

# Rainwater Ontology Documentation

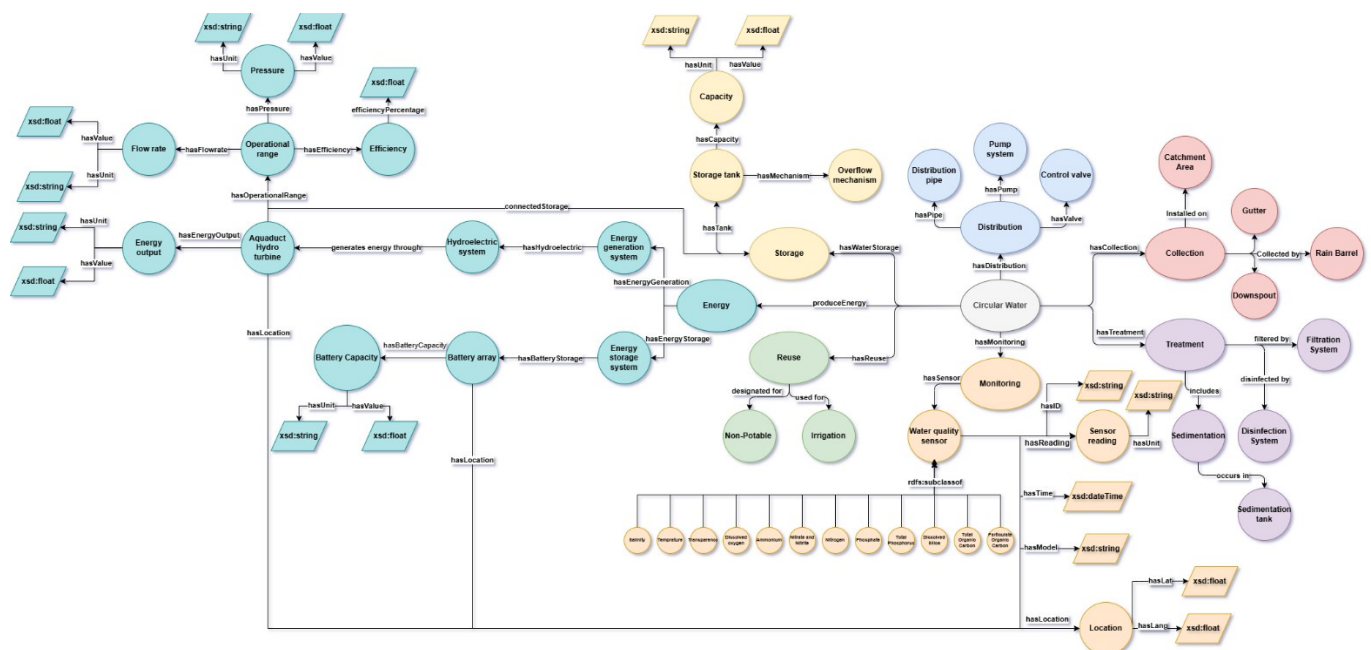
## Ontology

### 1. Overview

The Rainwater Ontology models the various components and processes involved in rainwater collection, storage, treatment, distribution, monitoring, and reuse. It provides a structured framework for representing knowledge about rainwater management systems.

In the future, the model will be extended to accommodate existing ontologies in order to avoid duplicate work. The starting point would be integrating “SSN SOSA” with the “Water Quality Sensor”.

This document describes the developed rainwater ontology along with its data, shapes and constraints. The ontology file is written in Turtle (TTL) format, which is a syntax for expressing data in the Resource Description Framework (RDF).



### 2. Ontology Metadata

- **URI:** `http://example.org#RainWaterOntology`
- **Label:** "Rain Water Ontology"
- **Description:** "This ontology models Rain water"
- **Version:** "1.0"

### 3. Core Classes

#### Main Class

- **RainWater** (ex:RainWater)

- The main class representing rainwater in the system
- Subclass of `owl:Thing`

### ***Collection System***

- **Collection** (`ex:Collection`)
  - Structures to collect rain
- **CatchmentArea** (`ex:CatchmentArea`)
  - Surface area where rainwater is collected
- **RainBarrel** (`ex:RainBarrel`)
- **Gutter** (`ex:Gutter`)
- **Downspout** (`ex:Downspout`)

### ***Storage System***

- **Storage** (`ex:Storage`)
- **StorageTank** (`ex:StorageTank`)
  - Containers where collected rainwater is stored
- **OverflowMechanism** (`ex:OverflowMechanism`)
  - Systems to handle excess water when storage tanks are full

### ***Treatment System***

- **Treatment** (`ex:Treatment`)
- **Sedimentation** (`ex:Sedimentation`)
  - Process where larger particles settle at the bottom of a tank
- **SedimentationTank** (`ex:SedimentationTank`)
- **FiltrationSystem** (`ex:FiltrationSystem`)
  - Devices or processes to remove particulates
- **DisinfectionSystem** (`ex:DisinfectionSystem`)
  - Methods to treat rainwater for potable uses

### ***Distribution System***

- **Distribution** (`ex:Distribution`)
- **DistributionPipe** (`ex:DistributionPipe`)
  - Networks that transport rainwater

- **PumpSystem** (ex:PumpSystem)
  - Devices that facilitate water movement
- **ControlValve** (ex:ControlValve)
  - Devices that regulate flow

### ***Reuse System***

- **Reuse** (ex:Reuse)
- **Irrigation** (ex:Irrigation)
- **NonPottable** (ex:NonPottable)

### ***Monitoring System***

- **Monitoring** (ex:Monitoring)
- **WaterQualitySensor** (ex:WaterQualitySensor)
  - Base class for all water quality sensors
- **SensorReading** (ex:SensorReading)
- **TimeStamp** (ex:TimeStamp)
- **Location** (ex:Location)

### ***Specific Sensor Types (all subclass of WaterQualitySensor)***

- **Salinity** (ex:Salinity)
- **Temperature** (ex:Temperature)
- **Transparency** (ex:Transparency)
- **DissolvedOxygen** (ex:DissolvedOxygen)
- **Ammonium** (ex:Ammonium)
- **NitrateNitrite** (ex:NitrateNitrite)
- **TotalNitrogen** (ex:TotalNitrogen)
- **Phosphate** (ex:Phosphate)
- **TotalPhosphorus** (ex:TotalPhosphorus)
- **DissolvedSilica** (ex:DissolvedSilica)
- **TotalOrganicCarbon** (ex:TotalOrganicCarbon)
- **ParticulateOrganicCarbon** (ex:ParticulateOrganicCarbon)

## 4. Object Properties

### *RainWater Relationships*

- **hasStorage** (ex:hasStorage)
  - Domain: RainWater
  - Range: Storage
- **hasReuse** (ex:hasReuse)
  - Domain: RainWater
  - Range: Reuse
- **hasDistribution** (ex:hasDistribution)
  - Domain: RainWater
  - Range: Distribution
- **hasMonitoring** (ex:hasMonitoring)
  - Domain: RainWater
  - Range: Monitoring
- **hasCollection** (ex:hasCollection)
  - Domain: RainWater
  - Range: Collection
- **hasTreatment** (ex:hasTreatment)
  - Domain: RainWater
  - Range: Treatment

### *Distribution System Relationships*

- **hasPipe** (ex:hasPipe)
  - Domain: Distribution
  - Range: DistributionPipe
- **hasPump** (ex:hasPump)
  - Domain: Distribution
  - Range: PumpSystem
- **hasValve** (ex:hasValve)
  - Domain: Distribution
  - Range: ControlValve

### ***Storage System Relationships***

- **hasTank** (ex:hasTank)
  - Domain: Storage
  - Range: StorageTank
- **hasmechanism** (ex:hasmechanism)
  - Domain: StorageTank
  - Range: OverflowMechanism

### ***Monitoring System Relationships***

- **hasSensor** (ex:hasSensor)
  - Domain: Monitoring
  - Range: WaterQualitySensor
- **hasReading** (ex:hasReading)
  - Domain: WaterQualitySensor
  - Range: SensorReading
- **hasLocation** (ex:hasLocation)
  - Domain: WaterQualitySensor
  - Range: Location

### ***Reuse System Relationships***

- **DesignatedFor** (ex:DesignatedFor)
  - Domain: Reuse
  - Range: NonPottable
- **UsedFor** (ex:UsedFor)
  - Domain: Reuse
  - Range: Irrigation

### **Collection System Relationships**

- **InstalledOn** (ex:InstalledOn)
  - Domain: Collection
  - Range: CatchmentArea
- **CollectedBy** (ex:CollectedBy)

- Domain: Collection
- Range: Union of (Gutter, Downspout, RainBarrel)

## Treatment System Relationships

- **includes** (ex:includes)
  - Domain: Treatment
  - Range: Sedimentation
- **OccursIn** (ex:OccursIn)
  - Domain: Sedimentation
  - Range: SedimentationTank
- **FilteredBy** (ex:FilteredBy)
  - Domain: Treatment
  - Range: FiltrationSystem
- **DisinfectedBy** (ex:DisinfectedBy)
  - Domain: Treatment
  - Range: DisinfectionSystem

## Datatype Properties

### Sensor Properties

- **hasID** (ex:hasID)
  - Domain: WaterQualitySensor
  - Range: xsd:string
- **hasTime** (ex:hasTime)
  - Domain: WaterQualitySensor
  - Range: xsd:dateTime
- **hasModel** (ex:hasModel)
  - Domain: WaterQualitySensor
  - Range: xsd:string

### Reading Properties

- **hasUnit** (ex:hasUnit)

- Domain: SensorReading
- Range: xsd:string

## Location Properties

- **hasLat** (ex:hasLat)
  - Domain: Location
  - Range: xsd:float
- **hasLang** (ex:hasLang)
  - Domain: Location
  - Range: xsd:float

## 5. Usage Notes

This ontology provides a comprehensive model for rainwater management systems, with particular emphasis on water quality monitoring through various sensor types. Each sensor type includes documentation about the measurement method used.

The ontology can be used to:

- Model rainwater collection and distribution systems
- Track water quality measurements over time
- Represent relationships between system components
- Support decision-making for rainwater reuse applications

## Data generator

Due to the lack of real-world data, a data generator was designed to produce sample rainwater harvesting system with all components defined in the ontology. The data produced is compared against constraints written in SHACL to ensure data compliance. The script saves the generated data in Turtle format.

```
7   ex:system_1a2b3c4d a ex:RainWater ;
8       ex:hasCollection ex:catchment_5e6f7g8h ;
9       ex:hasDistribution ex:distribution_9i0j1k2l ;
10      ex:hasMonitoring ex:monitoring_3m4n5o6p ;
11      ex:hasReuse ex:reuse_7q8r9s0t ;
12      ex:hasStorage ex:storage_u1v2w3x4 ;
13      ex:hasTreatment ex:treatment_y5z6a7b8 .
14
```

Sample of generated data

## Shapes & Constraints

The rules and constraints that the data must adhere to are written in SHACL (Shapes Constraint Language). It defines validation rules for the rainwater ontology. It's written in Turtle (TTL) format.

### 2. Key components

- `sh:NodeShape`: Defines constraints for a specific class
- `sh:targetClass`: Specifies which class the shape applies to
- `sh:property`: Defines constraints on properties
- `sh:path`: Indicates which property is being constrained
- `sh:minCount`: Requires at least N values for a property
- `sh:class`: Restricts property values to specific classes
- `sh:or`: Allows alternative valid classes/properties
- `sh:message`: Custom error messages for violations

## Validator

This module is developed to act as a SHACL validator. It is designed to compare SHACL shapes to RDF-compliant data. It produces a report of errors, if they exist. The goal is to automate quality control for data pipelines or APIs. The module is generic and can be used on any SHACL and RDF data. The validator will be published separately as its own repository.