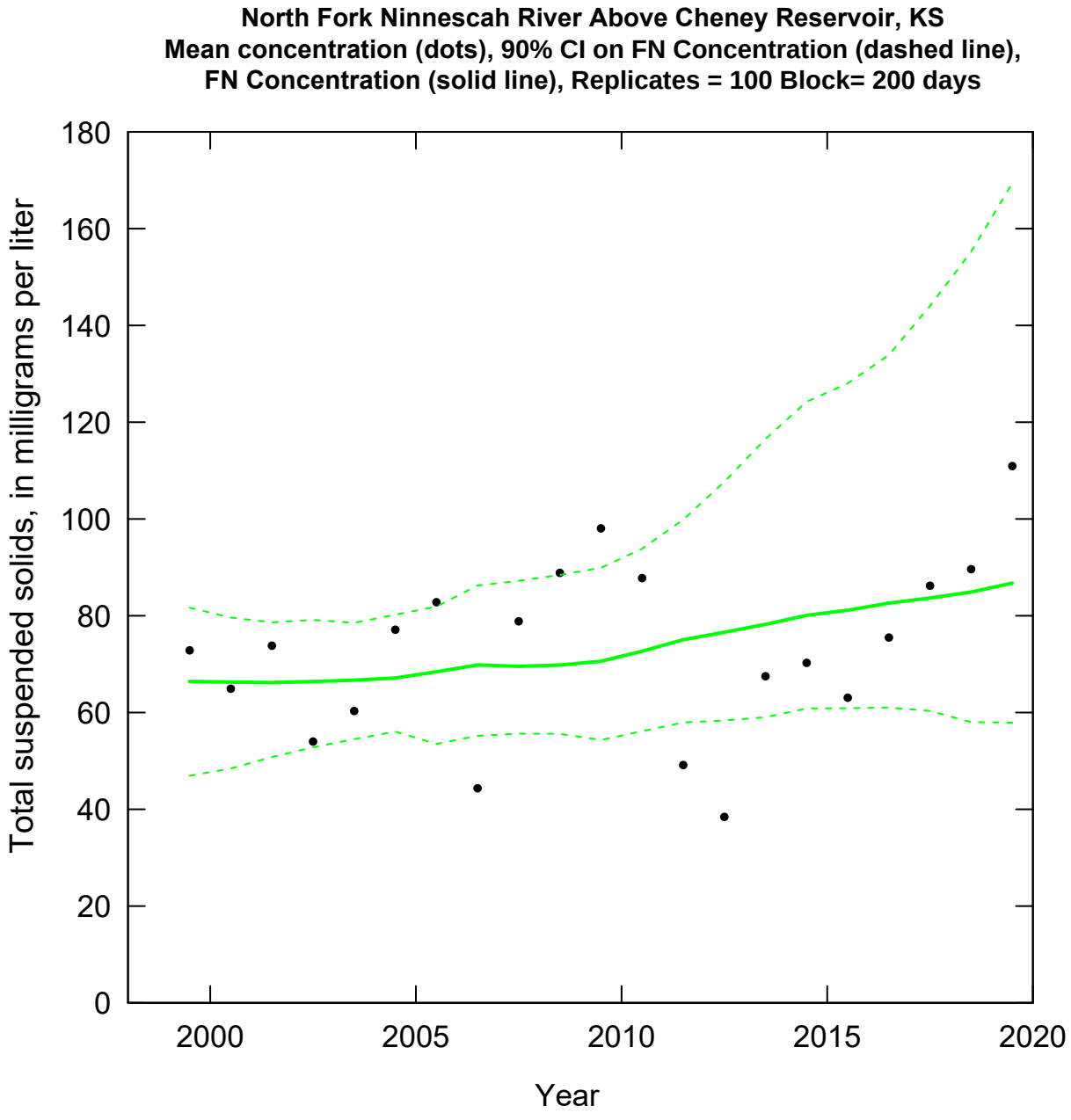


solid line = zero line (no trend)
dashed line = WRTDS trend estimate

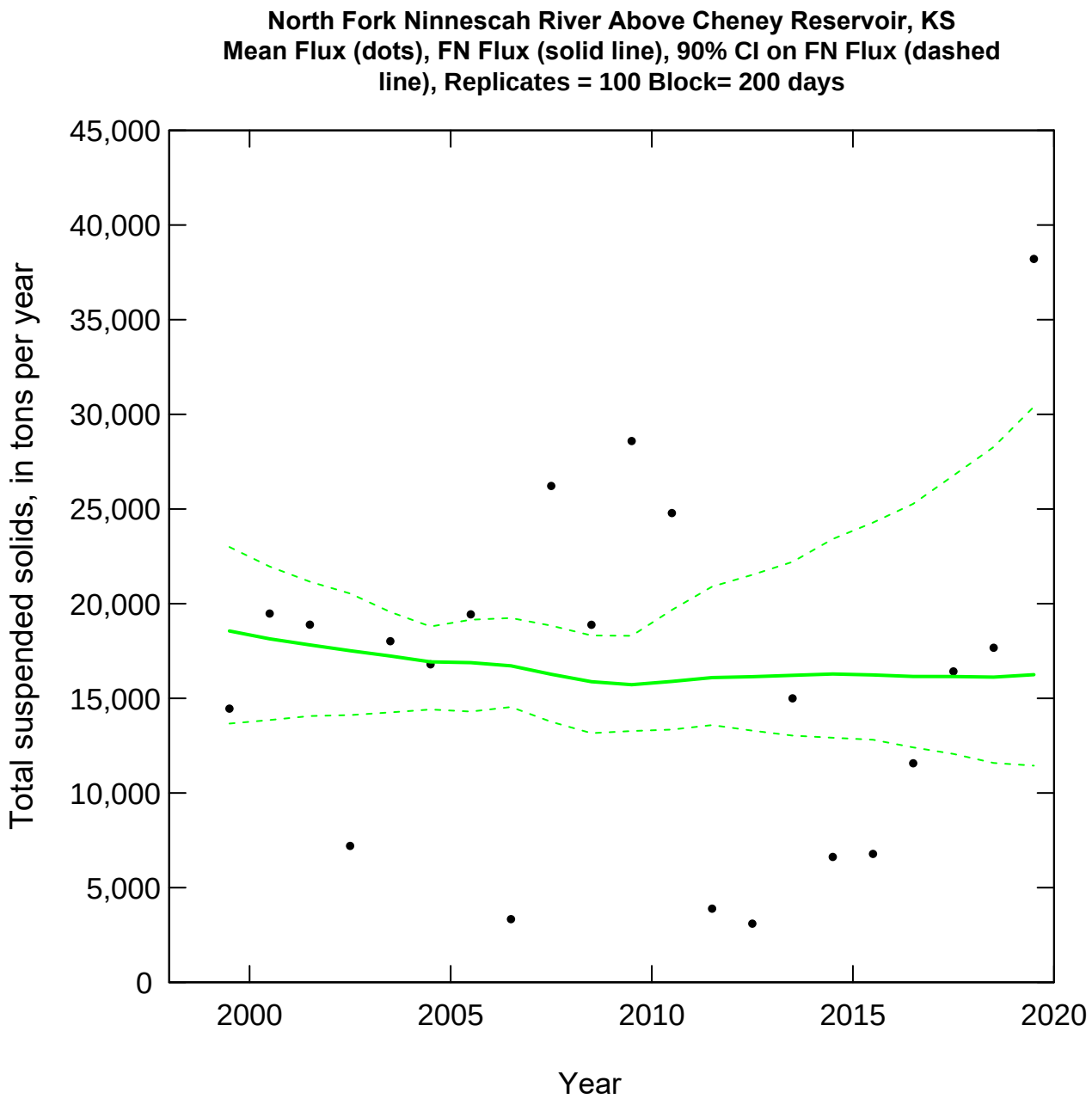


solid line = zero line (no trend)
dashed line = WRTDS trend estimate

```
par(mfrow=c(2,1))
plotConcHistBoot(wrtds, CIAnnualResults)
plotFluxHistBoot(wrtds, CIAnnualResults)
```



FN = Flow Normalized
CI = Confidence Interval



FN = Flow Normalized
CI = Confidence Interval

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References Cited

Hickman, R.E., and Hirsch, R.M., 2017, Trends in the quality of water in New Jersey streams, water years 1971–2011: U.S. Geological Survey Scientific Investigations Report 2016–5176, 58 p., accessed July 2020 at https://doi.org/10.3133/sir20165176.

Hirsch, R.M., Archfield, S.A., and De Cicco, L.A., 2015, A bootstrap method for estimating uncertainty of water quality trends: Environmental Modelling & Software, v. 73, p. 148–166. [Also available at https://doi.org/10.1016/j.envsoft.2015.07.017.]

Hirsch, R.M., and De Cicco, L.A., 2015, User guide to Exploration and Graphics for RivEr Trends (EGRET) and dataRetrieval—R packages for hydrologic data (ver. 2.0, February 2015): U.S. Geological Survey Techniques and Methods, book 4, chap. A10, 93 p., accessed July 2020 at https://doi.org/10.3133/tm4A10.

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