

Introduction to the dataRetrieval package

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1 Introduction to dataRetrieval

The dataRetrieval package was created to simplify the process of getting hydrologic data in the R environment. It has been specifically designed to work seamlessly with the EGRET package: Exploration and Graphics for RivEr Trends (EGRET). See: <https://github.com/USGS-R/EGRET/wiki> for information on EGRET.

There is a plethora of hydrological data available on the web. This package is designed specifically to load United States Geological Survey (USGS) hydrologic data to the R environment. This includes daily values, real-time (unit values), site information, and water quality sample data.

For information on getting started in R, downloading and installing the package, see Appendix 1: Getting Started.

2 USGS Web Retrieval Examples

In this section, we will run through 5 examples, documenting how to get raw data from the web. This includes historical daily values, real-time current values, water quality data, site information, and measured parameter information. We will use the Choptank River near Greensboro, MD as an example. The site-ID for this gage station is 01491000. Daily discharge measurements are available as far back as 1948. Additionally, forms of nitrate have been measured dating back to 1964. The functions/examples in this section are for raw data retrieval. This may or may not be the easiest data to work with. In the next section, we will use functions that retrieve and process the data in a dataframe that may prove more friendly for R analysis.

2.1 USGS Web Retrieval Introduction

The United States Geological Survey organizes their hydrological data in fairly standard structure. Gage stations are located throughout the United States, each station has a unique ID. Often (but not always), these ID's are 8 digits. The first step to finding data is discovering this 8-digit ID. One potential tool for discovering data is Environmental Data Discovery and Transformation (EnDDaT): <http://cida.usgs.gov/enddat/>. Follow the example in the User's Guide to learn how to discover USGS stations and available data from any location in the United States. Essentially, you can create a Project Location on the map, set a bounding box (in miles), then search for USGS Time Series and USGS Water Quality Data. Locations, ID's, available data, and available time periods will load on the map and appropriate tabs.

Once the site-ID is known, the next required input for USGS data retrievals is the 'parameter code'. This is a 5-digit code that specifies what measured parameter is being requested. A complete list of possible USGS parameter codes can be found at nwis.waterdata.usgs.gov. Not every station will measure all parameters. The following is a list of commonly measured parameters:

Table 1: Commonly found USGS Parameter Codes

	pCode	shortName
1	00060	Discharge [cfs]
2	00065	Gage height [ft]
3	00010	Temperature [C]
4	00045	Precipitation [in]
5	00400	pH

For real-time data, the parameter code and site ID will suffice. The USGS stores historical data as daily values however. The statistical process used to store the daily data is the final requirement for daily value retrievals. A 5-digit 'stat code' specifies the requested processing. A complete list of possible USGS stat codes can be found here:

http://nwis.waterdata.usgs.gov/nwis/help/?read_file=stat&format=table

The most common stat codes are:

Table 2: Commonly found USGS Stat Codes

	StatCode	shortName
1	00001	Maximum
2	00002	Minimum
3	00003	Mean
4	00008	Median

2.2 USGS Site Information Retrievals

To obtain all of the available site information, use the `getSiteFileData` function:

```
> library(dataRetrieval)
> # Site ID for Choptank River near Greensboro, MD
> siteNumber <- "01491000"
> ChoptankInfo <- getSiteFileData(siteNumber)
```

A list of the available columns are found in Appendix 2: INFO dataframe. Pulling out a specific example piece of information, in this case station name can be done as follows:

```
> ChoptankInfo$station_nm

[1] "CHOPTANK RIVER NEAR GREENSBORO, MD"
```

Site information is obtained from <http://waterservices.usgs.gov/rest/Site-Test-Tool.html>

2.3 USGS Parameter Information Retrievals

To obtain all of the available information concerning a measured parameter, use the `getParameterInfo` function:

```
> # Using defaults:
> parameterCd <- "00618"
> parameterINFO <- getParameterInfo(parameterCd)
> colnames(parameterINFO)

[1] "parameter_cd"          "parameter_group_nm"  "parameter_nm"
[4] "casrn"                 "srsname"             "parameter_units"
```

Pulling out a specific example piece of information, in this case station name can be done as follows:

```
> parameterINFO$parameter_nm

[1] "Nitrate, water, filtered, milligrams per liter as nitrogen"
```

Parameter information is obtained from <http://nwis.waterdata.usgs.gov/nwis/pmcodes/>

2.4 USGS Daily Value Retrievals

To obtain historic daily records of USGS data, use the `retrieveNWISData` function. The arguments for this function are `siteNumber`, `parameterCd`, `startDate`, `endDate`, `statCd`, and a logical (`true/false`) `interactive`. There are 2 default arguments: `statCd` defaults to "00003" and `interactive` defaults to `TRUE`. If you want to use the default values, you do not need to list them in the function call. Setting the 'interactive' option to `true` will walk you through the function. It might make more sense to run large batch collections with the `interactive` option set to `FALSE`.

The dates (start and end) need to be in the format "YYYY-MM-DD". Setting the start date to "" will indicate to the program to ask for the earliest date, setting the end date to "" will ask for the latest available date.

```
> # Using defaults:
> siteNumber <- "01491000"
> parameterCd <- "00060" # Discharge in cubic feet per second
> startDate <- "" # Will request earliest date
> endDate <- "" # Will request latest date
> discharge <- retrieveNWISData(siteNumber, parameterCd, startDate, endDate)
```

A dataframe is returned that looks like the following:

	agency_cd	site_no	datetime	X02_00060_00003	X02_00060_00003_cd
1	USGS	01491000	1948-01-01	190	A
2	USGS	01491000	1948-01-02	900	A
3	USGS	01491000	1948-01-03	480	A
4	USGS	01491000	1948-01-04	210	A
5	USGS	01491000	1948-01-05	210	A
6	USGS	01491000	1948-01-06	220	A

The variable `datetime` is automatically imported as a `Date`. Each requested parameter has a value and remark code column. The names of these columns depend on the requested parameter and stat code combinations. USGS remark codes are often "A" (approved for publication) or "P" (provisional data subject to revision). A more complete list of remark codes can be found here: http://waterdata.usgs.gov/usa/nwis/help?codes_help

Another example that doesn't use the defaults would be a request for mean and maximum daily temperature and discharge in early 2012:

```
> # Using defaults:
> siteNumber <- "01491000"
> parameterCd <- "00010,00060" # Temperature and discharge
> statCd <- "00001,00003" # Mean and maximum
```

```

> startDate <- "2012-01-01"
> endDate <- "2012-06-30"
> temperatureAndFlow <- retrieveNWISData(siteNumber, parameterCd,
      startDate, endDate, StatCd=statCd, interactive=FALSE)

```

Daily data is pulled from <http://waterservices.usgs.gov/rest/DV-Test-Tool.html>.

An example of plotting the above data (Figure 1):

```

> with(temperatureAndFlow, plot(
  datetime, X01_00010_00003,
  xlab="Date", ylab="Temperature [C]"
))
> par(new=TRUE)
> with(temperatureAndFlow, plot(
  datetime, X02_00060_00003,
  col="red", type="l", xaxt="n", yaxt="n", xlab="", ylab="", axes=FALSE
))
> axis(4, col="red", col.axis="red")
> mtext("Discharge [cfs]", side=4, line=3, col="red")
> title(paste(ChoptankInfo$station.nm, "2012", sep=" "))

```

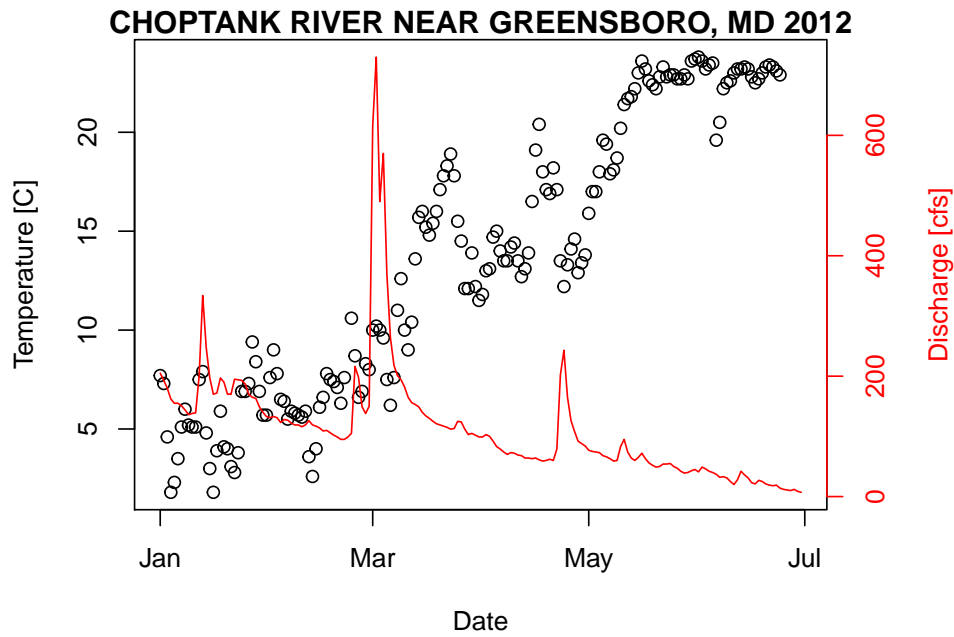


Figure 1: Temperature and discharge plot of Choptank River in 2012.

There are occasions where NWIS values are not reported as numbers, instead there might be text describing a certain event such as "Ice". Any value that cannot be converted to a number will be reported as NA in this package.

2.5 USGS Unit Value Retrievals

We can also get real-time, instantaneous measurements using the `retrieveUnitNWISData` function:

```
> siteNumber <- "01491000"
> parameterCd <- "00060" # Discharge (cfs)
> startDate <- as.character(Sys.Date()-1) # Yesterday
> # (or, the day before the dataRetrieval package was built)
> endDate <- as.character(Sys.Date()) # Today
> # (or, the day the dataRetrieval package was built)
>
> dischargeToday <- retrieveUnitNWISData(siteNumber, parameterCd,
  startDate, endDate)
```

Which produces the following dataframe:

	agency_cd	site_no	datetime	tz_cd	X02_00060	X02_00060_cd
1	USGS	01491000	2013-02-14 00:00:00	EST	197	P
2	USGS	01491000	2013-02-14 00:15:00	EST	197	P
3	USGS	01491000	2013-02-14 00:30:00	EST	202	P
4	USGS	01491000	2013-02-14 00:45:00	EST	197	P
5	USGS	01491000	2013-02-14 01:00:00	EST	197	P
6	USGS	01491000	2013-02-14 01:15:00	EST	197	P

Note that time now becomes important, so the variable `datetime` is a `POSIXct`, and the time zone is included in a separate column. Data is pulled from <http://waterservices.usgs.gov/rest/IV-Test-Tool.html>. There are occasions where NWIS values are not reported as numbers, instead a common example is "Ice". Any value that cannot be converted to a number will be reported as NA in this package.

A simple plotting example is shown in Figure 2:

```
> with(dischargeToday, plot(
  datetime, X02_00060,
  ylab="Discharge [cfs]", xlab=""
))
> title(ChoptankInfo$station.nm)
```

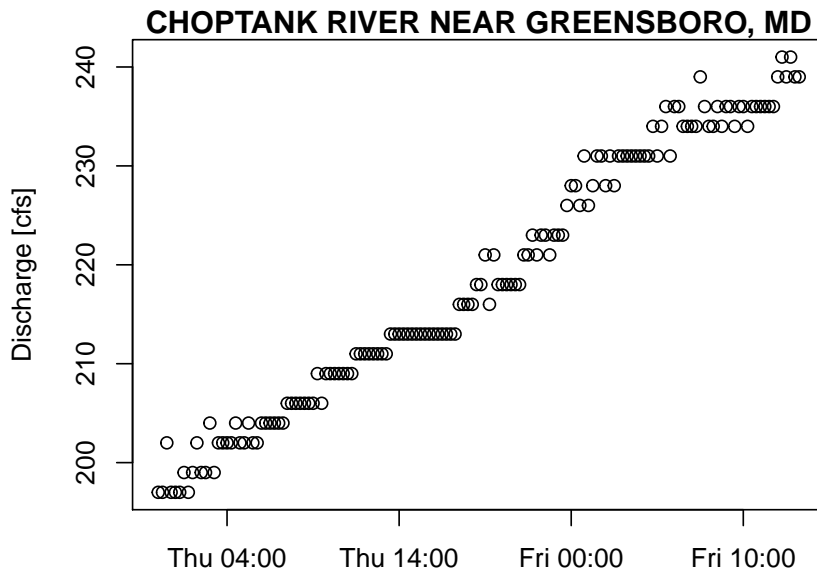



Figure 2: Real-time discharge plot of Choptank River.

2.6 USGS Water Quality Retrievals

Finally, we can use the `dataRetrieval` package to get USGS water quality data that is available on the water quality data portal: <http://www.waterqualitydata.us/>. The raw data is obtained from the function `getRawQWData`, with the similar input arguments: `siteNumber`, `parameterCd`, `startDate`, `endDate`, and `interactive`. The difference is in `parameterCd`, in this function multiple parameters can be queried using a ";" separator, and setting `parameterCd <- ""` will return all of the measured observations. The raw data can be overwhelming (as will be demonstrated), a simplified version of the data can be obtained using `getQWData`.

```
> siteNumber <- "01491000"
> # Dissolved Nitrate parameter codes:
> parameterCd <- "00618;71851"
> startDate <- "1964-06-11"
> endDate <- "2012-12-18"
> dissolvedNitrate <- getRawQWData(siteNumber, parameterCd,
  startDate, endDate)
```

There is a large amount of data returned for each observation. The column names are listed in Appendix 2.

To get a simplified dataframe that contains only datetime, value, and qualifier, use the function `getQWData`:

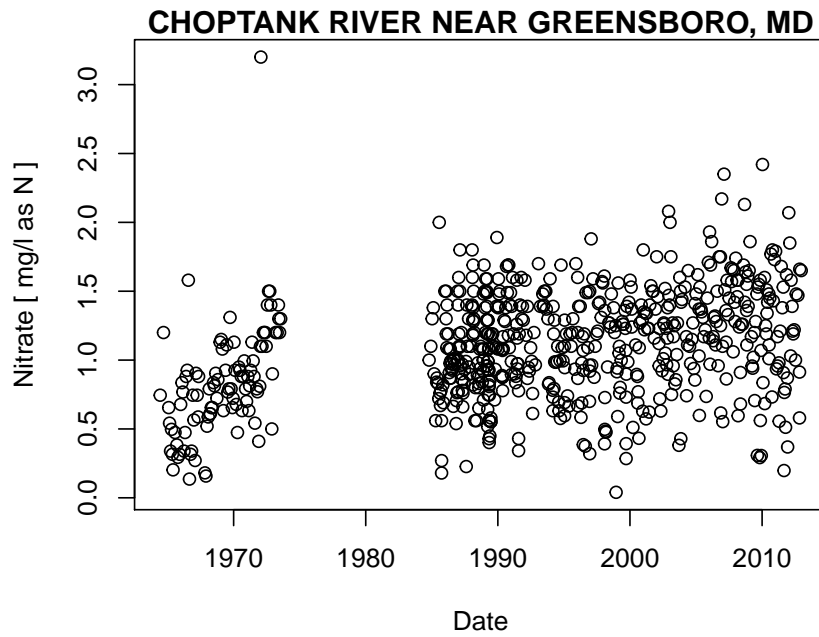


Figure 3: Nitrate plot of Choptank River.

```
> dissolvedNitrateSimple <- getQWData(siteNumber, parameterCd,
  startDate, endDate)
> names(dissolvedNitrateSimple)

[1] "dateTime"          "qualifier.71851" "value.71851"      "qualifier.00618"
[5] "value.00618"
```

Note that in this dataframe, datetime is imported as Dates (no times are included), and the qualifier is either blank or "<" signifying a censored value.

An example of plotting the above data (Figure 3):

```
> with(dissolvedNitrateSimple, plot(
  dateTime, value.00618,
  xlab="Date", ylab = paste(parameterINFO$srsname,
    "[", parameterINFO$parameter_units, "]")
))
> title(ChoptankInfo$station.nm)
```

2.7 Other Water Quality Retrievals

Additionally, there are additional data sets available on the Water Quality Portal (<http://www.waterqualitydata.us/>). These data sets can be housed in either the STORET or NWIS database. Since STORET does not use USGS parameter codes, a 'characteristic name' must be supplied. The following example retrieves specific conductance from a DNR site in Wisconsin.

```
> specificCond <- getWQPData('WIDNR_WQX-10032762',  
  'Specific conductance', '', '')  
> head(specificCond)
```

	dateTime	qualifier	Specific conductance value	Specific conductance
1	2011-02-14			1360
2	2011-02-17			1930
3	2011-03-03			1240
4	2011-03-10			1480
5	2011-03-29			1130
6	2011-04-07			1200

3 Polished Data: USGS Web Retrieval Examples

Rather than using the raw data as retrieved by the web, the dataRetrieval package also includes functions that return the data in a structure that has been designed to work with the EGRET R package (<https://github.com/USGS-R/EGRET/wiki>). In general, these dataframes may be much more 'R-friendly' than the raw data, and will contain additional date information that allows for efficient data analysis.

In this section, we use 3 dataRetrieval functions to get sufficient data to perform an EGRET analysis. We will continue analyzing the Choptank River. We will need essentially the same data that was retrieved in the previous section, but we will get the daily discharge values in a dataframe called Daily, the nitrate sample data in a dataframe called Sample, and the data about the station and parameters in a dataframe called INFO. These are the dataframes that were exclusively designed to work with the EGRET R package, however can be very useful for all hydrologic studies.

3.1 INFO Data

The function to obtain "metadata", data about the gage station and measured parameters is getMetaData. This function essentially combines getSiteFileData and getParameterInfo, producing one dataframe called INFO.

```
> INFO <-getMetaData(siteNumber,parameterCd, interactive=FALSE)
```

Column names in the INFO dataframe are listed in Appendix 2.

3.2 Daily Data

The function to obtain the daily values (discharge in this case) is getDVData. It requires the inputs siteNumber, ParameterCd, StartDate, EndDate, interactive, and convert. Most of these arguments are described in the previous section, however 'convert' is a new argument, it's default is TRUE, and it tells the program to convert the values from cfs to cms. If you don't want this conversion, set convert=FALSE in the function call.

```
> siteNumber <- "01491000"
> parameterCd <- "00631" # Nitrate
> startDate <- "1964-01-01"
> endDate <- "2013-01-01"
> Daily <- getDVData(siteNumber, "00060", startDate, endDate,interactive=FALSE)
> summary(Daily)
```

	Date	Q	Julian	Month
Min.	:1964-01-01	Min. : 0.00991	Min. :41637	Min. : 1.000
1st Qu.:	:1976-04-01	1st Qu.: 0.87782	1st Qu.:46112	1st Qu.: 4.000
Median :	:1988-07-02	Median : 2.26535	Median :50586	Median : 7.000
Mean :	:1988-07-02	Mean : 4.01787	Mean :50586	Mean : 6.522
3rd Qu.:	:2000-10-01	3rd Qu.: 4.55901	3rd Qu.:55061	3rd Qu.:10.000
Max.	:2013-01-01	Max. :246.35656	Max. :59535	Max. :12.000

	Day	DecYear	MonthSeq	Qualifier
Min.	: 1.0	Min. :1964	Min. :1369	Length:17899
1st Qu.:	: 92.0	1st Qu.:1976	1st Qu.:1516	Class :character
Median :	:183.0	Median :1989	Median :1663	Mode :character
Mean :	:183.1	Mean :1989	Mean :1663	
3rd Qu.:	:274.0	3rd Qu.:2001	3rd Qu.:1810	
Max.	:366.0	Max. :2013	Max. :1957	

	i	LogQ	Q7	Q30
Min.	: 1	Min. :-4.6141	Min. : 0.01808	Min. : 0.09606
1st Qu.:	: 4476	1st Qu.: -0.1303	1st Qu.: 0.92232	1st Qu.: 1.05811
Median :	: 8950	Median : 0.8177	Median : 2.45143	Median : 2.83074
Mean :	: 8950	Mean : 0.7258	Mean : 4.01655	Mean : 4.01178
3rd Qu.:	:13424	3rd Qu.: 1.5171	3rd Qu.: 4.92309	3rd Qu.: 5.61594
Max.	:17899	Max. : 5.5068	Max. :84.00395	Max. :25.47478
			NA's :6	NA's :29

Details of the Daily dataframe are listed below:

	ColumnName	Type	Description
1	Date	Date	Date
2	Q	number	Discharge in cms
3	Julian	number	Number of days since January 1, 1850
4	Month	integer	Month of the year [1-12]
5	Day	integer	Day of the year [1-366]
6	DecYear	number	Decimal year
7	MonthSeq	integer	Number of months since January 1, 1850
8	Qualifier	string	Qualifying code
9	i	integer	Index
10	LogQ	number	Natural logarithm of Q
11	Q7	number	7 day running average of Q
12	Q30	number	30 running average of Q

The code will shift the discharge values to 0.001 times the mean if there are zero values detected in order to perform the logarithm. Columns Q7 and Q30 are 7 and 30 day running averages.

3.3 Sample Data

The function to obtain sample data from the water quality portal is `getSampleData`. The arguments for this function are also `siteNumber`, `ParameterCd`, `StartDate`, `EndDate`, `interactive`. These are the same inputs as `getRawQWData` or `getQWData` as described in the previous section.

```
> Sample <-getSampleData(siteNumber,parameterCd,
  startDate, endDate,interactive=FALSE)
> summary(Sample)
```

Date	ConcLow	ConcHigh	Uncen
Min. :1973-06-04	Min. :0.176	Min. :0.050	Min. :0.0000
1st Qu.:1989-01-31	1st Qu.:0.900	1st Qu.:0.900	1st Qu.:1.0000
Median :1995-02-15	Median :1.150	Median :1.150	Median :1.0000
Mean :1996-04-07	Mean :1.145	Mean :1.143	Mean :0.9984
3rd Qu.:2003-08-26	3rd Qu.:1.400	3rd Qu.:1.400	3rd Qu.:1.0000
Max. :2012-12-18	Max. :2.430	Max. :2.430	Max. :1.0000
	NA's :1		
ConcAve	Julian	Month	Day
Min. :0.025	Min. :45079	Min. : 1.000	Min. : 2.0
1st Qu.:0.900	1st Qu.:50799	1st Qu.: 3.000	1st Qu.: 81.0
Median :1.150	Median :53005	Median : 6.000	Median :161.0
Mean :1.143	Mean :53423	Mean : 6.155	Mean :170.7

3rd Qu.:1.400	3rd Qu.:56119	3rd Qu.: 9.000	3rd Qu.:261.0
Max. :2.430	Max. :59521	Max. :12.000	Max. :363.0

DecYear	MonthSeq	SinDY	CosDY
Min. :1973	Min. :1482	Min. :-1.00000	Min. :-0.99996
1st Qu.:1989	1st Qu.:1670	1st Qu.: -0.65358	1st Qu.: -0.66655
Median :1995	Median :1742	Median : 0.16237	Median : 0.03433
Mean :1996	Mean :1756	Mean : 0.06474	Mean : 0.02331
3rd Qu.:2004	3rd Qu.:1844	3rd Qu.: 0.76785	3rd Qu.: 0.72212
Max. :2013	Max. :1956	Max. : 0.99985	Max. : 0.99967

Details of the Sample dataframe are listed below:

	ColumnName	Type	Description
1	Date	Date	Date
2	ConcLow	number	Lower limit of concentration
3	ConcHigh	number	Upper limit of concentration
4	Uncen	integer	Uncensored data (1=true, 0=false)
5	ConcAve	number	Average concentration
6	Julian	number	Number of days since January 1, 1850
7	Month	integer	Month of the year [1-12]
8	Day	integer	Day of the year [1-366]
9	DecYear	number	Decimal year
10	MonthSeq	integer	Number of months since January 1, 1850
11	SinDY	number	Sine of ...
12	CosDY	number	Cosine of ...
13	Q	number	Discharge in cms
14	LogQ	number	Natural logarithm of flow

In a more complex situation, the Sample data frame will combine all of the measured parameters. An example is provided to explain how the values are combined:

3.4 Complex Sample Data Example

As an example, let us say that in 2004 and earlier, we computed a total phosphorus (tp) as the sum of dissolved phosphorus (dp) and particulate phosphorus (pp). Form 2005 and onward, we have direct measurements of total phosphorus (tp). A small subset of this fictional data looks like this:

	cdate	rdp	dp	rpp	pp	rtp	tp
1	2003-02-15		0.02		0.50		
2	2003-06-30	<	0.01		0.30		
3	2004-09-15	<	0.00	<	0.20		
4	2005-01-30						0.43
5	2005-05-30					<	0.05
6	2005-10-30					<	0.02

The dataRetrieval package will "add up" all the values in a given row to form the total for that sample. Thus, you only want to enter data that should be added together. For example, we might know the value for dp on 5/30/2005, but we don't want to put it in the table because under the rules of this data set, we are not suppose to add it in to the values in 2005.

For every sample, the EGRET package requires a pair of numbers to define an interval in which the true value lies (ConcLow and ConcHigh). In a simple non-censored case (the reported value is above the detection limit), ConcLow equals ConcHigh and the interval collapses down to a single point. In a simple censored case, the value might be reported as <0.2, then ConcLow=NA and ConcHigh=0.2. We use NA instead of 0 as a way to elegantly handle future logarithm calculations.

For the more complex example case, let us say dp is reported as <0.01 and pp is reported as 0.3. We know that the total must be at least 0.3 and could be as much as 0.31. Therefore, ConcLow=0.3 and ConcHigh=0.31. Another case would be if dp is reported as <0.005 and pp is reported <0.2. We know in this case that the true value could be as low as zero, but could be as high as 0.205. Therefore, in this case, ConcLow=NA and ConcHigh=0.205. The Sample dataframe for the example data is therefore:

	Date	ConcLow	ConcHigh	Uncen	ConcAve	Julian	Month	Day	DecYear	MonthSeq
1	2003-02-15	0.52	0.520	1	0.5200	55927	2	46	2003.124	1838
2	2003-06-30	0.30	0.310	0	0.3050	56062	6	181	2003.493	1842
3	2004-09-15	NA	0.205	0	0.1025	56505	9	259	2004.706	1857
4	2005-01-30	0.43	0.430	1	0.4300	56642	1	30	2005.081	1861
5	2005-05-30	NA	0.050	0	0.0250	56762	5	150	2005.408	1865
6	2005-10-30	NA	0.020	0	0.0100	56915	10	303	2005.827	1870
	SinDY	CosDY								
1	0.70406552	0.7101350								
2	0.04290476	-0.9990792								
3	-0.96251346	-0.2712339								
4	0.48505985	0.8744810								
5	0.54391895	-0.8391378								
6	-0.88668032	0.4623830								

3.5 Merge Report

Finally, there is a function called `mergeReport` that will look at both the `Daily` and `Sample` dataframe, and populate `Q` and `LogQ` columns into the `Sample` dataframe. The default arguments are `Daily` and `Sample`, however if you want to use other similarly structured dataframes, you can specify `localDaily` or `localSample`.

```
> startDate <- '1985-01-01'
> endDate <- '1985-03-31'
> site <- '01594440'
> Daily <- getDVDData(site, '00060', startDate, endDate, interactive=FALSE)
> Sample <- getSampleData(site, '01075', startDate, endDate, interactive=FALSE)
> Sample <- mergeReport()
```

```
Discharge Record is 90 days long, which is 0 years
First day of the discharge record is 1985-01-01 and last day is 1985-03-31
The water quality record has 1 samples
The first sample is from 1985-03-13 and the last sample is from 1985-03-13
Discharge: Minimum, mean and maximum 2.83 8.41 106
Concentration: Minimum, mean and maximum 1 1 1
Percentage of the sample values that are censored is 100 %
```

```
> head(Sample)
```

	Date	ConcLow	ConcHigh	Uncen	ConcAve	Julian	Month	Day	DecYear	MonthSeq
1	1985-03-13	NA	1	0	0.5	49379	3	72	1985.195	1623
	SinDY	CosDY	Q	LogQ						
1	0.9416344	0.3366373	5.2103	1.650637						

4 Retrieving User-Generated Data Files

Aside from retrieving data from the USGS web services, the `dataRetrieval` package includes functions to generate the Daily and Sample data frame from local files.

4.1 `getDailyDataFromFile`

`getDailyDataFromFile` will load a user-supplied text file and convert it to the Daily dataframe. The file should have two columns, the first dates, the second values. The dates should be formatted either `mm/dd/yyyy` or `yyyy-mm-dd`. Using a 4-digit year is required. This function has the following inputs: `filePath`, `fileName`, `hasHeader` (TRUE/FALSE), `separator`, `qUnit`, and `interactive` (TRUE/FALSE). `filePath` is a string that defines the path to your file. This can either be a full path, or path relative to your R working directory. The input `fileName` is a string that defines the file name (including the extension).

Text files that contain this sort of data require some sort of a separator, for example, a 'csv' file (aka 'comma-separated value') file uses a comma to separate the date and value column. A tab delimited file would use a tab ("`\t`") rather than the comma (","). The type of separator you use can be defined in the function call in the 'separator' argument, the default is ",". Another function input is a logical variable: `hasHeader`. The default is TRUE. If your data does not have column names, set this variable to FALSE.

Finally, `qUnit` is a numeric input that defines the discharge/flow units. Flow from the NWIS web results are typically given in cubic feet per second (`qUnit=1`), but the EGRET package requires flow to be given in cubic meters per second (`qUnit=2`). Other allowed values are 10^3 cubic feet per second (`qUnit=3`) and 10^3 cubic meters per second (`qUnit=4`). If you do not want your data to be converted, use `qUnit=2`. The default is `qUnit=1` (assumes flow is in cubic feet per second).

So, if you have a file called "ChoptankRiverFlow.txt" located in a folder called "RData" on your C drive (this is a Window's example), and the file is structured as follows (tab-separated):

```
date    Qdaily
10/1/1999  3.029902561
10/2/1999  2.406931941
10/3/1999  2.152080324
10/4/1999  2.152080324
10/5/1999  3.19980364
10/6/1999  2.775050944
...
```

The call to open this file, convert the flow to cubic meters per second, and populate the Daily data frame would be:

```
> fileName <- "ChoptankRiverFlow.txt"
```

```
> filePath <- "C:/RData/"
> Daily <- getDailyDataFromFile(filePath,fileName,separator="\t",interactive=FALSE)
```

4.2 getSampleDataFromFile

Similarly to the previous section, getSampleDataFromFile will import a user-generated file and populate the Sample dataframe. The difference between sample data and flow data is that the code requires a third column that contains a remark code, either blank or "<", which will tell the program that the data was 'left-censored' (or, below the detection limit of the sensor). Therefore, the data is required to be in the form: date, remark, value. If multiple constituents are going to be used, the format can be date, remark_A, value_A, remark_b, value_b, etc... An example of a comma-delimited file would be:

```
cdate;remarkCode;Nitrate
10/7/1999,,1.4
11/4/1999,<,0.99
12/3/1999,,1.42
1/4/2000,,1.59
2/3/2000,,1.54
...
```

The call to open this file, and populate the Sample dataframe would be:

```
> fileName <- "ChoptankRiverNitrate.csv"
> filePath <- "C:/RData/"
> Sample <- getSampleDataFromFile(filePath,fileName,separator=",",interactive=FALSE)
```

5 Appendix 1: Getting Started

This section describes the options for downloading and installing the dataRetrieval package.

5.1 New to R?

If you are new to R, you will need to first install the latest version of R, which can be found here: <http://www.r-project.org/>.

There are many options for running and editing R code, one nice environment to learn R is RStudio. RStudio can be downloaded here: <http://rstudio.org/>. Once R and RStudio are installed, the dataRetrieval package needs to be installed as described in the next section.

5.2 R User: Installing dataRetrieval from downloaded binary

The latest dataRetrieval package build is available for download at https://github.com/USGS-R/dataRetrieval/blob/master/dataRetrieval_1.2.1.tar.gz. If the package's tar.gz file is saved in R's working directory, then the following command will fully install the package:

```
> install.packages("dataRetrieval_1.2.1.tar.gz",  
                  repos=NULL, type="source")
```

If the downloaded file is stored in an alternative location, include the path in the install command. A Windows example looks like this (notice the direction of the slashes, they are in the opposite direction that Windows normally creates paths):

```
> install.packages(  
  "C:/R/Packages/Statistics/dataRetrieval_1.2.1.tar.gz",  
  repos=NULL, type="source")
```

A Mac example looks like this:

```
> install.packages(  
  "/Users/userA/R/Packages/Statistic/dataRetrieval_1.2.1.tar.gz",  
  repos=NULL, type="source")
```

It is a good idea to re-start the R environment after installing the package, especially if installing an updated version (that is, restart RStudio). Some users have found it necessary to delete the previous version's package folder before installing newer version of dataRetrieval. If you are experiencing issues after updating a package, trying deleting the package folder -

the default location for Windows is something like this: C:/Users/userA/Documents/R/win-library/2.15/dataRetrieval, and the default for a Mac: /Users/userA/Library/R/2.15/library/dataRetrieval. Then, re-install the package using the directions above. Moving to CRAN should solve this problem.

After installing the package, you need to open the library each time you re-start R. This is done with the simple command:

```
> library(dataRetrieval)
```

Using RStudio, you could alternatively click on the checkbox for dataRetrieval in the Packages window.

5.3 R Developers: Installing dataRetrieval from gitHub

Alternatively, R-developers can install the latest version of dataRetrieval directly from gitHub using the devtools package. devtools is available on CRAN. Simply type the following commands into R to install the latest version of dataRetrieval available on gitHub. Rtools (for Windows) and appropriate L^AT_EX tools are required.

```
> library(devtools)
> install_github("dataRetrieval", "USGS-R")
```

To then open the library, simply type:

```
> library(dataRetrieval)
```


6 Appendix 2: Columns Names

6.1 INFO dataframe

agency.cd
site.no
station.nm
site.tp.cd
lat.va
long.va
dec.lat.va
dec.long.va
coord.meth.cd
coord.acy.cd
coord.datum.cd
dec.coord.datum.cd
district.cd
state.cd
county.cd
country.cd
map.nm
map.scale.fc
alt.va
alt.meth.cd
alt.acy.va
alt.datum.cd
huc.cd
basin.cd
topo.cd
construction.dt
inventory.dt
drain.area.va
contrib.drain.area.va
tz.cd
local.time.fg
reliability.cd
project.no
queryTime
drainSqKm
staAbbrev
param.nm
param.units
paramShortName
paramNumber
constitAbbrev

6.2 Water Quality Portal

There are 62 columns returned from the water quality portal.

OrganizationIdentifier
OrganizationFormalName
ActivityIdentifier
ActivityTypeCode
ActivityMediaName
ActivityMediaSubdivisionName
ActivityStartDate
ActivityStartTime.Time
ActivityStartTime.TimeZoneCode
ActivityEndDate
ActivityEndTime.Time
ActivityEndTime.TimeZoneCode
ActivityDepthHeightMeasure.MeasureValue
ActivityDepthHeightMeasure.MeasureUnitCode
ActivityDepthAltitudeReferencePointText
ActivityTopDepthHeightMeasure.MeasureValue
ActivityTopDepthHeightMeasure.MeasureUnitCode
ActivityBottomDepthHeightMeasure.MeasureValue
ActivityBottomDepthHeightMeasure.MeasureUnitCode
ProjectIdentifier
ActivityConductingOrganizationText
MonitoringLocationIdentifier
ActivityCommentText
SampleAquifer
HydrologicCondition
HydrologicEvent
SampleCollectionMethod.MethodIdentifier
SampleCollectionMethod.MethodIdentifierContext
SampleCollectionMethod.MethodName
SampleCollectionEquipmentName
ResultDetectionConditionText
CharacteristicName
ResultSampleFractionText
ResultMeasureValue
ResultMeasure.MeasureUnitCode
MeasureQualifierCode
ResultStatusIdentifier
StatisticalBaseCode
ResultValueTypeName
ResultWeightBasisText

ResultTimeBasisText
ResultTemperatureBasisText
ResultParticleSizeBasisText
PrecisionValue
ResultCommentText
USGSPCode
ResultDepthHeightMeasure.MeasureValue
ResultDepthHeightMeasure.MeasureUnitCode
ResultDepthAltitudeReferencePointText
SubjectTaxonomicName
SampleTissueAnatomyName
ResultAnalyticalMethod.MethodIdentifier
ResultAnalyticalMethod.MethodIdentifierContext
ResultAnalyticalMethod.MethodName
MethodDescriptionText
LaboratoryName
AnalysisStartDate
ResultLaboratoryCommentText
DetectionQuantitationLimitTypeName
DetectionQuantitationLimitMeasure.MeasureValue
DetectionQuantitationLimitMeasure.MeasureUnitCode
PreparationStartDate

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- [2] Hirsch, R. M., Moyer, D. L. and Archfield, S. A. (2010), Weighted Regressions on Time, Discharge, and Season (WRTDS), with an Application to Chesapeake Bay River Inputs. JAWRA Journal of the American Water Resources Association, 46: 857-880. doi: 10.1111/j.1752-1688.2010.00482.x <http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2010.00482.x/full>
- [3] Sprague, L. A., Hirsch, R. M., and Aulenbach, B. T. (2011), Nitrate in the Mississippi River and Its Tributaries, 1980 to 2008: Are We Making Progress? Environmental Science & Technology, 45 (17): 7209-7216. doi: 10.1021/es201221s <http://pubs.acs.org/doi/abs/10.1021/es201221s>