Mass Discharge - Outlet Alteck. 2016

PAZ

27 octobre 2016

Purpose

This file computes the discharged mass observed at the outlet. To do that it imports the weekly discharge summary and lab results for isotopes (^{13}C) and s-metolachlor concentrations.

Imports:

- **WeeklyHydro_R.csv** (R generated)
- **fluxAlteck2016_R.csv** (R generated)
- **OutletConc_W0toW17.csv**
- **MESAlteckWater.csv** (Concentration in filters)
- **Outlet_Isotopes_W0toW17.csv**
- **MESAlteck_FilterIsotopes.csv** (Isotopes in filters)
- **Outlet_ESAOXA_W0toW17.csv**
- **AO-Hydrochem.csv**

Generates:

- **WeeklyHydroContam_R.csv**

Required R-packages:

```
library("stringr")
library("plyr")
library("dplyr")
library("zoo")
library("ggplot2")
library("plotly")
```

Working directory

```
# setwd("D:/Documents/these_pablo/Alteckendorf2016/R")
# setwd("/Users/DayTightChunks/Documents/PhD/Routput/Alteck/R")
# setwd("D:/Documents/these_pablo/Alteckendorf2016/00_TransparencyFolder")
getwd()
```

```
## [1] "/Users/DayTightChunks/Documents/PhD/HydrologicalMonitoring"
```

Outlet Data - Alteckendorf 2016

1. Hydrological data on a subweekly basis

```
weeklyhydro = read.csv2("Data/WeeklyHydro_R.csv", header = TRUE)
colnames(weeklyhydro)[colnames(weeklyhydro) == "ID"] <- "WeekSubWeek"
head(weeklyhydro)
```

```
##   WeekSubWeek AveDischarge.m3.h Volume.m3 Sampled.Hrs     Sampled
## 1       W0-0x          1.204775  14.41714    11.96667 Not Sampled
## 2        W0-1          1.213511 100.15508    82.53333     Sampled
## 3       W0-2x          1.284719  48.34827    37.63333 Not Sampled
## 4        W1-1         14.316647 390.36726    27.26667     Sampled
## 5        W1-2         15.529299 359.24445    23.13333     Sampled
## 6       W1-3x          9.107720 877.37700    96.33333 Not Sampled
```

```
weeklyflux = read.csv2("Data/fluxAlteck2016_R.csv", header = TRUE)
head(weeklyflux)
```

```
##   WeekSubWeek                  ti                  tf     iflux     fflux
## 1       W0-0x 2016-03-25 00:04:00 2016-03-25 12:02:00  1.248600  1.129227
## 2        W0-1 2016-03-25 12:04:00 2016-03-28 22:36:00  1.124382  1.313125
## 3       W0-2x 2016-03-28 22:38:00 2016-03-30 12:16:00  1.308100  1.456349
## 4        W1-1 2016-03-30 12:18:00 2016-03-31 15:34:00  1.456080 16.445436
## 5        W1-2 2016-03-31 15:36:00 2016-04-01 14:44:00 16.334349 15.184536
## 6       W1-3x 2016-04-01 14:46:00 2016-04-05 15:06:00 15.203629  5.856380
##   changeflux      maxQ      minQ      dryHrs Duration.Hrs  chExtreme Event
## 1 -0.1193728  1.248600  1.118296  0.01666667     11.96667 -0.1303036    NA
## 2  0.1887431  1.380388  1.082199  6.01666667     82.53333  0.2560062    NA
## 3  0.1482496  1.637782  0.929055 47.30000000     37.63333  0.3296817    NA
## 4 14.9893566 38.399790  1.448977 66.13333333     27.26667 36.9437102     1
## 5 -1.1498131 18.668972 13.201113  1.65000000     23.13333 -3.1332355    NA
## 6 -9.3472489 15.895640  5.471042  6.26666667     96.33333 -9.7325862    NA
##    Markers TimeDiff
## 1       NA     <NA>
## 2       NA     <NA>
## 3       NA     <NA>
## 4 16.88972       24
## 5       NA     <NA>
## 6       NA     <NA>
```

2. Concentration data (dissolved and suspended solids) on a subweekly basis

```
outletConc = read.csv2("Data/OutletConc_W0toW17.csv", header = T)
outletConc$ID4 <- as.character(outletConc$ID4)
outletConc <- outletConc[outletConc$ID4 != "J+7", ]
outletConc <- outletConc[,c("WeekSubWeek", "Conc.mug.L", "Conc.SD")]
head(outletConc)
```

```
##   WeekSubWeek Conc.mug.L Conc.SD
## 1        W0-1  0.2456594 0.01931
## 2        W1-1  6.7882463 0.28942
## 3        W1-2  6.5609982 0.19064
## 4        W2-1  9.4443019 0.33354
## 5        W2-2  1.0421883 0.03904
## 6        W3-1  8.8357358 0.47086
```

```
filters = read.csv2("Data/MESAlteckWater.csv")
filters$MO.mg.L = ifelse(filters$MO.mg.L < 0, 0.0001, filters$MO.mg.L)
head(filters)
```

```
##   WeekSubWeek  MES.mg.L MES.sd MO.mg.L Conc.Solids.mug.gMES
## 1        W0-1  53.44444     NA  0.0000           0.64472899
## 2        W1-1  62.50000     NA  0.0010           0.12588974
## 3        W1-2  22.50000     NA  0.0001           0.43578716
## 4        W2-1  22.50000     NA  0.0001           0.07935267
## 5        W2-2   5.00000     NA  0.0001           0.05075270
## 6        W3-1 197.50000     NA  0.0058           0.08177487
##   Conc.Solids.ug.gMES.SD
## 1            0.023237548
## 2            0.027063685
## 3            0.123237064
## 4            0.004683719
## 5            0.001027205
## 6            0.001343089
```

```
# MESA/MOXA data cleaning
outletESAOXA = read.csv2("Data/Outlet_ESAOXA_W0toW17.csv", header = T)
outletESAOXA$ID <- as.character(outletESAOXA$ID)
split <- strsplit(outletESAOXA$ID, "-", fixed = TRUE)
outletESAOXA$ESAOXA_SD <- sapply(split, "[", 4)
split_vor <- strsplit(outletESAOXA$ID, "-SD", fixed = TRUE)
outletESAOXA$ESAOXA_Mean <- sapply(split_vor, "[", 1)

means_temp <- subset(outletESAOXA, is.na(outletESAOXA$ESAOXA_SD))
sd_temp <- subset(outletESAOXA, !is.na(outletESAOXA$ESAOXA_SD))
means_temp$ID <- NULL
sd_temp$ID <- NULL

head(sd_temp)
```

```
##      MOXA.ugL  MESA.ugL ESAOXA_SD ESAOXA_Mean
## 2   1.1414453 3.4972206        SD     AO-W0-1
## 4  10.1852510 3.0369845        SD     AO-W1-1
## 6   0.2430544 0.8533820        SD     AO-W1-2
## 8   1.1526489 2.8261924        SD     AO-W2-1
## 10  0.6100011 0.1910419        SD     AO-W2-2
## 12  2.6589421 0.3268637        SD     AO-W3-1
```

```
head(means_temp)
```

```
##      MOXA.ugL MESA.ugL ESAOXA_SD ESAOXA_Mean
## 1    4.824094 18.05531      <NA>     AO-W0-1
## 3   30.531235 45.98364      <NA>     AO-W1-1
## 5   32.492465 41.28052      <NA>     AO-W1-2
## 7  104.541255 98.56782      <NA>     AO-W2-1
## 9   26.885849 51.95245      <NA>     AO-W2-2
## 11  45.080673 24.04717      <NA>     AO-W3-1
```

```
outletESAOXA <- merge(means_temp, sd_temp, by = "ESAOXA_Mean", all = T)
outletESAOXA$ESAOXA_SD.x <- NULL
outletESAOXA$ESAOXA_SD.y <- NULL
split_ID <- strsplit(outletESAOXA$ESAOXA_Mean, "AO-", fixed = T)
outletESAOXA$ID <- sapply(split_ID, "[", 2)
outletESAOXA$ESAOXA_Mean <- NULL
outletESAOXA <- outletESAOXA[ , c("ID", "MOXA.ugL.x", "MOXA.ugL.y", "MESA.ugL.x", "MESA.ugL.y")]
colnames(outletESAOXA) <- c("WeekSubWeek", "OXA_mean", "OXA_SD", "ESA_mean",  "ESA_SD")
```

```
outletESAOXA$WeekSubWeek <- as.factor(outletESAOXA$WeekSubWeek)

head(outletESAOXA)
```

```
##   WeekSubWeek  OXA_mean      OXA_SD ESA_mean    ESA_SD
## 1        W0-1  4.824094  1.14144531 18.05531 3.4972206
## 2        W1-1 30.531235 10.18525095 45.98364 3.0369845
## 3        W1-2 32.492465  0.24305444 41.28052 0.8533820
## 4       W10-1 21.311423  0.05168437 82.87549 1.8167218
## 5       W10-2 13.095046  0.17703516 12.02387 0.3057521
## 6       W10-3 45.605808  1.92663562 11.31492 0.1763479
```

3. Isotope data

Isotopes selected where cleaned according to the following rules:

a) The isotope shift was not largely beyond (2x) Streitwieser theoretical limits (i.e. > 10)
b) Isotope shift was non-negative
c) Nanograms of carbon > 2.0.

```
# Outlet isotope data:

outletIso = read.csv2("Data/Outlet_Isotopes_W0toW17.csv", header = T)
if (length(outletIso) == 1){
  outletIso = read.csv("Data/Outlet_Isotopes_W0toW17.csv", header = T)
}
head(outletIso)
```

```
##   FileHeader..Filename ID Week Wnum SubWeek WeekSubWeek Repl d.13C.12C
## 1       AO_W2_2-1_.dxf AO   W2    2       2        W2-2    1   -28.609
## 2       AO_W2_2-2_.dxf AO   W2    2       2        W2-2    2   -28.894
## 3       AO_W2_2-3_.dxf AO   W2    2       2        W2-2    3   -28.503
## 4  AO_W3_1-1_-0001.dxf AO   W3    3       1        W3-1    1   -29.838
## 5  AO_W3_1-2_-0001.dxf AO   W3    3       1        W3-1    2   -29.840
## 6  AO_W3_1-3_-0001.dxf AO   W3    3       1        W3-1    3   -30.073
##   DD13...31.21. Ave...STDEV     Rt Ampl..44 Std.Ampl.    ng..C. no.ng10
## 1         2.601   0.2022136 2656.2      127       658  5.790274       0
## 2         2.316          NA 2656.2      163       658  7.431611       0
## 3         2.707          NA 2655.3      176       658  8.024316       0
## 4         1.372   0.1351037 2648.9      914       858 31.958042       1
## 5         1.370          NA 2649.3      905       858 31.643357       1
## 6         1.137          NA 2649.5      941       858 32.902098       1
```

```
colnames(outletIso)[colnames(outletIso) == "DD13...31.21."] <- "DD13"
colnames(outletIso)[colnames(outletIso) == "ng..C."] <- "ngC"
outletIso <- subset(outletIso, DD13 > 0 & DD13 < 10 & ngC >= 2)

# Filter isotope data:

filtersIso = read.csv2("Data/MESAlteck_FilterIsotopes.csv", header = T)
#filtersIso <- filtersIso[filtersIso$Level != "J+7", ]
if (length(filtersIso) == 1){
  filtersIso = read.csv("Data/MESAlteck_FilterIsotopes.csv", header = T)
}
filtersIso$WeekSubWeek = paste(filtersIso$Week, filtersIso$Num, sep = "-")
colnames(filtersIso)[colnames(filtersIso) == "DD13...31.21."] <- "DD13"
colnames(filtersIso)[colnames(filtersIso) == "ng..C."] <- "ngC"
```

```
head(filtersIso)
```

```
##    ID Week Wnum Num Levl Repl d.13C.12C  DD13       ngC WeekSubWeek
## 1 AFP   W2    1   1   NA    1   -25.154 6.056 0.7300885        W2-1
## 2 AFP   W2    1   1   NA    2   -28.187 3.023 0.8296460        W2-1
## 3 AFP   W2    1   1   NA    3   -28.283 2.927 0.8296460        W2-1
## 4 AFP   W2    2   2   NA    1   -30.618 0.592 0.6637168        W2-2
## 5 AFP   W2    2   2   NA    2   -26.304 4.906 0.7300885        W2-2
## 6 AFP   W2    2   2   NA    3   -26.024 5.186 0.7300885        W2-2
```

4. Hydrochemistry Data

```
hydroChem = read.csv2("Data/AO-Hydrochem.csv", header = T)
hydroChem = hydroChem[, c("WeekSubWeek",
                          "NH4.mM",
                          "TIC.ppm.filt",
                          "Cl.mM",
                          "NO3...mM",
                          "PO4..mM",
                          "NPOC.ppm" ,
                          "TIC.ppm.unfilt",
                          "TOC.ppm.unfilt" )]
head(hydroChem)
```

```
##   WeekSubWeek NH4.mM TIC.ppm.filt   Cl.mM NO3...mM PO4..mM NPOC.ppm
## 1        W1-1   0.05         51.8    1.48   616.00      NA      4.0
## 2        W1-2     NA         44.8 1574.00   778.00      NA      4.4
## 3       W10-1     NA         60.1    1.17   964.00      NA      2.0
## 4       W10-2   9.00         57.1 1013.00  1174.00      13      5.2
## 5       W10-3     NA         58.2  858.00     1.23      NA      5.0
## 6       W10-4  15.00         26.4  355.00  1409.00      NA      6.4
##   TIC.ppm.unfilt TOC.ppm.unfilt
## 1           44.8            4.7
## 2           26.4            5.4
## 3           63.2            2.0
## 4           55.9            4.0
## 5           60.4            4.3
## 6           24.5            6.4
```

Summarizing IRMS data

```
isoOutSummary = ddply(outletIso, c("WeekSubWeek"), summarise,
                          N    = length(d.13C.12C),
                          diss.d13C = mean(d.13C.12C),
                          SD.d13C = sd(d.13C.12C),
                          se.d13C = SD.d13C / sqrt(N),
                          N_ngC.diss = length(ngC),
                          ngC.mean.diss = mean(ngC),
                          ngC.SD.diss = sd(ngC))



head(isoOutSummary)
```

```
##   WeekSubWeek N diss.d13C   SD.d13C    se.d13C N_ngC.diss ngC.mean.diss
## 1        W1-1 3 -30.46867 0.1060016 0.06120004          3     42.692308
## 2        W1-2 3 -30.61967 0.1513550 0.08738484          3     54.696970
## 3       W10-1 2 -28.43800 0.5260874 0.37200000          2      9.811304
## 4       W10-2 3 -29.97667 0.6127261 0.35375761          3     44.807210
## 5       W10-3 3 -29.76967 0.3411749 0.19697744          3     19.092646
## 6       W10-4 3 -28.11367 0.4713240 0.27211905          3     16.921348
##   ngC.SD.diss
## 1   1.9211688
## 2   2.5407658
## 3   4.3931602
## 4  28.9991771
## 5   1.0603010
## 6   0.2430709
```

```
isoFiltSummary = ddply(filtersIso, c("WeekSubWeek"), summarise,
                       N    = length(d.13C.12C),
                       filt.d13C = mean(d.13C.12C),
                       filt.SD.d13C = sd(d.13C.12C),
                       filt.se.d13C = filt.SD.d13C / sqrt(N),
                       N_ngC.fl = length(ngC),
                       ngC.mean.fl = mean(ngC),
                       ngC.SD.fl = sd(ngC))
head(isoFiltSummary)
```

```
##   WeekSubWeek N filt.d13C filt.SD.d13C filt.se.d13C N_ngC.fl ngC.mean.fl
## 1        W2-1 3 -27.20800     1.779464    1.0273738        3   0.7964602
## 2        W2-2 3 -27.64867     2.575326    1.4868653        3   0.7079646
## 3        W6-3 3 -28.00667     1.593462    0.9199856        3   1.0619469
## 4        W9-1 2 -26.79150     1.745847    1.2345000        2   4.1783217
## 5        W9-2 3 -27.69633     2.013989    1.1627772        3   5.5594406
## 6        W9-3 3 -26.94633     1.685361    0.9730434        3   3.7645688
##    ngC.SD.fl
## 1 0.05747956
## 2 0.03831971
## 3 0.03318584
## 4 0.56865231
## 5 0.54280331
## 6 0.51189257
```

Merging and data wrangling stepts

1. Merge all data sets by the *WeekSubWeek* column ID, icluding:

```
# Dissolved
out.CoIs = merge(outletConc,  outletESAOXA, by = "WeekSubWeek", all = T)
out.CoIs = merge(out.CoIs, isoOutSummary, by = "WeekSubWeek", all = T)

# Filters (MES, Conc.MES)
out.CoIs = merge(out.CoIs, filters, by = "WeekSubWeek", all = T)
out.CoIs = merge(out.CoIs, isoFiltSummary, by= "WeekSubWeek", all = T)

# Pure and cuve isotope average
d13Co = -31.21
```

```
# Lab enrichment:
# epsilon = -1.61

# Lab enrichment:
# Alteck
epsilon_max = -1.5 # +/- 0.3 (@ 20C, 20% vwc)
epsilon_min = -2.0 # +/- 0.2 (@ 20C, 40% vwc)
epsilon_mean = -1.75

# Remaining fraction
out.CoIs$DD13C.diss <- (out.CoIs$diss.d13C - (d13Co))
out.CoIs$DD13C.filt <- (out.CoIs$filt.d13C - (d13Co))

out.CoIs$f.diss <- (((10**(-3)*out.CoIs$diss.d13C + 1)/(10**(-3)*d13Co + 1))**(1000/(epsilon_mean)))
out.CoIs$f.filt <- (((10**(-3)*out.CoIs$filt.d13C + 1)/(10**(-3)*d13Co + 1))**(1000/(epsilon_mean)))

out.CoIs$B.diss <- (1 - out.CoIs$f.diss)*100
out.CoIs$B.filt <- (1 - out.CoIs$f.filt)*100
#out.CoIs$invf <- 1/out.CoIs$f

# Discharge times
out.CoIs = merge(weeklyhydro, out.CoIs, by = "WeekSubWeek", all = T)

# Discharge summary
out.CoIs = merge(weeklyflux, out.CoIs, by = "WeekSubWeek", all = T)

# Hydrochemistrty
out.CoIs = merge(out.CoIs, hydroChem, by= "WeekSubWeek", all = T)


out.CoIs$tf <- as.POSIXct(out.CoIs$tf, "%Y-%m-%d %H:%M", tz = "EST")
out.CoIs$ti <- as.POSIXct(out.CoIs$ti, "%Y-%m-%d %H:%M", tz = "EST")
class(out.CoIs$tf)
```

```
## [1] "POSIXct" "POSIXt"
```

```
sum(is.na(out.CoIs$tf))
```

```
## [1] 7
```

```
# Temprarily remove Weeks 16 & 17 (need to get discharge data)
# No discharge data yet avaialble to multiply against...
out.CoIs <- out.CoIs[!is.na(out.CoIs$tf), ]
```

2. Weekly Exported Solids (Kg)

```
# V[m3] * MES [mg/L] * 1000 [L/m3] * [1 Kg/10^6 mg]
out.CoIs$ExpMES.Kg = out.CoIs$Volume.m3*out.CoIs$MES.mg.L/1000
```

Fork! Prepare Data for C-Q Hysteresis curves

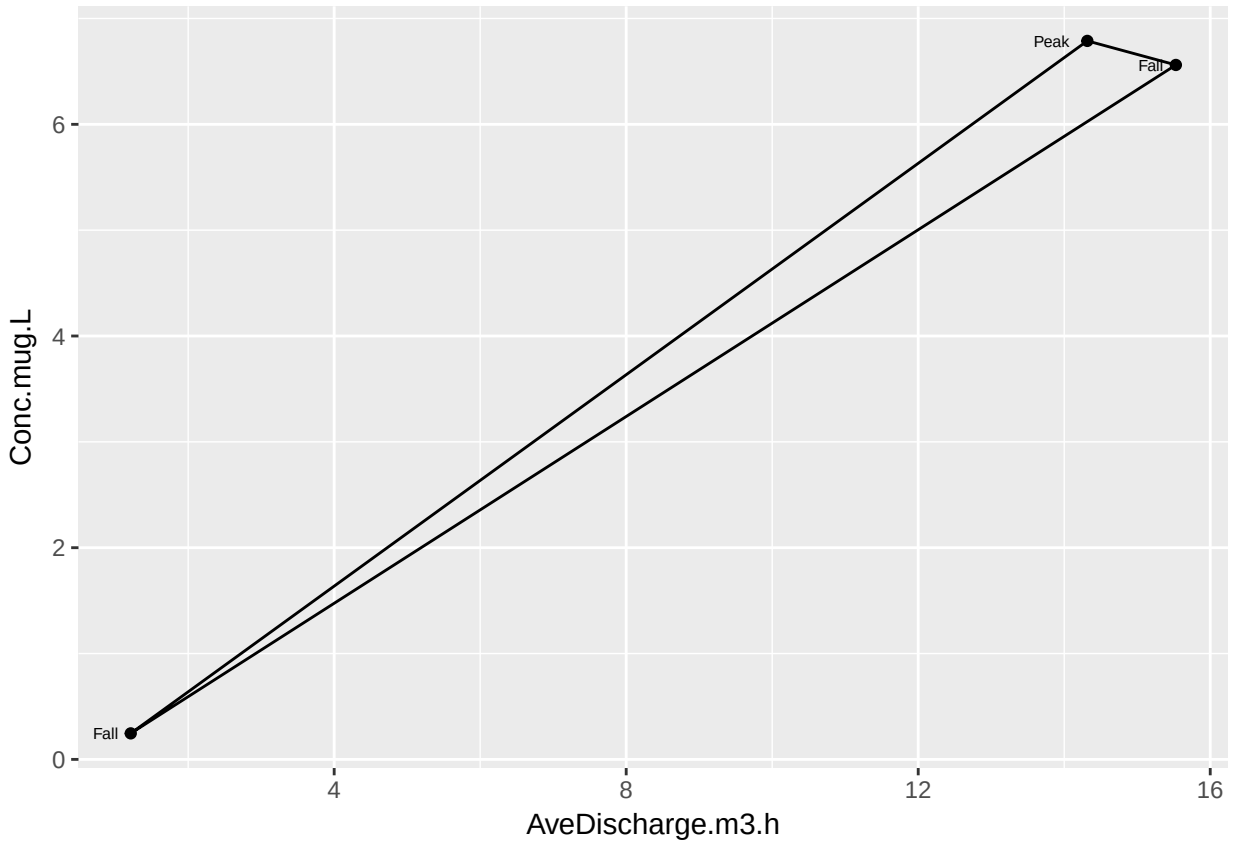
```
CQdata <- out.CoIs[with(out.CoIs, order(ti)), ]
CQdata$FlowType <- ifelse(is.na(CQdata$Event), "Fall", "Peak")
CQdata$Event[1:3]<- 0
```

```r
CQdata$EventMark <- NA

CQdata$EventMark <- na.locf(CQdata$Event)

CQdata$EventMark <- ifelse(is.na(CQdata$Event), CQdata$EventMark, CQdata$EventMark*10)
CQdata$Row <- seq.int(nrow(CQdata))

cq1 <- subset(CQdata[1:6, ])

cq1 <- cq1[cq1$Sampled != 'Not Sampled', ]

str(cq1)
```

```
## 'data.frame':    3 obs. of  61 variables:
##  $ WeekSubWeek           : Factor w/ 58 levels "W0-0x","W0-1",..: 2 4 5
##  $ ti                    : POSIXct, format: "2016-03-25 12:04:00" "2016-03-30 12:18:00" ...
##  $ tf                    : POSIXct, format: "2016-03-28 22:36:00" "2016-03-31 15:34:00" ...
##  $ iflux                 : num  1.12 1.46 16.33
##  $ fflux                 : num  1.31 16.45 15.18
##  $ changeflux            : num  0.189 14.989 -1.15
##  $ maxQ                  : num  1.38 38.4 18.67
##  $ minQ                  : num  1.08 1.45 13.2
##  $ dryHrs                : num  6.02 66.13 1.65
##  $ Duration.Hrs          : num  82.5 27.3 23.1
##  $ chExtreme             : num  0.256 36.944 -3.133
##  $ Event                 : num  0 1 NA
##  $ Markers               : num  NA 16.9 NA
##  $ TimeDiff              : Factor w/ 18 levels "106","136","150",..: NA 10 NA
##  $ AveDischarge.m3.h     : num  1.21 14.32 15.53
##  $ Volume.m3             : num  100 390 359
##  $ Sampled.Hrs           : num  82.5 27.3 23.1
##  $ Sampled               : Factor w/ 2 levels "Not Sampled",..: 2 2 2
##  $ Conc.mug.L            : num  0.246 6.788 6.561
##  $ Conc.SD               : num  0.0193 0.2894 0.1906
##  $ OXA_mean              : num  4.82 30.53 32.49
##  $ OXA_SD                : num  1.141 10.185 0.243
##  $ ESA_mean              : num  18.1 46 41.3
##  $ ESA_SD                : num  3.497 3.037 0.853
##  $ N.x                   : int  NA 3 3
##  $ diss.d13C             : num  NA -30.5 -30.6
##  $ SD.d13C               : num  NA 0.106 0.151
##  $ se.d13C               : num  NA 0.0612 0.0874
##  $ N_ngC.diss            : int  NA 3 3
##  $ ngC.mean.diss         : num  NA 42.7 54.7
##  $ ngC.SD.diss           : num  NA 1.92 2.54
##  $ MES.mg.L              : num  53.4 62.5 22.5
##  $ MES.sd                : num  NA NA NA
##  $ MO.mg.L               : num  0e+00 1e-03 1e-04
##  $ Conc.Solids.mug.gMES  : num  0.645 0.126 0.436
##  $ Conc.Solids.ug.gMES.SD: num  0.0232 0.0271 0.1232
##  $ N.y                   : int  NA NA NA
##  $ filt.d13C             : num  NA NA NA
##  $ filt.SD.d13C          : num  NA NA NA
##  $ filt.se.d13C          : num  NA NA NA
```

```
##  $ N_ngC.fl              : int  NA NA NA
##  $ ngC.mean.fl           : num  NA NA NA
##  $ ngC.SD.fl             : num  NA NA NA
##  $ DD13C.diss            : num  NA 0.741 0.59
##  $ DD13C.filt            : num  NA NA NA
##  $ f.diss                : num  NA 0.646 0.706
##  $ f.filt                : num  NA NA NA
##  $ B.diss                : num  NA 35.4 29.4
##  $ B.filt                : num  NA NA NA
##  $ NH4.mM                : num  NA 0.05 NA
##  $ TIC.ppm.filt          : num  NA 51.8 44.8
##  $ Cl.mM                 : num  NA 1.48 1574
##  $ NO3...mM              : num  NA 616 778
##  $ PO4..mM               : int  NA NA NA
##  $ NPOC.ppm              : num  NA 4 4.4
##  $ TIC.ppm.unfilt        : num  NA 44.8 26.4
##  $ TOC.ppm.unfilt        : num  NA 4.7 5.4
##  $ ExpMES.Kg             : num  5.35 24.4 8.08
##  $ FlowType              : chr  "Fall" "Peak" "Fall"
##  $ EventMark             : num  0 10 1
##  $ Row                   : int  2 4 5
```

```
p <- ggplot(cq1) +
  geom_point(aes(x=AveDischarge.m3.h, y=Conc.mug.L), colour="black") +
  geom_polygon(aes(x=AveDischarge.m3.h, y=Conc.mug.L), colour="black", fill = NA) +

  geom_text(data = cq1,
            aes(x=AveDischarge.m3.h, y=Conc.mug.L, label=FlowType), hjust=1.5, vjust=0.5, size = 2)
p
```




```
#p <- ggplotly(p)
#p
```

Section to UPDATE!!!

3. Weekly exported S-metolachlor mass (mg)

This section converts the observed S-metolachlor concentrations to [mg] in dissolved water and suspended solids. For non-sampled subsets a linear interpolation value based on the trailing and leading observed concentrations was assumed. An approximative model will be tested at a later stage.

To revise: SD for filtered samples!!

```
# Assume first observation is equivalent to second for all measured values
out.CoIs[1, c("Conc.mug.L")] <- out.CoIs[2, c("Conc.mug.L")]
out.CoIs[1, c("Conc.SD")] <- out.CoIs[2, c("Conc.SD")]

out.CoIs[1, c("OXA_mean")] <- out.CoIs[2, c("OXA_mean")]
out.CoIs[1, c("OXA_SD")] <- out.CoIs[2, c("OXA_SD")]

out.CoIs[1, c("ESA_mean")] <- out.CoIs[2, c("ESA_mean")]
out.CoIs[1, c("ESA_SD")] <- out.CoIs[2, c("ESA_SD")]

out.CoIs[1, c("Conc.Solids.mug.gMES")] <- out.CoIs[2, c("Conc.Solids.mug.gMES")]
out.CoIs[1, c("Conc.Solids.ug.gMES.SD")] <- out.CoIs[2, c("Conc.Solids.ug.gMES.SD")]

out.CoIs[1, c("ExpMES.Kg")] <- out.CoIs[2, c("ExpMES.Kg")]
```

```
# Assign linear approximation of trailing and leading observed values
out.CoIs <- out.CoIs[with(out.CoIs , order(ti)), ]

out.CoIs$Conc.mug.L <- na.approx(out.CoIs$Conc.mug.L)
out.CoIs$Conc.SD <- na.approx(out.CoIs$Conc.SD)

out.CoIs$OXA_mean <- na.approx(out.CoIs$OXA_mean)
out.CoIs$OXA_SD <- na.approx(out.CoIs$OXA_SD)

out.CoIs$ESA_mean <- na.approx(out.CoIs$ESA_mean)
out.CoIs$ESA_SD <- na.approx(out.CoIs$ESA_SD)

out.CoIs$Conc.Solids.mug.gMES <- na.approx(out.CoIs$Conc.Solids.mug.gMES)
out.CoIs$Conc.Solids.ug.gMES.SD <- na.approx(out.CoIs$Conc.Solids.ug.gMES.SD)

out.CoIs$ExpMES.Kg <- na.approx(out.CoIs$ExpMES.Kg)
```

4. Add the application dates and merge the total mass to the nearest discharge event

The five application dates were:

- 2016-03-20
- 2016-04-05
- 2016-04-13 and 2016-04-14
- 2016-05-26

So the total applied mass mass is merged at the nearest sampling time marker available :

```
ti = c(as.POSIXct('2016-03-25 00:04:00' , tz="EST"),
#       as.POSIXct('2016-04-05 15:08:00' , tz="EST"),
       as.POSIXct('2016-04-14 13:52:00' , tz="EST"),
       as.POSIXct('2016-05-23 18:02:00' , tz="EST"))

Appl.Mass.g = c(9497.87, 4744.571, 4982.038)

applics = as.data.frame(ti)
applics$Appl.Mass.g = Appl.Mass.g

out.CoIs = merge(out.CoIs, applics, by = "ti", all = T)
out.CoIs$Appl.Mass.g <- ifelse(is.na(out.CoIs$Appl.Mass.g), 0.0, out.CoIs$Appl.Mass.g)

out.CoIs$timeSinceApp <- NA
for (i in 1:length(out.CoIs$Duration.Hrs)){
  if (out.CoIs[i, ]['Appl.Mass.g'] != 0){
    out.CoIs[i,]['timeSinceApp'] = out.CoIs[i, ]['Duration.Hrs']
  } else {
    out.CoIs[i, ]['timeSinceApp'] = out.CoIs[i ,]['Duration.Hrs'] + out.CoIs[i-1,]['timeSinceApp']
  }
}

out.CoIs$Appl.Mass.g.NoSo <- out.CoIs$Appl.Mass.g
out.CoIs$Appl.Mass.g.NoSo[which(out.CoIs$ti == as.POSIXct('2016-05-23 18:02:00' , tz="EST"))] <- 0
out.CoIs$timeSinceApp.NoSo <- NA
for (i in 1:length(out.CoIs$Duration.Hrs)){
  if (out.CoIs[i, ]['Appl.Mass.g.NoSo'] != 0){
```

```
    out.CoIs[i,]['timeSinceApp.NoSo'] = out.CoIs[i, ]['Duration.Hrs']
  } else {
    out.CoIs[i, ]['timeSinceApp.NoSo'] = out.CoIs[i ,]['Duration.Hrs'] + out.CoIs[i-1,]['timeSinceApp.No
  }
}


out.CoIs$timeSinceApp <- round(out.CoIs$timeSinceApp/24, 1) # Convert to days
out.CoIs$timeSinceApp.NoSo <- round(out.CoIs$timeSinceApp.NoSo/24, 1)

# Cumulative (Continous)
out.CoIs$CumAppMass.g = cumsum(out.CoIs$Appl.Mass.g)
```

Section to UPDATE!!!

5. This section is based on approximate carried-last-observation for the observed concentration data (if no model has been conducted yet).

```
# First simulate a mass out to deal with missing values
# Option 1, just assume 0.0

# Dissolved - [mg] S-metolachlor exported per sub-week
# Conc. [mu.g s-meto/L H20] * Vol[m3] * [10^3 L/m^3] * [1 mg/10^3 mu.g]
out.CoIs$DissSmeto.mg = out.CoIs$Conc.mug.L*out.CoIs$Volume.m3
out.CoIs$DissSmeto.mg.SD = out.CoIs$Conc.SD*out.CoIs$Volume.m3
out.CoIs$DissSmeto.g = out.CoIs$DissSmeto.mg/10^3
out.CoIs$DissSmeto.g.SD = out.CoIs$DissSmeto.mg.SD/10^3

out.CoIs$DissOXA.mg = out.CoIs$OXA_mean*out.CoIs$Volume.m3
out.CoIs$DissOXA.mg.SD = out.CoIs$OXA_SD*out.CoIs$Volume.m3
out.CoIs$DissOXA.g = out.CoIs$DissOXA.mg/10^3
out.CoIs$DissOXA.g.SD = out.CoIs$DissOXA.mg.SD/10^3

out.CoIs$DissESA.mg = out.CoIs$ESA_mean*out.CoIs$Volume.m3
out.CoIs$DissESA.mg.SD = out.CoIs$ESA_SD*out.CoIs$Volume.m3
out.CoIs$DissESA.g = out.CoIs$DissESA.mg/10^3
out.CoIs$DissESA.g.SD = out.CoIs$DissESA.mg.SD/10^3

# Solids - [mg] S-metolachlor in solids exported per sub-week
# Conc. [mu.g s-meto / g MES] * Kg MES * [10^3 g/Kg] * [1 mg/10^3 mu.g]
out.CoIs$FiltSmeto.mg = out.CoIs$Conc.Solids.mug.gMES*out.CoIs$ExpMES.Kg
out.CoIs$FiltSmeto.mg.SD = out.CoIs$Conc.Solids.ug.gMES.SD*out.CoIs$ExpMES.Kg
out.CoIs$FiltSmeto.g = out.CoIs$FiltSmeto.mg/10^3
out.CoIs$FiltSmeto.g.SD  = out.CoIs$FiltSmeto.mg.SD/10^3

# Total SM
out.CoIs$TotSMout.mg = out.CoIs$DissSmeto.mg + out.CoIs$FiltSmeto.mg
out.CoIs$TotSMout.mg.SD = sqrt(((out.CoIs$DissSmeto.mg.SD)^2 + (out.CoIs$FiltSmeto.mg.SD)^2)/2)
out.CoIs$TotSMout.g = out.CoIs$TotSMout.mg/10^3
out.CoIs$TotSMout.g.SD = out.CoIs$TotSMout.mg.SD/10^3

# Distribution dissolved vs suspended solids
out.CoIs$FracDiss = out.CoIs$DissSmeto.mg/out.CoIs$TotSMout.mg
```

```
out.CoIs$FracFilt = out.CoIs$FiltSmeto.mg/out.CoIs$TotSMout.mg

#out.CoIs$DissSmeto.g = ifelse(is.na(out.CoIs$DissSmeto.g), 0.0, out.CoIs$DissSmeto.g)
#out.CoIs$FiltSmeto.g = ifelse(is.na(out.CoIs$FiltSmeto.g), 0.0, out.CoIs$FiltSmeto.g)
#out.CoIs$TotSMout.g = out.CoIs$DissSmeto.g + out.CoIs$FiltSmeto.g

# Need to update this :
# out.CoIs$TotSMout.g.SD = out.CoIs$DissSmeto.g.SD

mw.SM <- 283.796 # g/mol
mw.MOXA <- 279.33 # g/ml
mw.MESA <- 329.1 # g/mol
out.CoIs$MELsm.g <-
  out.CoIs$TotSMout.g +
  out.CoIs$DissOXA.g * (mw.SM/mw.MOXA) +
  out.CoIs$DissESA.g * (mw.SM/mw.MESA)

# How to sum a standard deviation
# http://stats.stackexchange.com/questions/25848/how-to-sum-a-standard-deviation
out.CoIs$MELsm.g.SD <-
  sqrt((out.CoIs$TotSMout.g.SD^2 +
     (out.CoIs$DissOXA.g.SD * (mw.SM/mw.MOXA))^2 +
     (out.CoIs$DissESA.g.SD * (mw.SM/mw.MESA))^2)/3)

# Cumulative OUT
out.CoIs$CumOutDiss.g = cumsum(out.CoIs$DissSmeto.g)
out.CoIs$CumOutFilt.g = cumsum(out.CoIs$FiltSmeto.g)
out.CoIs$CumOutSmeto.g = out.CoIs$CumOutDiss.g + out.CoIs$CumOutFilt.g
out.CoIs$CumOutMELsm.g = cumsum(out.CoIs$MELsm.g)

# Balance
out.CoIs$BalMassDisch.g = out.CoIs$CumAppMass.g - out.CoIs$CumOutMELsm.g

# Mass fraction
massOUT = tail(out.CoIs$CumOutSmeto.g, n=1)
MELsmOUT = tail(out.CoIs$CumOutMELsm.g, n=1)

TotAppl = tail(out.CoIs$CumAppMass.g, n=1)

out.CoIs$prctMassOut = (out.CoIs$TotSMout.g / massOUT)
out.CoIs$FracDeltaOut = (out.CoIs$TotSMout.g / massOUT)*out.CoIs$diss.d13C
out.CoIs$FracDeltaOut = ifelse(is.na(out.CoIs$FracDeltaOut), 0.0, out.CoIs$FracDeltaOut)

BulkDeltaOut = sum(out.CoIs$FracDeltaOut)
```

The total mass discharged (up to Week 15) and bulk isotope signature (up to week 11) was:

```
# Cummulative S-metolachlor [g] discharged (before correction)
cat("SM mass sampled: " , as.character(91.10687))
```

```
## SM mass sampled:  91.10687
```

```
# Cummulative S-metolachlor [g] discharged
cat("SM mass sampled and non-sampled: ",  as.character(massOUT))
```

```
## SM mass sampled and non-sampled:  140.392784355072
```

```
# Cummulative MEL-sm [g] discharged
cat("MEL-sm [g] sampled and non-sampled: ",  as.character(MELsmOUT))
```

```
## MEL-sm [g] sampled and non-sampled:  3096.82107110135
```

```
cat("% Mass applied in discahrge [MEL-sm]: ",  (MELsmOUT/TotAppl)*100)
```

```
## % Mass applied in discahrge [MEL-sm]:  16.10874
```

```
# Bulk isotope signature
BulkDeltaOut
```

```
## [1] -18.39794
```

6. Testing a regression tree (ommitted for now)

Save files

```
names(out.CoIs)[names(out.CoIs) == "Event"] <- "Peak"

out.CoIs$Events <- as.factor(c("0-1", "0-2", "0-3",
                          "1-1", "1-2", "1-3",
                          "2-1", "2-2", "2-3",
                          "3-1",
                          "4-1", "4-2", "4-3", "4-4", "4-5",
                          "5-1",
                          "6-1", "6-2", "6-3",
                          "7-1",
                          "8-1", "8-2", "8-3",
                          "9-1", "9-2", "9-3", "9-4", "9-5",
                          "10-1", "10-2", "10-3", "10-4", "10-5",
                          "11-1",
                          "12-1", "12-2", "12-3",
                          "13-1",
                          "14-1",
                          "15-1", "15-2", "15-3", "15-4",
                          "16-1", "16-2",
                          "17-1", "17-2",
                          "18-1", "18-2", "18-3", "18-4"))

# Adding a Weeks column for labelling
out.CoIs$WeekSubWeek <- as.character(out.CoIs$WeekSubWeek)
Split <- strsplit(out.CoIs$WeekSubWeek, "-", fixed = TRUE)
out.CoIs$Weeks <- sapply(Split, "[", 1)

Split2 <- strsplit(as.character(out.CoIs$Events), "-", fixed = T)
out.CoIs$Event <- as.factor(sapply(Split2, "[", 1))

out.CoIs$WeekSubWeek <- factor(out.CoIs$WeekSubWeek, levels = unique(out.CoIs$WeekSubWeek))
out.CoIs$Weeks <- factor(out.CoIs$Weeks, levels = unique(out.CoIs$Weeks))

out.CoIs$Events <- factor(out.CoIs$Events, levels = unique(out.CoIs$Events))
out.CoIs$Event <- factor(out.CoIs$Event, levels = unique(out.CoIs$Event))
```

```
head(out.CoIs)
```

```
##                    ti WeekSubWeek                   tf      iflux     fflux
## 1 2016-03-25 00:04:00       W0-0x 2016-03-25 12:02:00  1.248600  1.129227
## 2 2016-03-25 12:04:00        W0-1 2016-03-28 22:36:00  1.124382  1.313125
## 3 2016-03-28 22:38:00       W0-2x 2016-03-30 12:16:00  1.308100  1.456349
## 4 2016-03-30 12:18:00        W1-1 2016-03-31 15:34:00  1.456080 16.445436
## 5 2016-03-31 15:36:00        W1-2 2016-04-01 14:44:00 16.334349 15.184536
## 6 2016-04-01 14:46:00       W1-3x 2016-04-05 15:06:00 15.203629  5.856380
##   changeflux      maxQ      minQ      dryHrs Duration.Hrs  chExtreme Peak
## 1 -0.1193728  1.248600  1.118296  0.01666667     11.96667 -0.1303036   NA
## 2  0.1887431  1.380388  1.082199  6.01666667     82.53333  0.2560062   NA
## 3  0.1482496  1.637782  0.929055 47.30000000     37.63333  0.3296817   NA
## 4 14.9893566 38.399790  1.448977 66.13333333     27.26667 36.9437102    1
## 5 -1.1498131 18.668972 13.201113  1.65000000     23.13333 -3.1332355   NA
## 6 -9.3472489 15.895640  5.471042  6.26666667     96.33333 -9.7325862   NA
##    Markers TimeDiff AveDischarge.m3.h Volume.m3 Sampled.Hrs     Sampled
## 1       NA     <NA>           1.204775  14.41714    11.96667 Not Sampled
## 2       NA     <NA>           1.213511 100.15508    82.53333     Sampled
## 3       NA     <NA>           1.284719  48.34827    37.63333 Not Sampled
## 4 16.88972       24          14.316647 390.36726    27.26667     Sampled
## 5       NA     <NA>          15.529299 359.24445    23.13333     Sampled
## 6       NA     <NA>           9.107720 877.37700    96.33333 Not Sampled
##   Conc.mug.L  Conc.SD  OXA_mean     OXA_SD ESA_mean   ESA_SD N.x diss.d13C
## 1  0.2456594 0.019310  4.824094  1.1414453 18.05531 3.497221  NA        NA
## 2  0.2456594 0.019310  4.824094  1.1414453 18.05531 3.497221  NA        NA
## 3  3.5169528 0.154365 17.677665  5.6633481 32.01948 3.267103  NA        NA
## 4  6.7882463 0.289420 30.531235 10.1852510 45.98364 3.036985   3 -30.46867
## 5  6.5609982 0.190640 32.492465  0.2430544 41.28052 0.853382   3 -30.61967
## 6  8.0026500 0.262090 68.516860  0.6978517 69.92417 1.839787  NA        NA
##    SD.d13C    se.d13C N_ngC.diss ngC.mean.diss ngC.SD.diss MES.mg.L
## 1        NA         NA         NA            NA          NA       NA
## 2        NA         NA         NA            NA          NA 53.44444
## 3        NA         NA         NA            NA          NA       NA
## 4 0.1060016 0.06120004          3      42.69231    1.921169 62.50000
## 5 0.1513550 0.08738484          3      54.69697    2.540766 22.50000
## 6        NA         NA         NA            NA          NA       NA
##   MES.sd MO.mg.L Conc.Solids.mug.gMES Conc.Solids.ug.gMES.SD N.y filt.d13C
## 1     NA      NA            0.6447290              0.02323755  NA        NA
## 2     NA   0e+00            0.6447290              0.02323755  NA        NA
## 3     NA      NA            0.3853094              0.02515062  NA        NA
## 4     NA   1e-03            0.1258897              0.02706369  NA        NA
## 5     NA   1e-04            0.4357872              0.12323706  NA        NA
## 6     NA      NA            0.2575699              0.06396039  NA        NA
##   filt.SD.d13C filt.se.d13C N_ngC.fl ngC.mean.fl ngC.SD.fl DD13C.diss
## 1           NA           NA       NA          NA        NA         NA
## 2           NA           NA       NA          NA        NA         NA
## 3           NA           NA       NA          NA        NA         NA
## 4           NA           NA       NA          NA        NA  0.7413333
## 5           NA           NA       NA          NA        NA  0.5903333
## 6           NA           NA       NA          NA        NA         NA
##   DD13C.filt    f.diss f.filt   B.diss B.filt NH4.mM TIC.ppm.filt   Cl.mM
## 1         NA        NA     NA       NA     NA     NA           NA      NA
```

```
## 2         NA        NA     NA       NA     NA     NA           NA      NA
## 3         NA        NA     NA       NA     NA     NA           NA      NA
## 4         NA 0.6459075     NA 35.40925     NA   0.05         51.8    1.48
## 5         NA 0.7060321     NA 29.39679     NA     NA         44.8 1574.00
## 6         NA        NA     NA       NA     NA     NA           NA      NA
##   NO3...mM PO4..mM NPOC.ppm TIC.ppm.unfilt TOC.ppm.unfilt ExpMES.Kg
## 1       NA      NA       NA             NA             NA  5.352733
## 2       NA      NA       NA             NA             NA  5.352733
## 3       NA      NA       NA             NA             NA 14.875343
## 4      616      NA      4.0           44.8            4.7 24.397953
## 5      778      NA      4.4           26.4            5.4  8.083000
## 6       NA      NA       NA             NA             NA  7.935755
##   Appl.Mass.g timeSinceApp Appl.Mass.g.NoSo timeSinceApp.NoSo CumAppMass.g
## 1     9497.87          0.5          9497.87               0.5      9497.87
## 2        0.00          3.9             0.00               3.9      9497.87
## 3        0.00          5.5             0.00               5.5      9497.87
## 4        0.00          6.6             0.00               6.6      9497.87
## 5        0.00          7.6             0.00               7.6      9497.87
## 6        0.00         11.6             0.00              11.6      9497.87
##   DissSmeto.mg DissSmeto.mg.SD DissSmeto.g DissSmeto.g.SD  DissOXA.mg
## 1     3.541705       0.2783949 0.003541705   0.0002783949    69.54963
## 2    24.604033       1.9339946 0.024604033   0.0019339946   483.15756
## 3   170.038598       7.4632812 0.170038598   0.0074632812   854.68456
## 4  2649.909084     112.9800910 2.649909084   0.1129800910 11918.39439
## 5  2357.002211      68.4863626 2.357002211   0.0684863626 11672.73795
## 6  7021.341115     229.9517390 7.021341115   0.2299517390 60115.11746
##   DissOXA.mg.SD   DissOXA.g DissOXA.g.SD DissESA.mg DissESA.mg.SD
## 1      16.45637  0.06954963   0.01645637   260.3058      50.41991
## 2     114.32155  0.48315756   0.11432155  1808.3308     350.26441
## 3     273.81310  0.85468456   0.27381310  1548.0863     157.95877
## 4    3975.98846 11.91839439   3.97598846 17950.5083    1185.53932
## 5      87.31596 11.67273795   0.08731596 14829.7964     306.57276
## 6     612.27900 60.11511746   0.61227900 61349.8588    1614.18699
##    DissESA.g DissESA.g.SD FiltSmeto.mg FiltSmeto.mg.SD FiltSmeto.g
## 1  0.2603058   0.05041991     3.451062       0.1243844 0.003451062
## 2  1.8083308   0.35026441     3.451062       0.1243844 0.003451062
## 3  1.5480863   0.15795877     5.731609       0.3741240 0.005731609
## 4 17.9505083   1.18553932     3.071452       0.6602985 0.003071452
## 5 14.8297964   0.30657276     3.522468       0.9961252 0.003522468
## 6 61.3498588   1.61418699     2.044012       0.5075740 0.002044012
##   FiltSmeto.g.SD TotSMout.mg TotSMout.mg.SD  TotSMout.g TotSMout.g.SD
## 1   0.0001243844    6.992766      0.2156098 0.006992766  0.0002156098
## 2   0.0001243844   28.055095      1.3703661 0.028055095  0.0013703661
## 3   0.0003741240  175.770206      5.2839633 0.175770206  0.0052839633
## 4   0.0006602985 2652.980536     79.8903528 2.652980536  0.0798903528
## 5   0.0009961252 2360.524679     48.4322936 2.360524679  0.0484322936
## 6   0.0005075740 7023.385126    162.6008301 7.023385126  0.1626008301
##    FracDiss     FracFilt     MELsm.g MELsm.g.SD CumOutDiss.g CumOutFilt.g
## 1 0.5064812 0.4935188249   0.3021264 0.02689497  0.003541705  0.003451062
## 2 0.8769898 0.1230101642   2.0783329 0.18683762  0.028145738  0.006902124
## 3 0.9673915 0.0326085349   2.3790960 0.17885971  0.198184336  0.012633733
## 4 0.9988423 0.0011577363  30.2413655 2.40621294  2.848093419  0.015705185
## 5 0.9985078 0.0014922393  27.0082117 0.16340841  5.205095630  0.019227652
## 6 0.9997090 0.0002910294 121.0040582 0.88525127 12.226436745  0.021271664
```

```
##   CumOutSmeto.g CumOutMELsm.g BalMassDisch.g  prctMassOut FracDeltaOut
## 1   0.006992766     0.3021264       9497.568 4.980859e-05    0.0000000
## 2   0.035047862     2.3804594       9495.490 1.998329e-04    0.0000000
## 3   0.210818068     4.7595554       9493.110 1.251989e-03    0.0000000
## 4   2.863798604    35.0009209       9462.869 1.889684e-02   -0.5757616
## 5   5.224323282    62.0091326       9435.861 1.681372e-02   -0.5148304
## 6  12.247708409   183.0131909       9314.857 5.002668e-02    0.0000000
##   Events Weeks Event
## 1    0-1    W0     0
## 2    0-2    W0     0
## 3    0-3    W0     0
## 4    1-1    W1     1
## 5    1-2    W1     1
## 6    1-3    W1     1
```

```
write.csv2(out.CoIs,
           'Data/WeeklyHydroContam_R.csv', row.names = F)

# out.CoIs = read.csv2("Data/WeeklyHydroContam_R.csv")
# out.CoIs$ti = as.POSIXct(out.CoIs$ti, "%Y-%m-%d %H:%M", tz = "EST")
```