RRPAM-WDS: Risk-based renewal planning for asset management of water distribution systems

Risk based asset management covers a wide arrange of strategies aimed at prioritizing attention to critical steps, machinery, or infrastructure in order to avoid serious failures that may impact the operation of water distribution systems. Effective asset evaluation and planning include thorough knowledge on asset location, value, condition, and approximate residual life. This knowledge is the basis of future prioritised projections, performance and valuation reports, evaluation and renewal plans.

RRPAM-WDS, or Risk-based renewal planning for asset management of water distribution systems, is an educational software tool that demonstrates one of the many approaches for renewal planning in the domain of infrastructure asset management. It uses water distribution networks as basis for demonstrating the renewal planning approach. However, the principles demonstrated here are applicable for any other infrastructure asset system (e.g. roads, electrical grids, drainage/sewerage networks).

The purpose of this document is to present the basic steps needed to perform the tutorial of the RRPAM-WDS tool, fully available online in the BEWOP webpage.

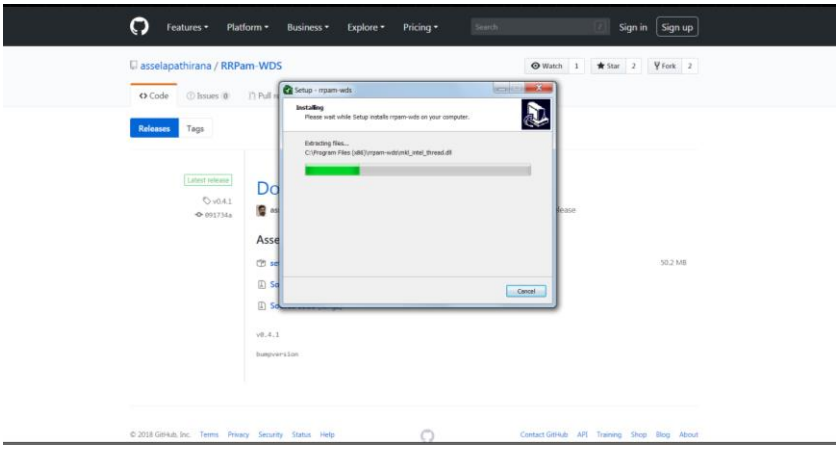
This tutorial covers the following content steps:

1. Installation
2. Usage
3. RRPAM-WDS Tutorial
4. Authors

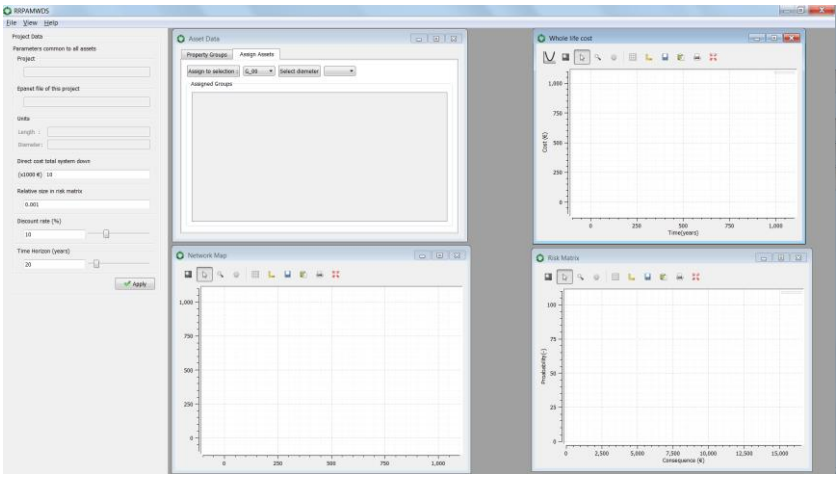
1 Installation

Windows installation

Access the latest self-extracting installation files from the [release documentation website](). Once there you can click on the setup.exe file, accept the terms and conditions. Download will start automatically.



Click on the option of opening the program after being installed. Once installation is complete, the program will start running. The first view of the program should look like this



Python installation

If you follow this path, make sure you have installed python and other required packages first. Then, at the command line write:

```
pip install rrpam-wds
```

2 Usage

If you have installed windows self-installation file (as shown in the first part of this manual), simply double-click on the start-menu entry *RRPAMWDS*

If you have installed as a python package (e.g. using pip install RRPAM-WDS), then type:

```
python -mrrpam_wds
```

This should open the RRPAM-WDS desktop application. Now we can follow the hands-on tutorial on asset management.

3 RRPAM-WDS Tutorial

Requirements

The following information is required to do an analysis with RRPAM-WDS:

a) Water distribution network in EPANET 2.0 network format (**.inp**): EPANET 2.0 model uses two model file formats, namely **.net format* - which is a binary format- and the text-based 'network file', *.inp* format. RRPAM-WDS can read the (**.inp**) format. If you follow the installation for windows, then the **.inp** example files will be saved in *C:\Program Files (x86)\rrpam-wds\rrpam_wds\examples*

b) Reasonable estimations for the parameters of the exponential aging formula by Shamir and Howard (1979)

$$N(t) = N_0 * e^{A*t}$$

Where N (t) → number of failures per year, per unit length (# km /year), t → age of the asset (in this case pipe), and N_o and A are aging parameters

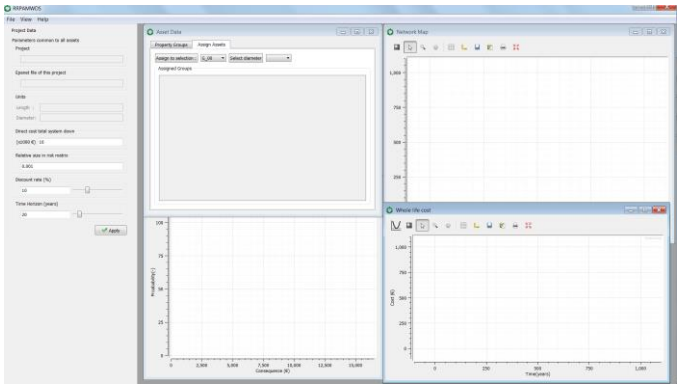
This exponential background-aging model calculates the number of failures per year, per unit length.

For the development of this guideline example data for N_o and A will be given. However, in real life scenarios, it is important to obtain these data either from real measurements or extrapolation exercises.

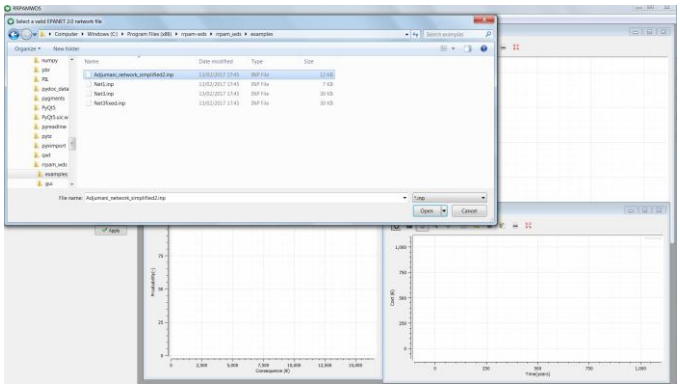
Getting started

1- We will first create a new project, so we have to navigate to find the files we need. Go to *C:\Program Files (x86)\rrpam-wds\rrpam_wds\examples* and there choose the **Adjumani_network_simplified2.inp**

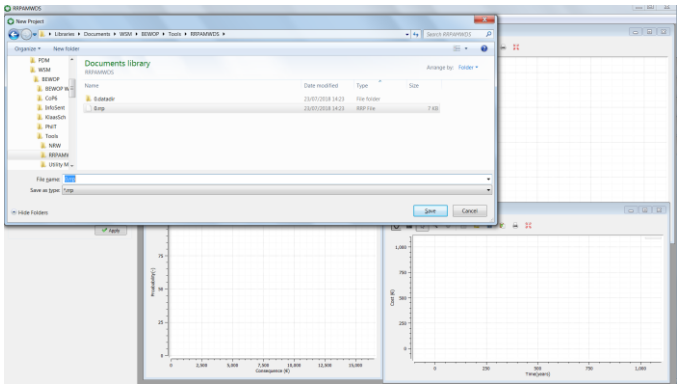
At the beginning, all analysis panes appear blank:



Then, navigate to open *C:\Program Files (x86)\rrpam-wds\rrpam_wds\examples*, find the indicated location of the Adjumani network file. Choose the **Adjumani_network_simplified2.inp** file

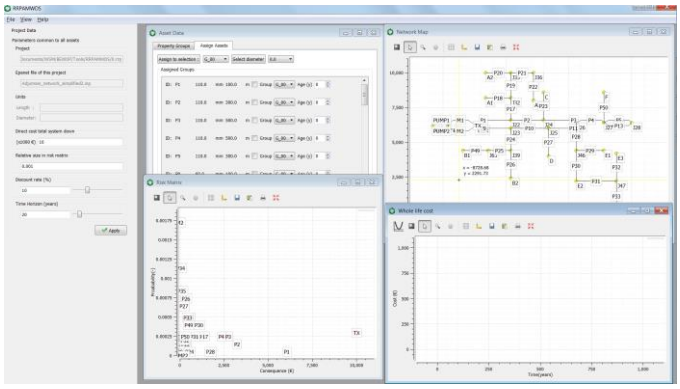


Then, we are asked to create a new project file. It is convenient to create a new folder with our exercises, in this case we will create a 0.rrp file, as follows



After this, the program will take some moments to do the initial hydraulic calculations.

We will see 4 different windows. One will have the *Asset Data* showing links and characteristics of the network; the second one will have a *Network Map* diagram representing the hydraulic network; the third one will show the *Risk Matrix* plot and the fourth will correspond to the *Whole life cost* (these two will be empty since we have not entered calculation values yet). It should look like this:



From this getting started phase we will proceed to perform the first calculations.

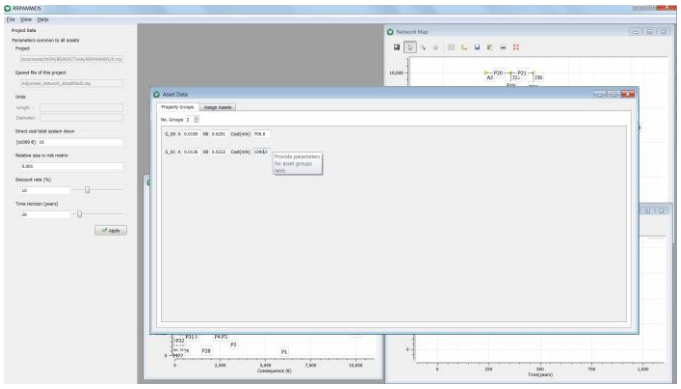
Input of failure data

2- In order to perform the first calculations we will input the following example data for N_o, A, and cost of replacement:

Table 1- RRPAM-WDS input data

Diameter Range	N_o	A	Cost (mil/km)
d ≤ 80 mm	0.0291	0.0185	0.7
80 mm > d	0.0222	0.0136	1.0

Go to the *Asset Data* window, there choose the *Property Groups* tab. For this exercise we will perform the analysis for two groups and enter the data from Table 1. It should look like this:



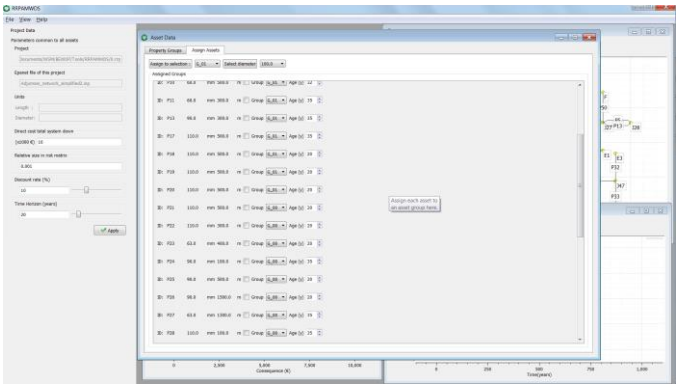
Now the next step is to assign each pipe to one of these two groups. Go to the **Assign Assets** tab on the **Asset Data** (same) window. Use the table below to enter the Age values.

Table 2- Example age values

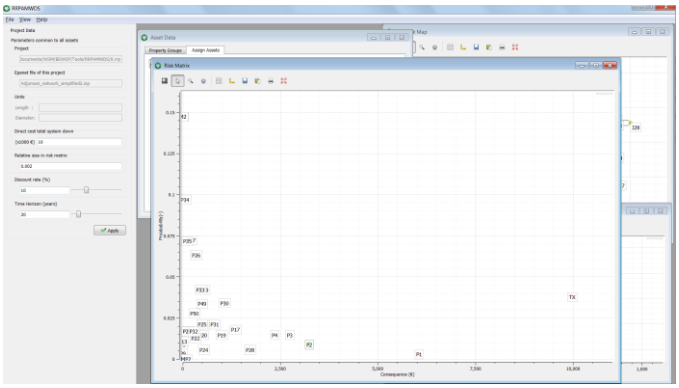
Pipe ID	Age (Years)
TX	35
P1	20
P2	20
P9	30

Pipe ID	Age (Years)
P10	32
P3	20
P11	35
P4	20
P5	20
P13	35
P17	35
P24	35
P27	35
P28	35
P50	35
OTHERS	20

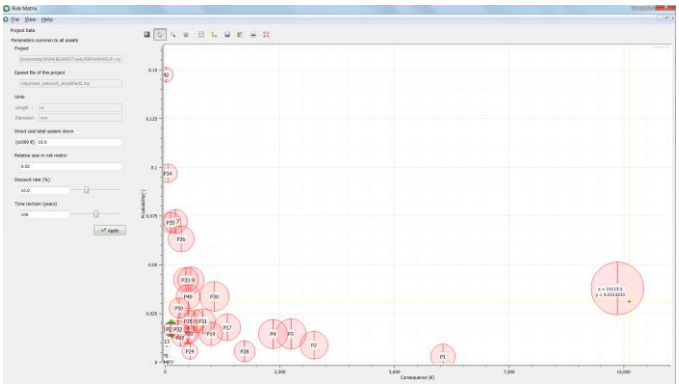
We also need to choose the diameter values for each group, which need to be selected at the top of the window. Remember that G_00 has diameter values d ≤ 80 mm, while G_001 has diameter values d > 80 mm. The window should look like this



After entering these data, we will have a plot that shows the probability of failure versus the economic consequence for each asset in the network, the window will look like this



Use some moments to explore this first output. For example, if we adjust the relative size in matrix to 0.02 and set the time horizon to 100 years, we will see a matrix looking like this

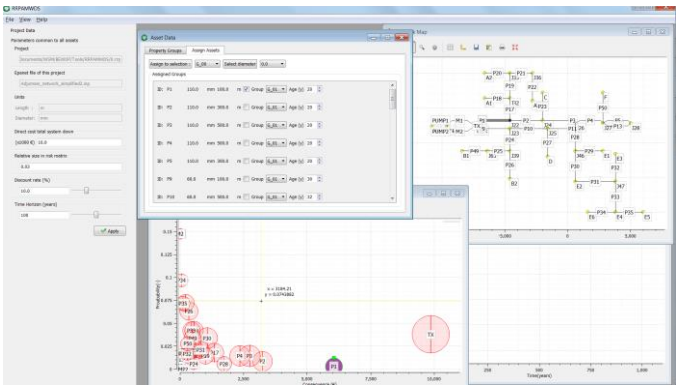


There are number of other facilities provided with these graphs like rectangular-zoom/reset, change axes scales/styles, save graphs in variety of formats, etc. Go explore!

Whole life cost

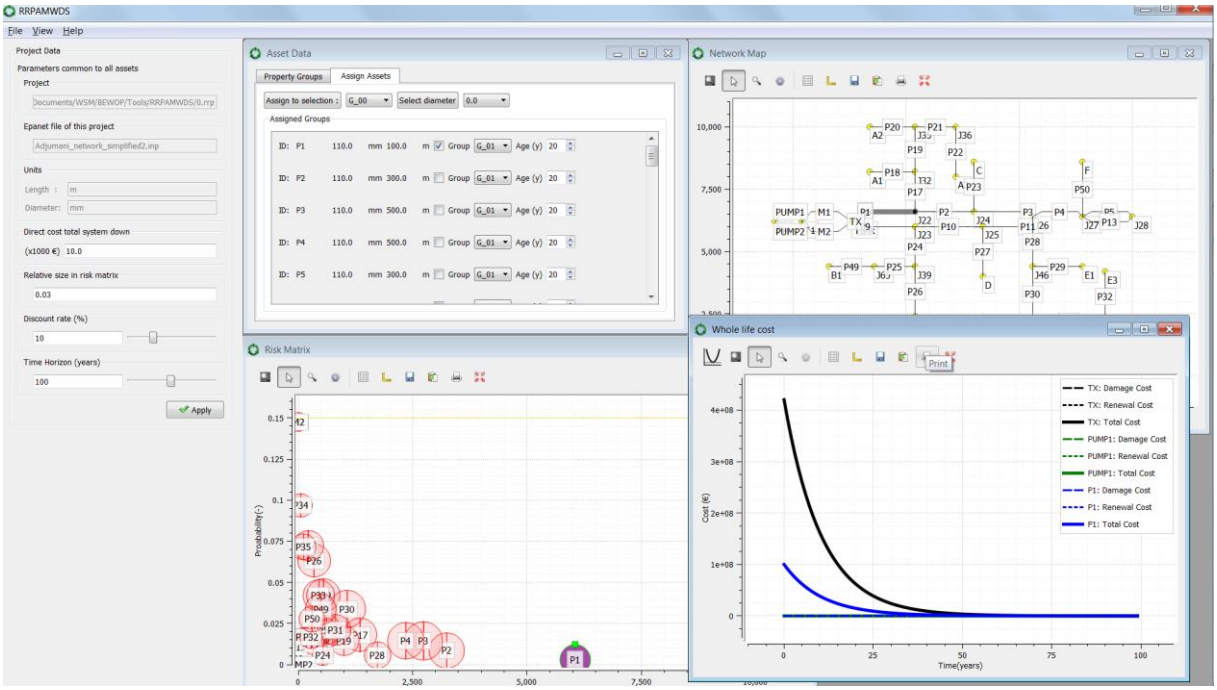
To continue our journey in the RRPAM-WDS tool, we will explore the Whole life cost matrix.

To start, select an asset from the water distribution system. You can do this by selecting one of the assets in the Asset Data window. After clicking on one of them the same asset should appear highlighted in the other window panes (i.e. in the Network Map and in the Risk Matrix windows). It should look like this



Then, adjust the preferences of analysis regarding the discount rate and the time horizon. For this example, let's choose assets P1, PUMP1, and TX. Also, let's define a discount rate of 10 % and a time horizon of 100 years.

Click on plot button to calculate the Whole life cost and obtain a plot that should look something like this



In this tutorial we have seen the many ways this tool can help us explore different aspects of risk-based renewal planning for asset management of water distribution systems. The tool is fully available in this webpage . Check out this and many other water operation management tools in the BEWOP tool webpage, available here.

4 Authors

RRPAMWDS is a software tool that demonstrates the concepts of Risk Based Decision Making and Whole Life Cost Analysis concepts using water distribution networks as examples.

The intended use of the tool is for Asset Management Class

The software was developed by Assela Pathirana

Development was supported with a grant under the Global Partnership for Water and Development facility of UNESCO-IHE and Ministry of Foreign Affairs of the Kingdom of Netherlands.