

# Package ‘WRSS’

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**Type** Package

**Title** Water Resources System Simulator

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**Description** Water resources system simulator is a tool for simulation and analysis of large-scale water resources systems. 'WRSS' proposes functions and methods for construction, simulation and analysis of primary storage and hydropower water resources features (e.g. reservoirs, aquifers, and etc.) based on Standard Operating Policy (SOP).

**License** GPL-3

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WRSS-package

*Water Resources System Simulator*


---

## Description

The WRSS is an object-oriented R package, which provides tools for simulation and analysis of large-scale supply and hydropower water resources systems. The package includes functions and methods for building, simulation, and visualization of water resources components.

## Details

Package: WRSS  
Type: Package  
Version: 3.0  
Date: 2022-05-17  
License: GPL-3

the package includes three major types of functions as follows:

1- functions for construction and manipulation of water resources features:

- a) `createArea` constructor for basin/study area objects
- b) `createJunction` constructor for junction objects
- c) `createRiver` constructor for reach, river, and channel objects
- d) `createReservoir` constructor for reservoir objects
- e) `createDiversion` constructor for diversion objects
- f) `createAquifer` constructor for aquifer objects
- g) `createDemandSite` constructor for demand site objects
- h) `set.as` WRSS objects connector
- i) `addObjectToArea` adds objects from mentioned above constructors to a basin inherited from class of `createBasin`

2- functions for analysis and operation of water resources objects using Standard Operating Policy (SOP):

- a) `riverRouting` river operation using
- b) `reservoirRouting` reservoir operation
- c) `aquiferRouting` aquifer operation
- d) `diversionRouting` diversion operation
- e) `sim` simulates an objects inherited from class of `createArea`
- f) `ripppl` computes no-failure storage volume using the sequent peak algorithm(SPA)
- g) `cap_design` computes RRV measures for a range of design parameters

3- functions for performance analysis and visualization.

- a) `plot.sim` plots the results of simulations for an object inherited from class of `sim`
- b) `plot.createArea` plots an object from class of `createArea`
- c) `risk` computes risk-based criteria for an object inherited from class of `sim`
- d) `GOF` Goodness of fit function

#### Author(s)

Rezgar Arabzadeh; Parisa Aberi; Kaveh Panaghi; Shahab Araghinejad; Majid Montaseri

Maintainer: Rezgar Arabzadeh <rezgararabzadeh@ut.ac.ir>

#### References

Loucks, Daniel P., et al. Water resources systems planning and management: an introduction to methods, models and applications. Paris: Unesco, 2005. Arabzadeh, R.; Aberi, P.; Hesarkazzazi, S.; Hajibabaei, M.; Rauch, W.; Nikmehr, S.; Sitenfrei, R. WRSS: An Object-Oriented R Package for Large-Scale Water Resources Operation. *Water* 2021, 13, 3037. <https://doi.org/10.3390/w13213037>



```

        capacity=max,
        storageAreaTable=RC))
River<-createRiver(name='Markhuz-River',downstream=Markhuz,discharge=Q)
A<-createDemandSite(name='A3',demandTS=A,returnFlowFraction=0.3,
    suppliers=list(Markhuz),downstream=J,priority=1)
Area<-addObjectToArea(Area, River)
Area<-addObjectToArea(Area, Markhuz)
Area<-addObjectToArea(Area, A)

###----- Cheragh Veys dam
Q<-zarrineh$cheraghVeys$timeSeries[,1]
E<-zarrineh$cheraghVeys$timeSeries[,2]
R<-zarrineh$cheraghVeys$timeSeries[,3]
D<-zarrineh$cheraghVeys$timeSeries[,4]
A<-zarrineh$cheraghVeys$timeSeries[,5]
RC<-zarrineh$cheraghVeys$ratingCurve
min<-zarrineh$cheraghVeys$capacity[1]$min
max<-zarrineh$cheraghVeys$capacity[2]$max
cheraghVeys<-createReservoir(name='cheraghVeys',netEvaporation=E,
    downstream=J,initialStorage=max,
    geometry=list(deadStorage=min,
        capacity=max,
        storageAreaTable=RC))
River<-createRiver(name='Cheragh Veys-River',downstream=cheraghVeys,discharge=Q)
R<-createDemandSite(name='E2',demandTS=R,returnFlowFraction=1.0,
    suppliers=list(cheraghVeys),downstream=J,priority=1)
D<-createDemandSite(name='U2',demandTS=D,returnFlowFraction=0.7,
    suppliers=list(cheraghVeys),downstream=J,priority=2)
A<-createDemandSite(name='A2',demandTS=A,returnFlowFraction=0.3,
    suppliers=list(cheraghVeys),downstream=J,priority=3)
Area<-addObjectToArea(Area, River)
Area<-addObjectToArea(Area, cheraghVeys)
Area<-addObjectToArea(Area, R)
Area<-addObjectToArea(Area, D)
Area<-addObjectToArea(Area, A)

###----- Sonata dam
Q<-zarrineh$Sonata$timeSeries[,1]
E<-zarrineh$Sonata$timeSeries[,2]
R<-zarrineh$Sonata$timeSeries[,3]
A<-zarrineh$Sonata$timeSeries[,4]
RC<-zarrineh$Sonata$ratingCurve
min<-zarrineh$Sonata$capacity[1]$min
max<-zarrineh$Sonata$capacity[2]$max
Sonata<-createReservoir(name='Sonata',netEvaporation=E,downstream=J,
    initialStorage=max,
    geometry=list(deadStorage=min,
        capacity=max,
        storageAreaTable=RC))
River<-createRiver(name='Sonata-River',downstream=Sonata,discharge=Q)
R<-createDemandSite(name='E3',demandTS=R,returnFlowFraction=1.0,
    suppliers=list(Sonata),downstream=J,priority=1)
A<-createDemandSite(name='A4',demandTS=A,returnFlowFraction=0.3,

```

```

        suppliers=list(Sonata),downstream=J,priority=2)
Area<-addObjectToArea(Area, River)
Area<-addObjectToArea(Area, Sonata)
Area<-addObjectToArea(Area, R)
Area<-addObjectToArea(Area, A)

###----- Sarogh dam
Q<-zarrineh$Sarogh$timeSeries[,1]
E<-zarrineh$Sarogh$timeSeries[,2]
D<-zarrineh$Sarogh$timeSeries[,3]
A<-zarrineh$Sarogh$timeSeries[,4]
RC<-zarrineh$Sarogh$ratingCurve
min<-zarrineh$Sarogh$capacity[1]$min
max<-zarrineh$Sarogh$capacity[2]$max
Sarogh<-createReservoir(name='Sarogh',netEvaporation=E,downstream=J,
                        initialStorage=max,
                        geometry=list(deadStorage=min,
                                      capacity=max,
                                      storageAreaTable=RC))
River<-createRiver(name='Sarogh-River',downstream=Sarogh,discharge=Q)
D<-createDemandSite(name='U3',demandTS=D,returnFlowFraction=0.7,
                    suppliers=list(Sarogh),downstream=J,priority=1)
A<-createDemandSite(name='A5',demandTS=A,returnFlowFraction=0.3,
                    suppliers=list(Sarogh),downstream=J,priority=2)
Area<-addObjectToArea(Area, River)
Area<-addObjectToArea(Area, Sarogh)
Area<-addObjectToArea(Area, D)
Area<-addObjectToArea(Area, A)
## Not run:
plot(Area)

## End(Not run)
plot(sim(Area))

```

---

addObjectToArea	<i>Adds a feature to area</i>
-----------------	-------------------------------

---

### Description

This function adds objects from the basin primary features to the object inherited from class of createArea.

### Usage

```
addObjectToArea(area, object)
```

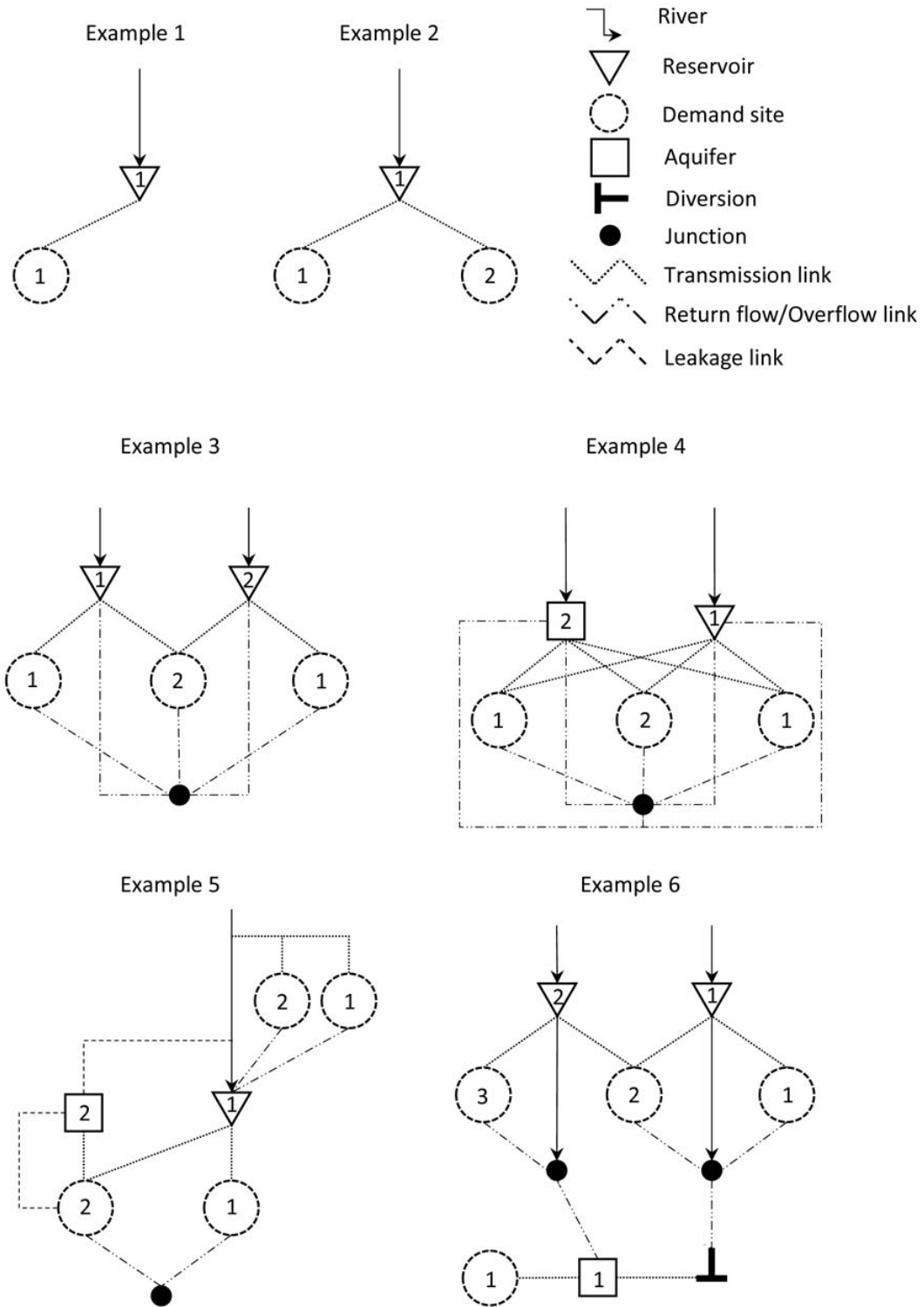
### Arguments

area	An object inherited from <a href="#">createArea</a>
------	---

object      An objects inherited from any of the following constructors: [createAquifer](#), [createRiver](#), [createReservoir](#), [createJunction](#), [createDiversion](#), and [createDemandSite](#).

## **Details**

The examples included in this documentation show construction and simulation of primary features of a water resources system using WRSS package. The Figure below presents schematic layouts attributed to the examples at the rest of the page:





**Value**

an object from class of createArea

**Author(s)**

Rezgar Arabzadeh

**References**

Loucks, Daniel P., et al. Water resources systems planning and management: an introduction to methods, models and applications. Paris: Unesco, 2005.

**See Also**

[sim](#)

**Examples**

```
#-----1st Example-----
R<-createRiver(name="river1",discharge=rnorm(120,5,1.5))
Res<-createReservoir(name="res3",type='storage',
                    priority=1,netEvaporation=rnorm(120,0.5,0.1),
                    geometry=list(deadStorage= 10 ,capacity= 90 ,
                    storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                      100/sum(sin(seq(0,pi,length.out=12))))
D<-createDemandSite(name ="Agri1",
                    demandParams=list(waterUseRate=1,
                                       waterVariation=waterVariation,
                                       cropArea=1000))

R<-set.as(Res,R,'downstream')
D<-set.as(Res,D,'supplier')

area<-createArea(name="unknown",location="unknown",
                simulation=list(start='2000-01-01',
                               end  ='2000-04-29',
                               interval='day'))

area<-addObjectToArea(area,R)
area<-addObjectToArea(area,Res)
area<-addObjectToArea(area,D)
## Not run:
plot(area)
simulated<-sim(area)
plot(simulated)

## End(Not run)

#-----2nd Example-----
Res<-createReservoir(name="res3",type='storage',
                    priority=1,netEvaporation=rnorm(120,0.5,0.1),
```



```

        returnFlowFraction =0.2,priority=1)
D2<-createDemandSite(name ="Agri2",
        demandParams=list(waterUseRate=1,
                            waterVariation=waterVariation,
                            cropArea=1000),
        returnFlowFraction =0.2,priority=2)
D3<-createDemandSite(name ="Agri3",
        demandParams=list(waterUseRate=1,
                            waterVariation=waterVariation,
                            cropArea=1000),
        returnFlowFraction =0.2,priority=1)
area<-createArea(name="unknown",location="unknown",
        simulation=list(start='2000-01-01',
                        end  ='2000-04-29',
                        interval='day'))

R1<-set.as(Res1,R1,'downstream')
R2<-set.as(Res2,R2,'downstream')
Res1<-set.as(J1,Res1,'downstream')
Res2<-set.as(J1,Res2,'downstream')
D1<-set.as(J1,D1,'downstream')
D2<-set.as(J1,D2,'downstream')
D3<-set.as(J1,D3,'downstream')
D1<-set.as(Res1,D1,'supplier')
D2<-set.as(Res1,D2,'supplier')
D2<-set.as(Res2,D2,'supplier')
D3<-set.as(Res2,D3,'supplier')

area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,R2)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Res2)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
area<-addObjectToArea(area,J1)
## Not run:
plot(area)
simulated<-sim(area)
plot(simulated)

## End(Not run)

#-----4th Example-----
J1<-createJunction(name="j1")
Res1<-createReservoir(name="res1",type='storage',
        priority=1,netEvaporation=rnorm(120,0.5,0.1),downstream =J1 ,
        geometry=list(deadStorage= 10 ,capacity= 90 ,
        storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
Auq1<-createAquifer(name="Aquifer1",area=100,volume=5000,
        rechargeTS=rnorm(120,10,3),Sy=0.1,
        leakageFraction=0.02,leakageObject=J1,priority=2)
waterVariation<-round(sin(seq(0,pi,length.out=12))*)

```

```

100/sum(sin(seq(0,pi,length.out=12))))
R1<-createRiver(name="river1",downstream=Res1,discharge=rnorm(120,5,1.5))
R2<-createRiver(name="river2",downstream=Auq1,discharge=rnorm(120,5,1.5))
D1<-createDemandSite(name ="Agri1",
  demandParams=list(waterUseRate=1,
                    waterVariation=waterVariation,
                    cropArea=1000),
  returnFlowFraction =0.2,suppliers=list(Res1,Auq1),
  downstream=J1,priority=1)
D2<-createDemandSite(name ="Agri2",
  demandParams=list(waterUseRate=1,
                    waterVariation=waterVariation,
                    cropArea=1000),
  returnFlowFraction =0.2,suppliers=list(Res1,Auq1),
  downstream=J1,priority=2)
D3<-createDemandSite(name ="Agri3",
  demandParams=list(waterUseRate=1,
                    waterVariation=waterVariation,
                    cropArea=1000),
  returnFlowFraction =0.2,suppliers=list(Res1,Auq1),
  downstream=J1,priority=1)
area<-createArea(name="unknown",location="unknown",
  simulation=list(start='2000-01-01',
                 end  ='2000-04-29',
                 interval='day'))

area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,R2)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Auq1)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
area<-addObjectToArea(area,J1)
## Not run:
plot(area)
simulated<-sim(area)
plot(simulated)

## End(Not run)

#-----5th Example-----
J1<-createJunction(name="junction1")
Res1<-createReservoir(name="res1",type='storage',
  priority=1,netEvaporation=rnorm(120,0.5,0.1),
  geometry=list(deadStorage= 10 ,capacity= 90 ,
  storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
Auq1<-createAquifer(name="Aquifer1",area=100,volume=5000,
  rechargeTS=rnorm(120,10,3),Sy=0.1,priority=2)
waterVariation<-round(sin(seq(0,pi,length.out=12))*
  100/sum(sin(seq(0,pi,length.out=12))))
R1<-createRiver(name="River1",
  downstream=Res1,discharge=rnorm(120,20,3),
  seepageFraction=0.1,seepageObject=Auq1)

```



```

Div1<-createDiversion(name="Div1",capacity=10)
J2<-createJunction(name="junc2")

Res2<-createReservoir(name="res2",type='storage',
                      priority=1,netEvaporation=rnorm(120,0.5,0.1),
                      geometry=list(deadStorage= 10 ,capacity= 90 ,
                      storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R2<-createRiver(name="river2",discharge=rnorm(120,12,3))
D3<-createDemandSite(name ="Agri3",
                     demandParams=list(waterUseRate=1,
                                         waterVariation=waterVariation,
                                         cropArea=1000),
                     returnFlowFraction =0.2,priority=2)
J1<-createJunction(name="junc1")
Res1<-createReservoir(name="res1",type='storage',
                      priority=1,netEvaporation=rnorm(120,0.5,0.1),
                      geometry=list(deadStorage= 10 ,capacity= 90 ,
                      storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R1<-createRiver(name="river1",discharge=rnorm(120,5,1))
D2<-createDemandSite(name ="Agri2",
                     demandParams=list(waterUseRate=1,
                                         waterVariation=waterVariation,
                                         cropArea=1000),
                     returnFlowFraction =0.2,priority=2)
D1<-createDemandSite(name ="Agri1",
                     demandParams=list(waterUseRate=1,
                                         waterVariation=waterVariation,
                                         cropArea=1000),
                     returnFlowFraction =0.2,priority=1)
area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                end  ='2000-04-29',
                                interval='day'))

R1<-set.as(Res1,R1,'downstream')
R2<-set.as(Res2,R2,'downstream')
Res1<-set.as(J1,Res1,'downstream')
Res2<-set.as(J2,Res2,'downstream')
J1<-set.as(Div1,J1,'downstream')
J2<-set.as(Auq1,J2,'downstream')
Div1<-set.as(Auq1,Div1,'divertObject')
D1<-set.as(J1,D1,'downstream')
D2<-set.as(J1,D2,'downstream')
D3<-set.as(J2,D3,'downstream')
D1<-set.as(Res1,D1,'supplier')
D2<-set.as(Res1,D2,'supplier')
D2<-set.as(Res2,D2,'supplier')
D3<-set.as(Res2,D3,'supplier')
D0<-set.as(Auq1,D0,'supplier')

area<-addObjectToArea(area,R1)

```

```

area<-addObjectToArea(area,R2)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Res2)
area<-addObjectToArea(area,D0)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
area<-addObjectToArea(area,Div1)
area<-addObjectToArea(area,Auq1)
area<-addObjectToArea(area,J1)
area<-addObjectToArea(area,J2)

simulated<-sim(area)
## Not run:
plot(area)
plot(simulated)

## End(Not run)

```

---

aquiferRouting

*base function for aquifer simulation*


---

### Description

Given a sort of demand(s), aquiferRouting function simulates a lumped and simple model of an unconfined aquifer under an optional given recharge time series, rechargeTS, and specific yield, Sy.

### Usage

```

aquiferRouting(demand, priority = NA, area, volume,
               rechargeTS = NA, leakageFraction = NA,
               initialStorage = NA, Sy, simulation)

```

### Arguments

demand	(optional) A matrix: is column-wise matrix of demands, at which the rows present demands for each monthly time step and columns are for different individual demand sites (MCM).
priority	(optional) A vector: is a vector of priorities associated to demand
area	The area of aquifer (Km <sup>2</sup> )
volume	The aquifer volume (MCM)
rechargeTS	(optional) A vector : a vector of water flowing into the aquifer (MCM)
leakageFraction	(optional) The leakage coefficient of aquifer storage. The leakage is computed as the product of leakageFraction and aquifer storage. It is in [0, 1] interval
initialStorage	(optional) The initial volume of aquifer at the first step of the simulation (MCM). If missing, the function iterates to carry over the aquifer

Sy	Specific yield (default: 0.1)
simulation	A list: simulation is a list of three vectors: start, end, and interval. the start and end components must be in 'YYYY-MM-DD' format. the interval component can takes either of 'day', 'week', or 'month'.

### Value

the aquiferRouting function returns a list of objects as bellow:

- release: a matrix of release(s) equivalent to each demand (MCM)
- leakage: a vector of leakage time series (MCM)
- storage: a vector of storage time series (MCM)

### Author(s)

Rezgar Arabzadeh

### References

Mart nez-Santos, P., and J. M. Andreu. "Lumped and distributed approaches to model natural recharge in semiarid karst aquifers." *Journal of hydrology* 388.3 (2010): 389-398.

### See Also

[reservoirRouting](#)

### Examples

```

area          <-200
leakageFraction<-0.01
Sy            <-0.15
volume        <-20000
priority      <-c(3,1,1,2)
rechargeTS    <-rnorm(120,60,8)
demand        <-matrix(rnorm(480,10,3),120)
simulation    <-list(start='2000-01-01',end='2009-12-29',interval='month')

res<-
  aquiferRouting(demand      =demand      ,
                 priority    =priority    ,
                 area        =area        ,
                 volume      =volume      ,
                 rechargeTS  =rechargeTS  ,
                 leakageFraction=leakageFraction,
                 Sy          =Sy          ,
                 simulation   =simulation)

plot(res$storage$storage,ylab='Storage (MCM)',xlab='time steps(month)',type='o')
```



---

`cap_design`*Constructor for class of cap\_design*

---

**Description**

Calculates the RRV measures for multiple design candidates.

**Usage**

```
cap_design(area, params, w, plot)
```

**Arguments**

<code>area</code>	An object from class of 'createArea'
<code>params</code>	A list of list(s), which each sub-list can contains an object from either of classes 'createDemandSite' or 'createReservoir' and a vector of scale factors multiplied to the set design parameters. For reservoirs the scale factor will be multiplied to the capacity for the and for demand site, it will be multiplied to the demand time series
<code>w</code>	(optional) A vector of weights of sustainability indices summing 1 with length of equal with the number of demand site objects built-in 'params' argument or equal with number of demand sites supplied by the reservoirs built-in 'params'. If missing the weights will be assumed equal
<code>plot</code>	(optional) logical: plot the result or not. The default is TRUE

**Value**

A matrix of RRV and sustainability index proposed by Hashemitto et al. (1982) and Loucks (1997).

**Author(s)**

Rezgar Arabzadeh

**References**

Hashimoto, T., Stedinger, J. R., & Loucks, D. P. (1982). Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. *Water resources research*, 18(1), 14-20.

Loucks, D. P. (1997). Quantifying trends in system sustainability. *Hydrological Sciences Journal*, 42(4), 513-530.

**See Also**

[addObjectToArea](#)

**Examples**

```

Res1<-createReservoir(name="res1",type='storage',
                    priority=1,netEvaporation=rnorm(120,0.5,0.1),
                    geometry=list(deadStorage= 10 ,capacity= 50 ,
                                storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R1<-createRiver(name="river1",discharge=rnorm(120,25,1.5))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                    100/sum(sin(seq(0,pi,length.out=12))))
D1<-createDemandSite(name ="Agri1",
                    demandParams=list(waterUseRate=1,
                                       waterVariation=waterVariation,
                                       cropArea=500),
                    returnFlowFraction =0.2,priority=2)
area<-createArea(name="unknown",location="unknown",
                simulation=list(start='2000-01-01',
                               end  ='2000-04-29',
                               interval='day'))

R1<-set.as(Res1,R1,'downstream')
D1<-set.as(Res1,D1,'supplier')
area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,D1)
params<-list(
  list(Res1,seq(0.5,1.5,0.1))
)
cap_design(area,params)

```

---

cap\_design.base

*base function for class of cap\_design*


---

**Description**

Calculates the RRV measures for multiple design candidates.

**Usage**

```
## S3 method for class 'base'
cap_design(area,params,w,plot)
```

**Arguments**

area	An object from class of 'createArea'
params	A list of list(s), which each sub-list can contains an object from either of classes 'createDemandSite' or 'createReservoir' and a vector of scale factors multiplied to the set design parameters. For reservoirs the scale factor will be multiplied to the capacity for the and for demand site, it will be multiplied to the demand time series

w	(optional) A vector of weights of sustainability indices summing 1 with length of equal with the number of demand site objects built-in 'params' argument or equal with number of demand sites supplied by the reservoirs built-in 'params'. If missing the weights will be assumed equal
plot	(optional) logical: plot the result or not. The default is TRUE

**Value**

A matrix of RRV and sustainability index proposed by Hashemitto et al. (1982) and Loucks (1997).

**Author(s)**

Rezgar Arabzadeh

**References**

Hashimoto, T., Stedinger, J. R., & Loucks, D. P. (1982). Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. *Water resources research*, 18(1), 14-20.  
 Loucks, D. P. (1997). Quantifying trends in system sustainability. *Hydrological Sciences Journal*, 42(4), 513-530.

**See Also**

[cap\\_design](#)

---

cap\_design.default      *default function for class of cap\_design*

---

**Description**

Calculates the RRV measures for multiple design candidates.

**Usage**

```
## Default S3 method:
cap_design(area, params, w=NA, plot=TRUE)
```

**Arguments**

area	An object from class of 'createArea'
params	A list of list(s), which each sub-list can contains an object from either of classes 'createDemandSite' or 'createReservoir' and a vector of scale factors multiplied to the set design parameters. For reservoirs the scale factor will be multiplied to the capacity for the and for demand site, it will be multiplied to the demand time series

w	(optional) A vector of weights of sustainability indices summing 1 with length of equal with the number of demand site objects built-in 'params' argument or equal with number of demand sites supplied by the reservoirs built-in 'params'. If missing the weights will be assumed equal
plot	(optional) logical: plot the result or not. The default is TRUE

**Value**

A matrix of RRV and sustainability index proposed by Hashemitto et al. (1982) and Loucks (1997).

**Author(s)**

Rezgar Arabzadeh

**References**

Hashimoto, T., Stedinger, J. R., & Loucks, D. P. (1982). Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. *Water resources research*, 18(1), 14-20.  
 Loucks, D. P. (1997). Quantifying trends in system sustainability. *Hydrological Sciences Journal*, 42(4), 513-530.

**See Also**

[cap\\_design](#)

---

createAquifer	<i>Constructor for class of createAquifer</i>
---------------	---

---

**Description**

this function constructs an object from class of createAquifer that prescribes a simplified lumped model of unconfined aquifer.

**Usage**

```
createAquifer(name, area, volume,
              rechargeTS, Sy, leakageFraction,
              initialStorage, leakageObject, priority)
```

**Arguments**

name	(optional) A string: the name of the aquifer
area	The area of aquifer (Km <sup>2</sup> )
volume	The aquifer volume (MCM)
rechargeTS	(optional) A vector : a vector of water flowing into the aquifer (MCM)
Sy	Specific yield (default: 0.1)

leakageFraction	(optional) The leakage coefficient of aquifer storage. The leakage is computed as the product of leakageFraction and aquifer storage. It is in $[0, 1]$ interval
initialStorage	(optional) The initial volume of aquifer in the first step of the simulation (MCM). If missing, the function iterates to carry over the aquifer.
leakageObject	(optional) an object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which leakage volume pours to it.
priority	(optional) An integer: the supplying priority. priority is a value in $[1, 99]$ interval. If missing, the priority is set to Inf.

**Value**

An object from class of createAquifer

**Author(s)**

Rezgar Arabzadeh

**References**

Mart nez-Santos, P., and J. M. Andreu. "Lumped and distributed approaches to model natural recharge in semiarid karst aquifers." Journal of hydrology 388.3 (2010): 389-398.

**See Also**

[addObjectToArea](#)

---

createAquifer.base      *base function for class of createAquifer*

---

**Description**

this function constructs an object from class of createAquifer that prescribes a simplified lumped model of unconfined aquifer.

**Usage**

```
## S3 method for class 'base'
createAquifer(name, area, volume,
              rechargeTS, Sy,leakageFraction,
              initialStorage, leakageObject, priority)
```

**Arguments**

name	(optional) A string: the name of the aquifer
area	The area of aquifer (Km <sup>2</sup> )
volume	The aquifer volume (MCM)
rechargeTS	(optional) A vector : a vector of water flowing into the aquifer (MCM)
Sy	Specific yield (default: 0.1)
leakageFraction	(optional) The leakage coefficient of aquifer storage. The leakage is computed as the product of leakageFraction and aquifer storage. It is in [0, 1] interval
initialStorage	(optional) The initial volume of aquifer in the first step of the simulation (MCM). If missing, the function iterates to carry over the aquifer.
leakageObject	(optional) an object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which leakage volume pours to it.
priority	(optional) An integer: the supplying priority. Is a value in [1, 99] interval. If missing, the priority is set to Inf.

**Value**

An object from class of list

**See Also**

[createAquifer](#)

---

`createAquifer.default` *default function for class of createAquifer*

---

**Description**

this function constructs an object from class of `createAquifer` that prescribes a simplified lumped model of unconfined aquifer.

**Usage**

```
## Default S3 method:
createAquifer(name = "Aquifer1",
              area           ,
              volume        ,
              rechargeTS    = NA ,
              Sy             = 0.1,
              leakageFraction = NA ,
              initialStorage = NA ,
              leakageObject  = NA ,
              priority       = NA)
```

**Arguments**

name	(optional) A string: the name of the aquifer
area	The area of aquifer (Km <sup>2</sup> )
volume	The aquifer volume (MCM)
rechargeTS	(optional) A vector : a vector of water flowing into the aquifer (MCM)
Sy	Specific yield (default: 0.1)
leakageFraction	(optional) The leakage coefficient of aquifer storage. The leakage is computed as the product of leakageFraction and aquifer storage. It is in [0, 1] interval
initialStorage	(optional) The initial volume of aquifer in the first step of the simulation (MCM). If missing, the function iterates to carry over the aquifer.
leakageObject	(optional) an object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which leakage volume pours to it.
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.

**Value**

An object from class of createAquifer

**See Also**

[createAquifer](#)

---

createArea	<i>Constructor for class of createArea</i>
------------	--

---

**Description**

this function constructs an object from class of createArea, supporting objects inherited from any of the following classes: createAquifer, createDemandSite, createDiversion, createJunction, createReservoir, and createRiver.

**Usage**

```
createArea(name, location, simulation)
```

**Arguments**

name	(optional) A string: the name of the aquifer
location	(optional) A string: the physical location of name
simulation	A list: simulation is a list of three vectors: start, end, and interval. the start and end components must be in 'YYYY-MM-DD' format. The interval component can takes either of 'day', 'week', or 'month'

**Value**

An object from class of createArea

**Author(s)**

Rezgar Arabzadeh

**See Also**

[addObjectToArea](#)

---

createArea.base	<i>base function for class of createArea</i>
-----------------	--

---

**Description**

this function constructs an object from class of createArea, supporting objects inherited from any of the following classes: createAquifer, createDemandSite, createDiversion, createJunction, createReservoir, and createRiver.

**Usage**

```
## S3 method for class 'base'
createArea(name, location, simulation)
```

**Arguments**

name	(optional) A string: the name of the aquifer
location	(optional) A string: the physical location of name
simulation	A list: simulation is a list of three vectors: start, end, and interval. the start and end components must be in 'YYYY-MM-DD' format and the interval component is a string that can takes either of 'day', 'week', or 'month'

**Value**

An object from class of list

**See Also**

[createArea](#)



---

createArea.default      *default function for class of createArea*

---

### Description

this function constructs an object from class of createArea, supporting objects inherited from the any of following classes: createAquifer, createDemandSite, createDiversion, createJunction, createReservoir, and createRiver.

### Usage

```
## Default S3 method:
createArea(name = "unknown", location = "unknown",
           simulation = list(start = NULL, end = NULL, interval=NULL))
```

### Arguments

name	(optional) A string: the name of the aquifer
location	(optional) A string: the physical location of createArea
simulation	A list: simulation is a list of three vectors: start, end, and interval. the start and end components must be in 'YYYY-MM-DD' format and the interval component can takes either of 'day', 'week', or 'month'

### Value

An object from class of createArea

### See Also

[createArea](#)

---

createDemandSite      *Constructor for class of createDemandSite*

---

### Description

this function constructs an object from class of createDemandSite, which represents a demand site such as domestic, agricultural, and etc, with a specified demand time series.

### Usage

```
createDemandSite(name, demandTS, demandParams,
                 returnFlowFraction, suppliers,
                 downstream, priority)
```

**Arguments**

name	(optional) A string: the name of the demand site
demandTS	A vector: a vector of demand time series (MCM). If demandParams is null, providing the demandTS is compulsory.
demandParams	A list: If demandTS is missing, the demandParams must be provided to establish demandTS. The demandParams includes three parts as follows: <ul style="list-style-type: none"> <li>• waterUseRate: The total water demand per hectare (MCM) per a given water cycle.</li> <li>• waterVariation: A vector of the percentages for water demand distribution within a water cycle (the percentages in each interval). For instance, if the cycle is annually and the interval is 'month'ly, the waterVariation could be a vector of length of 12, for which its indices signify the monthly portion of water demand, in percentage, by the total water demand required for the whole cycle.</li> <li>• cropArea: the area of cropping farms (in hectare).</li> </ul>
returnFlowFraction	(optional) returnFlowFraction is fraction of total supplied water to the demand site. The return flow is computed as the product of returnFlowFraction and the amount of water the demand sites receives. returnFlowFraction must be in [0, 1] interval.
suppliers	(optional) A list of object(s) inherited from the following classes: <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createDiversion</a> .
downstream	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which return flow volume pours to it.
priority	(optional) An integer: the priority to be supplied. A value in [1, 99] interval.

**Value**

An object from class of createDemandSite

**Author(s)**

Rezgar Arabzadeh

**See Also**

[addObjectToArea](#)

---

createDemandSite.base *base function for class of createDemandSite*

---

### Description

this function constructs an object from class of createDemandSite, which represents a demand site such as domestic, agricultural, and etc, with a specified demand time series.

### Usage

```
## S3 method for class 'base'
createDemandSite(name, demandTS, demandParams,
                 returnFlowFraction, suppliers,
                 downstream, priority)
```

### Arguments

name	(optional) A string: the name of the demand site
demandTS	A vector: a vector of demand time series (MCM). If demandParams is null, providing the demandTS is compulsory.
demandParams	A list: If demandTS is missing, the demandParams must be provided to establish demandTS. The demandParams includes three parts as follows: <ul style="list-style-type: none"> <li>• waterUseRate: The total water demand per hectare (MCM) per a given water cycle</li> <li>• waterVariation: A vector of the percentages for water demand distribution within a water cycle (the percentages in each interval). For instance, if the cycle is annually and the interval is 'month'ly, the waterVariation could be a vector of length of 12, for which its indices signify the monthly portion of water demand, in percentage, by the total water demand required for the whole cycle</li> <li>• cropArea: the area of cropping farms (in hectare)</li> </ul>
returnFlowFraction	(optional) returnFlowFraction is fraction of total supplied water to the demand site. The return flow is computed as the product of returnFlowFraction and the amount of water the demand sites receives. returnFlowFraction must be in [0, 1] interval.
suppliers	(optional) A list of object(s) inherited from the following classes: <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createDiversion</a> .
downstream	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which return flow volume pours to it.
priority	(optional) An integer: the priority to be supplied. A value in [1, 99] interval.

### Value

An object from class of list

**See Also**[createDemandSite](#)

---

`createDemandSite.default`*default function for class of createDemandSite*

---

**Description**

this function constructs an object from class of `createDemandSite`, which represents a demand site such as domestic, agricultural, and etc, with a specified demand time series.

**Usage**

```
## Default S3 method:
createDemandSite(name = "Unknown",
                 demandTS = NA,
                 demandParams=list(waterUseRate=NULL,
                                   waterVariation=NULL,
                                   cropArea=NULL),
                 returnFlowFraction = 0.0,
                 suppliers = NA,
                 downstream = NA,
                 priority = NA)
```

**Arguments**

name	(optional) A string: the name of the demand site
demandTS	A vector: a vector of demand time series (MCM). If <code>demandParams</code> is null, providing the <code>demandTS</code> is compulsory.
demandParams	A list: If <code>demandTS</code> is missing, the <code>demandParams</code> must be provided to establish <code>demandTS</code> . The <code>demandParams</code> includes three parts as follows: <ul style="list-style-type: none"> <li>• <code>waterUseRate</code>: The total water demand per hectare (MCM) per a given water cycle.</li> <li>• <code>waterVariation</code>: A vector of the percentages for water demand distribution within a water cycle (the percentages in each interval). For instance, if the cycle is annually and the interval is 'month'ly, the <code>waterVariation</code> could be a vector of length of 12, for which its indices signify the monthly portion of water demand, in percentage, by the total water demand required for the whole cycle.</li> <li>• <code>cropArea</code>: the area of cropping farms (in hectare).</li> </ul>
returnFlowFraction	(optional) <code>returnFlowFraction</code> is fraction of total supplied water to the demand site. The return flow is computed as the product of <code>returnFlowFraction</code> and the amount of water the demand sites receives. <code>returnFlowFraction</code> must be in [0, 1] interval.

suppliers	(optional) A list of object(s) inherited from the following classes: <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createDiversion</a> .
downstream	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which return flow volume pours to it.
priority	(optional) An integer: the priority to be supplied. A value in [1, 99] interval.

**Value**

An object from class of [createDemandSite](#)

**See Also**

[createDemandSite](#)

---

createDiversion	<i>Constructor for class of createDiversion</i>
-----------------	---

---

**Description**

this function constructs an object from class of [createDiversion](#), acting as a diversion dam which is able to divert water up to a specified capacity.

**Usage**

```
createDiversion(name, capacity,
                divertObject, downstream, priority)
```

**Arguments**

name	(optional) A string: the name of the diversion
capacity	The maximum capacity of diversion dam (CMS).
divertObject	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which receives the diverted water volume.
downstream	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which overflow volume pours to it.
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.

**Value**

An object from class of [createDiversion](#)

**Author(s)**

Rezgar Arabzadeh

**See Also**

[addObjectToArea](#)

---

createDiversion.base *base function for class of createDiversion*

---

**Description**

this function constructs an object from class of createDiversion, acting as a diversion dam which is able to divert water up to a specified capacity.

**Usage**

```
## S3 method for class 'base'  
createDiversion(name, capacity,  
                divertObject, downstream, priority)
```

**Arguments**

name	(optional) A string: the name of the diversion
capacity	The maximum capacity of diversion dam (CMS).
divertObject	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which receives the diverted water volume.
downstream	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which overflow volume pours to it.
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.

**Value**

An object from class of list

**See Also**

[createDiversion](#)

---

```
createDiversion.default  
      default function for class of createDiversion
```

---

### Description

this function constructs an object from class of `createDiversion`, acting as a diversion dam which is able to divert water up to a specified capacity.

### Usage

```
## Default S3 method:  
createDiversion(name = "Div1",  
                capacity      ,  
                divertObject = NA,  
                downstream    = NA,  
                priority       = NA)
```

### Arguments

<code>name</code>	(optional) A string: the name of the diversion
<code>capacity</code>	The maximum capacity of diversion dam (CMS).
<code>divertObject</code>	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which receives the diverted water volume.
<code>downstream</code>	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which overflow volume pours to it.
<code>priority</code>	(optional) An integer: the supplying priority. <code>priority</code> is a value in [1, 99] interval. If missing, the priority is set to Inf.

### Value

An object from class of `createDiversion`

### See Also

[createDiversion](#)

---

createJunction      *Constructor for class of createJunction*

---

### Description

this function constructs an object from class of createDiversion, acting as a junction in the basin which is able to aggregate outflow water from upper tributaries and/or objects in the upstream.

### Usage

```
createJunction(name, downstream)
```

### Arguments

name	(optional) A string: the name of the junction
downstream	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which outflow volume pours to it.

### Value

An object from class of createJunction

### Author(s)

Rezgar Arabzadeh

### See Also

[addObjectToArea](#)

---

createJunction.base      *base function for class of createJunction*

---

### Description

this function constructs an object from class of createDiversion, acting as a junction in the basin which is able to aggregate outflow water from upper tributaries and/or objects in the upstream.

### Usage

```
## S3 method for class 'base'
createJunction(name, downstream)
```



**Arguments**

name	(optional) A string: the name of the junction
downstream	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which outflow volume pours to it.

**Value**

An object from class of list

**See Also**

[createJunction](#)

---

createJunction.default

*default function for class of createJunction*

---

**Description**

this function constructs an object from class of createDiversion, acting as a junction in the basin which is able to aggregate outflow water from upper tributaries and/or objects in the upstream.

**Usage**

```
## Default S3 method:
createJunction(name = "junc1", downstream = NA)
```

**Arguments**

name	(optional) A string: the name of the junction
downstream	(optional) An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which outflow volume pours to it.

**Value**

An object from class of list

**See Also**

[createJunction](#)

---

createReservoir      *Constructor for class of createReservoir*

---

### Description

this function constructs an object from class of createReservoir, which is able to simulate a storage reservoir under given a sort of demand(s).

### Usage

```
createReservoir(type,
                name,
                priority,
                downstream,
                netEvaporation,
                seepageFraction,
                seepageObject,
                geometry,
                plant,
                penstock,
                initialStorage)
```

### Arguments

type	A string: the type of the reservoir being instantiated: by default 'storage', however, it can be 'hydropower'
name	(optional) A string: the name of the reservoir.
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.
downstream	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which spillage volume pours to it.
netEvaporation	A vector: is a vector of net evaporation depth time series at the location of dam site (meter). If omitted, the evaporation is assumed to be zero.
seepageFraction	(optional) The seepage coefficient of reservoir storage. The seepage is computed as the product of seepageFraction and reservoir storage. It is in [0, 1] interval
seepageObject	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which seepage volume pours to it.
geometry	A list of reservoir geometric specifications: <ul style="list-style-type: none"> <li>• storageAreaTable: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains reservoir area (in Km<sup>2</sup>) corresponding to the first column</li> </ul>

- storageElevationTable: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains elevation (in meter) corresponding to the first column
  - dischargeElevationTable: is a matrix whose first column includes the capacity of reservoir tailwater discharge rate (in cms) for different elevation levels and the second column contains elevation levels corresponding to the first column, required if the type = 'hydropower' and the item submerged = TRUE
  - deadStorage: refers to water in a reservoir that cannot be drained by gravity through the dam outlet works (MCM)
  - capacity: The maximum capacity of the reservoir
- plant A list of power plant specifications. It is provided if type = 'hydropower':
- installedCapacity: the plant installed capacity (MW)
  - efficiency: is a matrix whose first column includes discharge rate (in cms) and the second column turbine efficiency, in [0 1] interval, corresponding to the first column
  - designHead: A vector of length of two, containing the minimum and maximum design water head (in meter) of the turbine respectively, that the it is in active state
  - designFlow: A vector of length of two, containing the minimum and maximum design flow rate (in cms) of the turbine respectively, that the it is in active state
  - turbineAxisElevation: The elevation of axis of the installed turbine (in meter)
  - submerged: logical: if the turbine is of type of submerged on, TRUE, otherwise, FALSE
  - loss: losses associated with the turbine (in meter)
- penstock (optional) A list of penstock specifications. It is provided if type = 'hydropower':
- diameter: The diameter of the penstock (in meter)
  - length: The length of the penstock (in meter)
  - roughness: pipe roughness coefficient used for Hazen-Williams formulation
- initialStorage (optional) The initial stored water at the reservoir in the first step of the simulation (MCM). If is missing the the function iterate to carry over the reservoir.

**Value**

An object from class of createReservoir

**Author(s)**

Rezgar Arabzadeh

**See Also**

[addObjectToArea](#)

---

createReservoir.base *base function for class of createReservoir*

---

### Description

this function constructs an object from class of createReservoir, which is able to simulate a storage reservoir under given a sort of demand(s).

### Usage

```
## S3 method for class 'base'
createReservoir(type,
                name,
                priority,
                downstream,
                netEvaporation,
                seepageFraction,
                seepageObject,
                geometry,
                plant,
                penstock,
                initialStorage)
```

### Arguments

type	A string: the type of the reservoir being instantiated: by default 'storage', however, it can be 'hydropower'
name	(optional) A string: the name of the reservoir.
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.
downstream	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which spillage volume pours to it.
netEvaporation	A vector: is a vector of net evaporation depth time series at the location of dam site (meter). If omitted, the evaporation is assumed to be zero.
seepageFraction	(optional) The seepage coefficient of reservoir storage. The seepage is computed as the product of seepageFraction and reservoir storage. It is in [0, 1] interval
seepageObject	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which seepage volume pours to it.
geometry	A list of reservoir geometric specifications: <ul style="list-style-type: none"> <li>• storageAreaTable: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains reservoir area (in Km<sup>2</sup>) corresponding to the first column</li> </ul>

- storageElevationTable: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains elevation (in meter) corresponding to the first column
  - dischargeElevationTable: is a matrix whose first column includes the capacity of reservoir tailwater discharge rate (in cms) for different elevation levels and the second column contains elevation levels corresponding to the first column, required if the type = 'hydropower' and the item submerged = TRUE
  - deadStorage: refers to water in a reservoir that cannot be drained by gravity through the dam outlet works (MCM)
  - capacity: The maximum capacity of the reservoir
- plant A list of power plant specifications. It is provided if type = 'hydropower':
- installedCapacity: the plant installed capacity (MW)
  - efficiency: is a matrix whose first column includes discharge rate (in cms) and the second column turbine efficiency, in [0 1] interval, corresponding to the first column
  - designHead: A vector of length of two, containing the minimum and maximum design water head (in meter) of the turbine respectively, that the it is in active state
  - designFlow: A vector of length of two, containing the minimum and maximum design flow rate (in cms) of the turbine respectively, that the it is in active state
  - turbineAxisElevation: The elevation of axis of the installed turbine (in meter)
  - submerged: logical: if the turbine is of type of submerged on, TRUE, otherwise, FALSE
  - loss: losses associated with the turbine (in meter)
- penstock (optional) A list of penstock specifications. It is provided if type = 'hydropower':
- diameter: The diameter of the penstock (in meter)
  - length: The length of the penstock (in meter)
  - roughness: pipe roughness coefficient used for Hazen-Williams formulation
- initialStorage (optional) The initial stored water at the reservoir in the first step of the simulation (MCM). If is missing the the function iterate to carry over the reservoir.

**Value**

An object from class of list

**See Also**

[createReservoir](#)

---

```
createReservoir.default
    default function for class of createReservoir
```

---

### Description

this function constructs an object from class of createReservoir, which is able to simulate a storage reservoir under given a sort of demand(s).

### Usage

```
## Default S3 method:
createReservoir(type='storage',
                name='unknown',
                priority=NA,
                downstream=NA,
                netEvaporation=NA,
                seepageFraction=NA,
                seepageObject=NA,
                geometry=list(storageAreaTable=NULL,
                              storageElevationTable=NULL,
                              dischargeElevationTable=NULL,
                              deadStorage=NULL,
                              capacity=NULL),
                plant=list(installedCapacity=NULL,
                            efficiency=NULL,
                            designHead=NULL,
                            designFlow=NULL,
                            turbineAxisElevation=NULL,
                            submerged=FALSE,
                            loss=0),
                penstock=list(diameter=NULL,
                              length=NULL,
                              roughness=110),
                initialStorage=NA)
```

### Arguments

type	A string: the type of the reservoir being instantiated: by default 'storage', however, it can be 'hydropower'
name	(optional) A string: the name of the reservoir.
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.
downstream	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which spillage volume pours to it.

netEvaporation	A vector: is a vector of net evaporation depth time series at the location of dam site (meter). If omitted, the evaporation is assumed to be zero.
seepageFraction	(optional) The seepage coefficient of reservoir storage. The seepage is computed as the product of seepageFraction and reservoir storage. It is in $[0, 1]$ interval
seepageObject	(optional) An object; from either of classes of <code>createAquifer</code> , <code>createRiver</code> , <code>createReservoir</code> , <code>createJunction</code> , <code>createDiversion</code> , or <code>createDemandSite</code> ; which seepage volume pours to it.
geometry	A list of reservoir geometric specifications: <ul style="list-style-type: none"> <li>• <code>storageAreaTable</code>: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains reservoir area (in <math>\text{Km}^2</math>) corresponding to the first column</li> <li>• <code>storageElevationTable</code>: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains elevation (in meter) corresponding to the first column</li> <li>• <code>dischargeElevationTable</code>: is a matrix whose first column includes the capacity of reservoir tailwater discharge rate (in cms) for different elevation levels and the second column contains elevation levels corresponding to the first column, required if the type = 'hydropower' and the item submerged = TRUE</li> <li>• <code>deadStorage</code>: refers to water in a reservoir that cannot be drained by gravity through the dam outlet works (MCM)</li> <li>• <code>capacity</code>: The maximum capacity of the reservoir</li> </ul>
plant	A list of power plant specifications. It is provided if type = 'hydropower': <ul style="list-style-type: none"> <li>• <code>installedCapacity</code>: the plant installed capacity (MW)</li> <li>• <code>efficiency</code>: is a matrix whose first column includes discharge rate (in cms) and the second column turbine efficiency, in <math>[0, 1]</math> interval, corresponding to the first column</li> <li>• <code>designHead</code>: A vector of length of two, containing the minimum and maximum design water head (in meter) of the turbine respectively, that the it is in active state</li> <li>• <code>designFlow</code>: A vector of length of two, containing the minimum and maximum design flow rate (in cms) of the turbine respectively, that the it is in active state</li> <li>• <code>turbineAxisElevation</code>: The elevation of axis of the installed turbine (in meter)</li> <li>• <code>submerged</code>: logical: if the turbine is of type of submedged on, TRUE, otherwise, FALSE</li> <li>• <code>loss</code>: losses associated with the turbine (in meter)</li> </ul>
penstock	(optional) A list of penstock specifications. It is provided if type = 'hydropower' <ul style="list-style-type: none"> <li>• <code>diameter</code>: The diameter of the penstock (in meter)</li> <li>• <code>length</code>: The length of the penstock (in meter)</li> <li>• <code>roughness</code>: pipe roughness coefficient used for Hazen-Williams formulation</li> </ul>
initialStorage	(optional) The initial stored water at the reservoir in the first step of the simulation (MCM). If is missing the the function iterate to carry over the reservoir.

**Value**

An object from class of createReservoir

**See Also**

[createReservoir](#)

---

createRiver	<i>Constructor for class of createRiver</i>
-------------	---

---

**Description**

this function constructs an object from class of createRiver, which is able to act as a chanel or resource to supply a seort of demand(s).

**Usage**

```
createRiver(name, downstream, seepageFraction,
            seepageObject, discharge, priority)
```

**Arguments**

name	(optional) A string: the name of the river
downstream	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which outflow volume pours to it.
seepageFraction	(optional) The seepage coefficient of river discharge flow. The seepage is computed as the product of seepageFraction and river discharge. It is in [0, 1] interval
seepageObject	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which seepage volume pours to it.
discharge	(optional) A vector: is a vector of river discharge time series (MCM).
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.

**Value**

An object from class of createRiver

**Author(s)**

Rezgar Arabzadeh

**See Also**

[addObjectToArea](#)



---

createRiver.base	<i>base function for class of createRiver</i>
------------------	---

---

### Description

this function constructs an object from class of createRiver, which is able to act as a chanel or resource to supply a seort of demand(s).

### Usage

```
## S3 method for class 'base'
createRiver(name, downstream, seepageFraction,
            seepageObject, discharge, priority)
```

### Arguments

name	(optional) A string: the name of the river
downstream	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which outflow volume pours to it.
seepageFraction	(optional) The seepage coefficient of river discharge flow. The seepage is computed as the product of seepageFraction and river discharge. It is in [0, 1] interval
seepageObject	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which seepage volume pours to it.
discharge	(optional) A vector: is a vector of river discharge time series (MCM).
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.

### Value

An object from class of list

### See Also

[createRiver](#)

---

createRiver.default    *default function for class of createRiver*

---

### Description

this function constructs an object from class of createRiver, which is able to act as a channel or resource to supply a sort of demand(s).

### Usage

```
## Default S3 method:
createRiver(name = "river1",
            downstream      = NA,
            seepageFraction = NA,
            seepageObject   = NA,
            discharge        = NA,
            priority         = NA)
```

### Arguments

name	(optional) A string: the name of the river
downstream	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which outflow volume pours to it.
seepageFraction	(optional) The seepage coefficient of river discharge flow. The seepage is computed as the product of seepageFraction and river discharge. It is in [0, 1] interval
seepageObject	(optional) An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which seepage volume pours to it.
discharge	(optional) A vector: is a vector of river discharge time series (MCM).
priority	(optional) An integer: the supplying priority. priority is a value in [1, 99] interval. If missing, the priority is set to Inf.

### Value

An object from class of createRiver

### See Also

[createRiver](#)

---

diversionRouting      *base function for diversion simulation*

---

### Description

Given a sort of demand(s), diversionRouting function enable us to simulate the performance and effect of a diversion dam under a givn recharge time series, inflow, on the drainage network.

### Usage

```
diversionRouting(demand=NA, priority = NA,  
                capacity, inflow, simulation)
```

### Arguments

demand	A matrix: is column-wise matrix of demands, at which the rows presents demands for each time step and columns are for different individual demand sites (MCM).
priority	A vector: is a vector of priorities associated to demand
capacity	The maximum capacity of diversion dam (CMS).
inflow	A vector : a vector of water flowing into the diversion (MCM)
simulation	A list: simulation is a list of three vectors: start, end, and interval. the start and end components must be in 'YYYY-MM-DD' format. the interval component can takes either of 'day', 'week', or 'month'.

### Value

the diversionRouting function returns a list of features given as below:

- release : a matrix of release(s) equivalant to each demand (MCM)
- diverted: a vector of diverted volumes (MCM), release(s) are included
- overflow: a vector of overflow passing through the diversion (MCM)

### Author(s)

Rezgar Arabzadeh

### See Also

[aquiferRouting](#)

**Examples**

```

demand      <-matrix(rnorm(480,10,3),120)
priority    <-sample(1:3,4,replace=TRUE)
capacity    <-12
inflow      <-rlnorm(120,log(50),log(4))
simulation  <-list(start='2000-01-01',end='2009-12-29',interval='month')
res<-diversionRouting(demand=demand,
                      priority=priority,
                      capacity=capacity,
                      inflow=inflow,
                      simulation=simulation)
plot(ecdf(res$diverted$diverted),xlab='cms',ylab='exceedance probability')

```

GOF

*Goodness of fit***Description**

this function calculates the goodness of fit (gof) using chi-squared test.

**Usage**

```
GOF(basin,object,observed)
```

**Arguments**

basin	An object from class of sim.
object	An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which is associated with observed time series and exists in the basin.
observed	A vector of observed time series.

**Value**

A list with class "htest".

**Author(s)**

Rezgar Arabzadeh

**See Also**

[sim](#)

**Examples**

```

J1<-createJunction(name="j1")
Res1<-createReservoir(name="res1",type='storage',
                      priority=1,netEvaporation=rnorm(120,0.5,0.1),
                      geometry=list(deadStorage= 10 ,capacity= 90 ,
                                    storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
Res2<-createReservoir(name="res2",type='storage',
                      priority=2,netEvaporation=rnorm(120,0.5,0.1),
                      geometry=list(deadStorage= 10 ,capacity= 90 ,
                                    storageAreaTable= cbind(seq(0,90,10),seq(0,9,1))))
R1<-createRiver(name="river1",discharge=rnorm(120,5,1.5))
R2<-createRiver(name="river2",discharge=rnorm(120,5,1.5))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                      100/sum(sin(seq(0,pi,length.out=12))))
D1<-createDemandSite(name ="Agri1",
                     demandParams=list(waterUseRate=1,
                                         waterVariation=waterVariation,
                                         cropArea=1000),
                     returnFlowFraction =0.2,priority=1)
D2<-createDemandSite(name ="Agri2",
                     demandParams=list(waterUseRate=1,
                                         waterVariation=waterVariation,
                                         cropArea=1000),
                     returnFlowFraction =0.2,priority=2)
D3<-createDemandSite(name ="Agri3",
                     demandParams=list(waterUseRate=1,
                                         waterVariation=waterVariation,
                                         cropArea=1000),
                     returnFlowFraction =0.2,priority=1)
area<-createArea(name="unknown",location="unknown",
                 simulation=list(start='2000-01-01',
                                end  ='2000-04-29',
                                interval='day'))

R1<-set.as(Res1,R1,'downstream')
R2<-set.as(Res2,R2,'downstream')
Res1<-set.as(J1,Res1,'downstream')
Res2<-set.as(J1,Res2,'downstream')
D1<-set.as(J1,D1,'downstream')
D2<-set.as(J1,D2,'downstream')
D3<-set.as(J1,D3,'downstream')
D1<-set.as(Res1,D1,'supplier')
D2<-set.as(Res1,D2,'supplier')
D2<-set.as(Res2,D2,'supplier')
D3<-set.as(Res2,D3,'supplier')

area<-addObjectToArea(area,R1)
area<-addObjectToArea(area,R2)
area<-addObjectToArea(area,Res1)
area<-addObjectToArea(area,Res2)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)

```

```

area<-addObjectToArea(area,D3)
area<-addObjectToArea(area,J1)
## Not run:
  plot(area)

## End(Not run)
simulated<-sim(area)
observed<-apply(simulated$operation$operation$junctions[[1]]$operation$outflow,1,sum)
observed<-observed+rnorm(length(observed),mean(observed)*0.2,sd(observed)*0.1)
GOF(simulated,J1,observed)

```

---

GOF.base

*base function for class of GOF*


---

### Description

this function calculates the goodness of fit (gof) using chi-squared test.

### Usage

```

## S3 method for class 'base'
GOF(basin,object,observed)

```

### Arguments

basin	An object from class of sim.
object	An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which is associated with observed time series and exists in the basin.
observed	A vector of observed time series.

### Value

A list with class "hstest".

### Author(s)

Rezgar Arabzadeh

### See Also

[GOF](#)

---

GOF.default	<i>default function for class of GOF</i>
-------------	--

---

**Description**

this function calculates the goodness of fit (gof) using chi-squared test.

**Usage**

```
## Default S3 method:  
GOF(basin,object,observed)
```

**Arguments**

basin	An object from class of sim.
object	An object from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a> ; which is associated with observed time series and exists in the basin.
observed	A vector of observed time series.

**Value**

A list with class "htest".

**Author(s)**

Rezgar Arabzadeh

**See Also**

[GOF](#)

---

plot.createArea	<i>plot method for an object from class of createArea</i>
-----------------	---

---

**Description**

plot method for objects inherited from class of createArea

**Usage**

```
## S3 method for class 'createArea'  
plot(x,...)
```

**Arguments**

x                    an object from class of createArea  
...                   other objects that can be passed to plot function

**Author(s)**

Rezgar Arabzadeh

**See Also**

[createArea](#)

---

plot.sim

*plot method for an WRSS object*

---

**Description**

plot method for objects inherited from class of sim

**Usage**

```
## S3 method for class 'sim'  
plot(x,...)
```

**Arguments**

x                    an object from class of sim  
...                   other objects that can be passed to plot function

**Author(s)**

Rezgar Arabzadeh

**See Also**

[sim](#)



---

reservoirRouting	<i>base function for reservoir simulation</i>
------------------	---

---

### Description

Given a sort of demand(s), reservoirRouting function simulates the effect of a dam under given hydrometeorological time series, e.g. inflow and netEvaporation, on the drainage network.

### Usage

```
reservoirRouting(type='storage',
                 inflow,
                 netEvaporation=NA,
                 demand=NA,
                 priority=NA,
                 seepageFraction=NA,
                 geometry=list(storageAreaTable=NULL,
                              storageElevationTable=NULL,
                              dischargeElevationTable=NULL,
                              deadStorage=0,
                              capacity=NULL),
                 plant=list(installedCapacity=NULL,
                             efficiency=NULL,
                             designHead=NULL,
                             designFlow=NULL,
                             turbineAxisElevation=NULL,
                             submerged=FALSE,
                             loss=0),
                 penstock=list(diameter=NULL,
                               length=0,
                               roughness=110),
                 initialStorage=NA,
                 simulation)
```

### Arguments

type	A string: the type of the reservoir being instantiated: by default 'storage', however, it can be 'hydropower'
inflow	A vector : a vector of water flowing into the diversion (MCM)
netEvaporation	A vector: is a vector of net evaporation depth time series at the location of dam site (meter). If omitted, the evaporation is assumed to be zero.
demand	A matrix: is column-wise matrix of demands, at which the rows presents demands for each monthly time steps and columns are for different individual demand sites (MCM).
priority	(optional) A vector: is a vector of priorities associated to demand

seepageFraction	(optional) The seepage coefficient of reservoir storage. The seepage is computed as the product of seepageFraction and reservoir storage.
geometry	<p>A list of reservoir geometric specifications:</p> <ul style="list-style-type: none"> <li>• storageAreaTable: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains reservoir area (in Km<sup>2</sup>) corresponding to the first column</li> <li>• storageElevationTable: is a matrix whose first column includes reservoir volume (MCM) for different elevation levels and the second column contains elevation (in meter) corresponding to the first column</li> <li>• dischargeElevationTable: is a matrix whose first column includes the capacity of reservoir tailwater discharge rate (in cms) for different elevation levels and the second column contains elevation levels corresponding to the first column, required if the type = 'hydropower' and the item submerged = TRUE</li> <li>• deadStorage: refers to water in a reservoir that cannot be drained by gravity through the dam outlet works (MCM)</li> <li>• capacity: The maximum capacity of the reservoir</li> </ul>
plant	<p>A list of power plant specifications. It is provided if type = 'hydropower':</p> <ul style="list-style-type: none"> <li>• efficiency: is a matrix whose first column includes discharge rate (in cms) and the second column turbine efficiency, in [0 1] interval, corresponding to the first column</li> <li>• designHead: A vector of length of two, containing the minimum and maximum design water head (in meter) of the turbine respectively, that the it is in active state</li> <li>• designFlow: A vector of length of two, containing the minimum and maximum design flow rate (in cms) of the turbine respectively, that the it is in active state</li> <li>• turbineAxisElevation: The elevation of axis of the installed turbine (in meter)</li> <li>• submerged: logical: if the turbine is of type of submedged on, TRUE, otherwise, FALSE</li> <li>• loss: losses associated with the turbine (in meter)</li> </ul>
penstock	<p>(optional) A list of penstock specifications. It is provided if type = 'hydropower'</p> <ul style="list-style-type: none"> <li>• diameter: The diameter of the penstock (in meter)</li> <li>• length: The length of the penstock (in meter)</li> <li>• roughness: pipe roughness coefficient used for Hazen-Williams formulation</li> </ul>
initialStorage	(optional) The initial stored water at the reservoir in the first step of the simulation (MCM). If is missing the the function iterate to carry over the reservoir.
simulation	A list: simulation is a list of three vectors: start, end, and interval. the start and end components must be in 'YYYY-MM-DD' format. the interval component can takes either of 'day', 'week', or 'month'.

**Value**

the reservoirRouting function returns a list of features given as follows:

- release: a matrix of release(s) equivalent to each demand (MCM)
- spill : a vector of spillage time series (MCM)
- seepage: a vector of seepage time series (MCM)
- storage: a vector of storage time series (MCM)
- loss : a vector of evaporation loss time series (MCM)

**Author(s)**

Rezgar Arabzadeh

**References**

Yeh, William WG. "Reservoir management and operations models: A state of the art review." Water resources research 21.12 (1985): 1797-1818.

**See Also**

[aquiferRouting](#)

**Examples**

```

type          <-c('storage', 'hydropower')
demand        <-matrix(rnorm(480,10,3),120)
priority      <-sample(1:3,4,replace=TRUE)
inflow        <-rlnorm(120,log(50),log(4))
netEvaporation <-rnorm(120,0.4,0.1)
simulation    <-list(start='2000-01-01',end='2009-12-29',interval='month')
seepageFraction<-0.05
geometry      <-list(storageAreaTable=cbind(seq(0,100,10),seq(0,10,1)),
                    storageElevationTable=cbind(seq(0,100,10),seq(0,200,20)),
                    dischargeElevationTable=cbind(seq(0,50,10),seq(0,10,2)),
                    deadStorage=50,
                    capacity=100)
plant         <-list(installedCapacity=50,
                    efficiency=cbind(c(5,25,45),c(0.5,0.9,0.7)),
                    designHead=c(100,200),
                    designFlow=c(10,40),
                    turbineAxisElevation=5,
                    submerged=TRUE,
                    loss=2)
penstock      <-list(diameter=2,
                    length=50,
                    roughness=110)

#-----Storage Reservoir-----
reservoirRouting(type=type[1],
                 inflow=inflow,
```

```

        netEvaporation=netEvaporation,
        demand=demand,
        priority=priority,
        seepageFraction=seepageFraction,
        geometry=geometry,
        plant=plant,
        penstock=penstock,
        simulation=simulation)
## Not run:
##-----Takes Several Minutes-----

#-----Hydropower Reservoir with demand-----
reservoirRouting(type=type[2],
                 inflow=inflow,
                 netEvaporation=netEvaporation,
                 demand=demand,
                 priority=priority,
                 seepageFraction=seepageFraction,
                 geometry=geometry,
                 plant=plant,
                 penstock=penstock,
                 simulation=simulation)

#-----Hydropower Reservoir-----
reservoirRouting(type=type[2],
                 inflow=inflow,
                 netEvaporation=netEvaporation,
                 priority=priority,
                 seepageFraction=seepageFraction,
                 geometry=geometry,
                 plant=plant,
                 penstock=penstock,
                 simulation=simulation)

## End(Not run)

```

---

rippl

*Rippl's method*


---

### Description

Computes the Rippl-no-failure storage for given set of discharges and target.

### Usage

```
rippl(discharge, target, plot=TRUE)
```

**Arguments**

discharge	a vector of natural discharge at the reservoir site.
target	a vector of demand time series with length equal that of discharge. If the time scale doesn't match, the target will be cycled or truncated.
plot	logical: whether plot the Rippl's method process or merely report the result.

**Value**

no-failure storage value for the given time series, discharge and target.

**References**

Rippl, Wengel. The capacity of storage reservoirs for water supply. Van Nostrand's Engineering Magazine (1879-1886) 29.175 (1883): 67.

**See Also**

[sim](#)

**Examples**

```
## Not run:
ripl(Nile,mean(Nile)*0.95)

## End(Not run)
```

---

risk	<i>risk-based criteria</i>
------	----------------------------

---

**Description**

this function returns risk-based criteria for demand site(s) built-in the object inherited from class of `sim`.

**Usage**

```
risk(object , s.const = 0.95)
```

**Arguments**

object	an object from class of <code>sim</code>
s.const	satisfactory constant: a value in [0, 1] interval, which refers to the level at which if a demand is supplied over the s.const is considered fully supplied.

**Details**

This function computes the risks criteria based on the formulations proposed by Hashimoto et.al (1982).

**Value**

a matrix of criteria

**Author(s)**

Rezgar Arabzadeh

**References**

Hashimoto, Tsuyoshi, Jerry R. Stedinger, and Daniel P. Loucks. "Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation." *Water resources research* 18.1 (1982): 14-20.

**See Also**

[sim](#)

**Examples**

```
Res<-createReservoir(name="R1",type='storage',
                    netEvaporation=rnorm(120,0.5,0.1),
                    geometry=list(deadStorage= 10,
                                  capacity= 700,
                                  storageAreaTable= cbind(seq(0,900,100),seq(0,9,1))))
R<-createRiver(name="Riv1",downstream=Res,discharge=rnorm(120,500,4))
waterVariation<-round(sin(seq(0,pi,length.out=12))*
                      100/sum(sin(seq(0,pi,length.out=12))))
D1<-createDemandSite(name ="D1",
                    demandParams=list(waterUseRate=5,
                                       waterVariation=waterVariation,
                                       cropArea=500),
                    suppliers=list(Res),priority=1)
D2<-createDemandSite(name ="D2",
                    demandParams=list(waterUseRate=5,
                                       waterVariation=waterVariation,
                                       cropArea=500),
                    suppliers=list(Res),priority=2)
D3<-createDemandSite(name ="D3",
                    demandParams=list(waterUseRate=5,
                                       waterVariation=waterVariation,
                                       cropArea=500),
                    suppliers=list(Res),priority=3)
area<-createArea(simulation=list(start='2000-01-01',end='2009-12-29',interval='month'))
area<-addObjectToArea(area,R)
area<-addObjectToArea(area,Res)
area<-addObjectToArea(area,D1)
area<-addObjectToArea(area,D2)
area<-addObjectToArea(area,D3)
risk(sim(area))
```

---

riverRouting	<i>base function for rivers and reaches simulation</i>
--------------	--

---

### Description

Given a sort of demand(s), riverRouting function enable us to simulate rivers and channels under givn a hydrologic time series, inflow, and optional demand(s).

### Usage

```
riverRouting(demand=NA, priority = NA, discharge, seepageFraction=NA, simulation)
```

### Arguments

demand	(optional) A matrix: is column-wise matrix of demands, at which the rows presents demands for each time step and columns are for different individual demand sites (MCM).
priority	(optional) A vector: is a vector of priorities associated to demand
discharge	(optional) A vector : a vector of water flowing into the diversion (MCM)
seepageFraction	(optional) The seepage coefficient of river discharge flow. The seepage is computed as the product of seepageFraction and river discharge. It is in [0, 1] interval
simulation	A list: simulation is a list of three vectors: start, end, and interval. the start and end components must be in 'YYYY-MM-DD' format. the interval component can takes either of 'day', 'week', or 'month'.

### Value

the riverRouting returns a matrix of release(s) corresponding to each demand(s).

### Author(s)

Rezgar Arabzadeh

### See Also

[diversionRouting](#)

### Examples

```
demand      <-matrix(rnorm(480,15,3),120)
priority    <-sample(1:3,4,replace=TRUE)
discharge   <-rlnorm(120,log(50),log(4))
simulation  <-list(start='2000-01-01',end='2000-04-29',interval='day')

riverRouting(demand = demand ,
```

```

priority = priority ,
discharge = discharge,
simulation= simulation)

```

---

set.as

*WRSS objects connector*


---

### Description

this function connects a base object as a either of: 'downstream', 'supplier', 'leakageObject', 'seepageObject', or 'divertObject' to a target object, which are both instantiated by WRSS constructors.

### Usage

```
set.as(base, target, type='downstream')
```

### Arguments

base	An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a>
target	An object; from either of classes of <a href="#">createAquifer</a> , <a href="#">createRiver</a> , <a href="#">createReservoir</a> , <a href="#">createJunction</a> , <a href="#">createDiversion</a> , or <a href="#">createDemandSite</a>
type	the type of base object to be set as to the target object: 'downstream', 'supplier', 'leakageObject', 'seepageObject', or 'divertObject'

### Value

an object from class of target object.

### Author(s)

Rezgar Arabzadeh

### See Also

[addObjectToArea](#)



sim *Constructor for class of sim*

**Description**

sim simulates an object inherited from class of createArea using Standard Operating Policy (SOP).

**Usage**

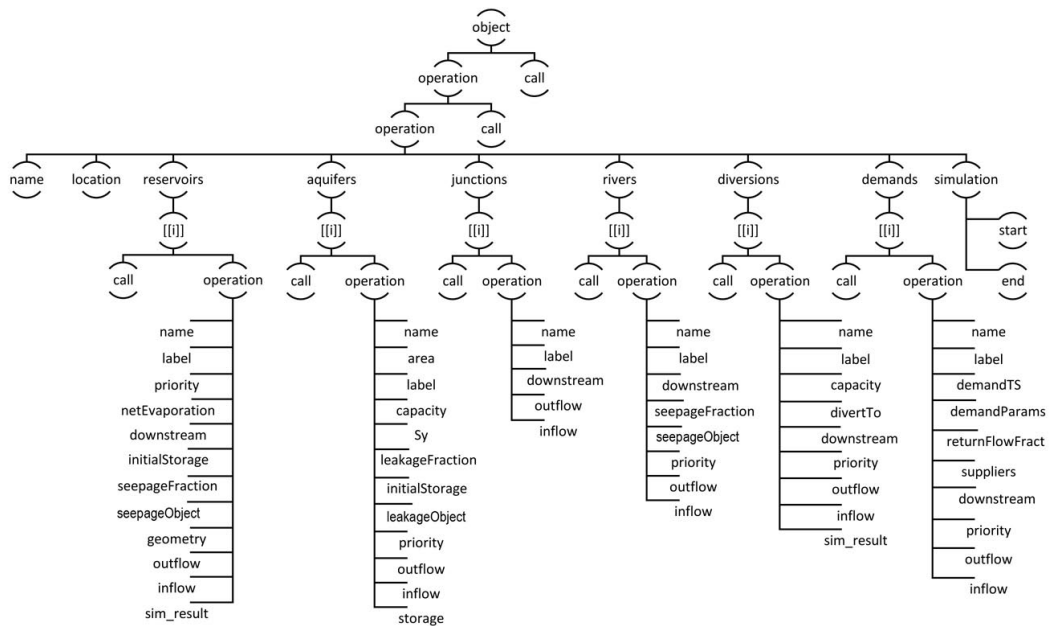
sim(object)

**Arguments**

object an object inherited from class of createArea.

**Value**

an object inherited from class of sim. Address keys to access components built-in an object inherited from class of sim is as figure below:



**Author(s)**

Rezgar Arabzadeh

**References**

Loucks, Daniel P., et al. Water resources systems planning and management: an introduction to methods, models and applications. Paris: Unesco, 2005.

**See Also**

[addObjectToArea](#)

---

sim.base	<i>base function for class of sim</i>
----------	---------------------------------------

---

**Description**

sim simulates an object inherited from class of createArea using Standard Operating Policy (SOP).

**Usage**

```
## S3 method for class 'base'
sim(object)
```

**Arguments**

object            an object inherited from class of createArea.

**Value**

an object inherited from class of list and including features as list(s), which are accessible as follows:

reservoirs: operation\$reservoirs rivers: operation\$rivers junctions: operation\$junctions aquifers: operation\$aquifers diversions: operation\$diversions demands: operation\$demands

**See Also**

[sim](#)

---

sim.default	<i>default function for class of sim</i>
-------------	--

---

**Description**

sim simulates an object inherited from class of createArea using Standard Operating Policy (SOP).

**Usage**

```
## Default S3 method:
sim(object)
```

**Arguments**

object            an object inherited from class of createArea.

**Value**

an object inherited from class of `sim` and including features as list(s), which are accessible as follows:

reservoirs: `$operation$operation$reservoirs` rivers: `$operation$operation$rivers` junctions: `$operation$operation$junctions` aquifers: `$operation$operation$aquifers` diversions: `$operation$operation$diversions` demands: `$operation$operation$demands`

**See Also**

[sim](#)

---

zarrineh

*data of Zarrineh-rud river basin*

---

**Description**

The `zarrineh` object, is a list of objects including time series and detail a five-reservoir system in the Zarrineh-rud river basin.

**Format**

list object

**References**

Iran Water Resources Management Company, 2016.

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