D.5.1.1 – Alert Tool for the Bathing Water Management

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1. INTRODUCTION

In this report, we describe the design, development, implementation and testing of the Alert Tool for the Bathing Water Management.

The flow of information stored in the Water Quality Integrated System (WQIS) database is managed by a continuously running software that processes the data by means of a forecast operational model connected to an alert tool. These tools are the WQIS results and allow generation and delivery of FIB dispersion forecast maps, which are then used by decisionmakers. Therefore, the system outputs real-time data that update historical series with new data.

The alert tool notifies users of:

- system progress;
- any abnormalities in the environmental parameters;
- any hardware abnormalities detected in real time.

The alert tool has been tested and applied to the five pilot sites in the Adriatic Sea.

2. Alert Tool design

The alert tool is a dedicated software that runs continuously in real time using the data stored in the WQIS database (Penna P. et al, 2021). The alert tool provides the notification through a communication channel (email or Telegram).

The alert tool notifies an event to recipients/actors through a predetermined communication channel (e.g. email, SMS, or Telegram). A simplified scheme with some correspondence relationships between the events and the WQIS actors/recipients is shown in Figure 1 to demonstrate how the alert tool functions. The recipients/actors who can interact with the WQIS and receive notifications from the Alert Tool include:

1. **Decisionmakers**: Person(s) in charge of bather protection. As per Italian legislation, the mayor decides beach closures. The WQIS can help them decide whether bathing should be prohibited, the extension of the closed area and the duration of the ban.

2. **Water manager**: body managing the transport and distribution of public water and wastewater. In the case of the Fano pilot site, these services are provided by PP1-ASET Spa; the company communicates the opening/closure of the Arzilla spillway (Arzilla is a stream which runs in the City of Fano (Marche Region – Italy)).

3. **Scientific site manager**: person in charge of interpreting the WQIS weather-marine forecasts and of selecting the strategy to be applied. The scientific site manager is responsible for starting the sampling cycle and for coordinating the logistic activities related to sample management.

4. **Monitoring manager**: person responsible for the management and maintenance of the equipment installed at the study site and for restoring the system after any failure or malfunction so that it can continue to collect valid and useable data for scientific and research purposes. The manager is also responsible for cleaning and calibrating the CTD multiparameter probe.

5. Sample manager: person responsible for sample management including bottle replacement and the sterilization of the pump and discharge tubes of the Avalanche sampler.

6. Laboratory analyst: person in charge of the analyses according to current quality and safety standards. The analyst also enters the results in the WQIS database using the dedicated web interface.

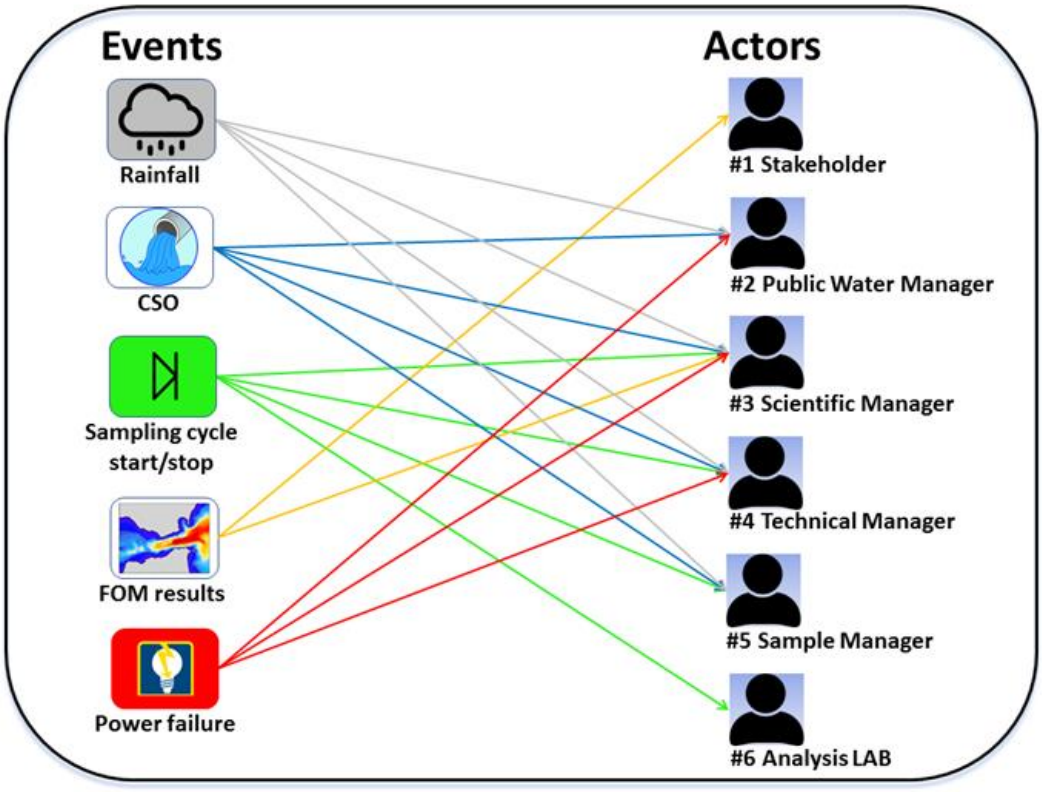

Figure 1. A simplified scheme with some correspondence relationships between the events and the WQIS actors/recipients (Penna P. et al,2021).

3. Alert Tool structure

The conceptual model of the Alert Tool is composed of several levels as showed in Figure 2.

The datalogger firmware checks communication with sensors and data consistence and store these states in LOG table. The Campbell Scientific's LoggerNet software retrieves in real-time raw data from remote dataloggers and inserts it into the WQIS Centralized Database (CDB). In order to ensure interoperability, a dedicated python script saves the data with a suitable formatting in specific tables of the WQIS CDB. Grafana service was programmed to generate the alerts envisaged by the alert tool.

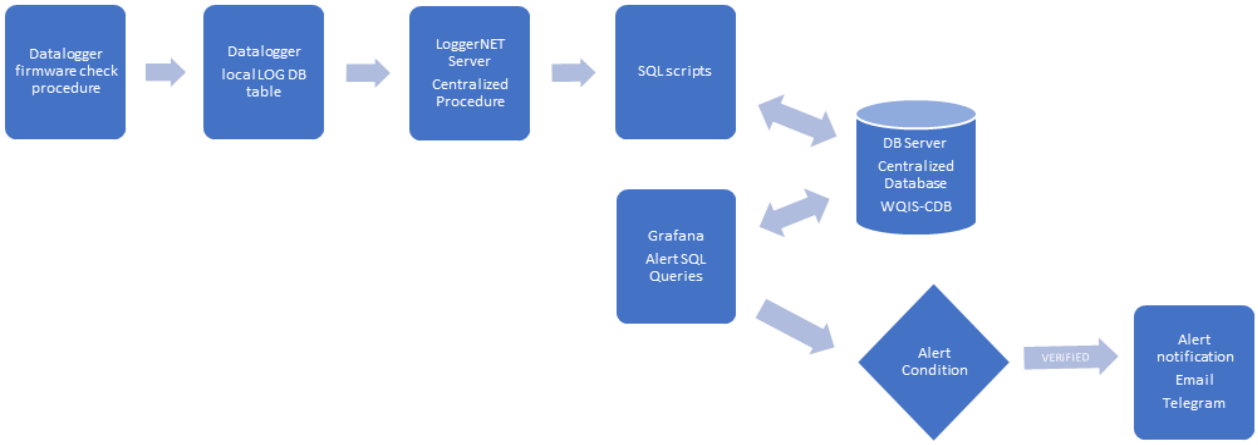

Figure 2. Block Diagram showing the operation of the Alert Tool system.

3.1. Firmware

The firmware installed in the datalogger, programmed by the CNR staff, is designed to store all data and information on a local DB (issues, malfunctions, sampling status and all logs are saved in the LOG table).

The firmware includes a procedure that performs the following iterations every minute:

- It checks the communication with the installed sensors (Weather station, multiparameter sonde, level sensor, water pump, avalanche sampler, etc.) and it verifies the consistency of the raw data received. In case of issues, the firmware sets the Flag associated with the type of error to True value and it writes a record in the LOG table (Figure 3).

TmStamp	Failure220VAC	FailurePTC	PumpProtection	ClimaVUE50CommErr	EXO2CommErr
02/09/2019 13:47	0	0	0	0	0
02/09/2019 13:48	1	0	0	1	0
02/09/2019 13:49	1	0	0	1	0
02/09/2019 13:50	1	0	0	1	0
02/09/2019 13:51	1	0	1	1	0
02/09/2019 13:52	1	0	1	1	1
02/09/2019 13:53	1	0	1	0	1
03/09/2019 01:47	0	0	0	0	1
03/09/2019 01:48	0	0	0	0	1
03/09/2019 01:49	0	0	0	0	1
03/09/2019 01:50	0	0	0	0	1
03/09/2019 01:51	0	0	0	0	1
03/09/2019 01:52	0	0	0	0	0
03/09/2019 01:53	0	1	0	0	0
03/09/2019 09:02	0	1	0	0	0
03/09/2019 09:03	0	1	0	0	0
03/09/2019 09:06	0	1	0	0	0
03/09/2019 09:09	0	0	0	0	0

Figure 3. Extract from the LOG table of Fano Outfall station. This data relates to the laboratory test period. The firmware sets to True (1) in case of errors detected. For example, between 13:48 and 13:53 on September 2 a 220V power failure was reported and between 13:48 and 13:52 a communication issue with the weather station was identified.

- It stores in LOG table every variation in the automatic sampling status (sampling start, end, bottle number variation, sampler errors, etc) (Figure 4).

TmStamp	AvalancheCommErr	AvalancheCodeStatus	AvalancheCodeStatusDescription	AvalancheLastSamplingStatus	AvalancheLastSamplingStatus	LastBottle
02/09/2019 13:47	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	1
02/09/2019 13:48	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	1
02/09/2019 13:49	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	1
02/09/2019 13:50	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	2
02/09/2019 13:51	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	2
02/09/2019 13:52	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	2
02/09/2019 13:53	0	1	WAITING TO SAMPLE	0	SAMPLE OK	2
03/09/2019 01:47	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	3
03/09/2019 01:48	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	3
03/09/2019 01:49	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	3
03/09/2019 01:50	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	4
03/09/2019 01:51	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	4
03/09/2019 01:52	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	4
03/09/2019 01:53	0	1	WAITING TO SAMPLE	0	SAMPLE OK	4
03/09/2019 09:02	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	5
03/09/2019 09:03	1	1	WAITING TO SAMPLE	0	SAMPLE OK	5
03/09/2019 09:06	0	12	SAMPLE IN PROGRESS	12	SAMPLE IN PROGRESS	5
03/09/2019 09:09	0	1	WAITING TO SAMPLE	0	SAMPLE OK	5

Figure 4. Extract of avalanche section from the LOG table of Fano Outfall station. This data relates to the laboratory test period. this section reports information of the automatic sampler status. AvalancheCommErr is True in case of communication problems with the device; AvalancheCodeStatus and Description shows the latest state of the sampler (Sample in progress, waiting to sample, Power failed, etc.). AvalancheLastSamplingStatus is the results of attempting the most recent sample (Sample OK, No liquid found, pump hummed, etc.). Last Bottle reports the number of the sampled bottle.

- It saves states and activities related to automatic sampling such as a floodway event, the pressing of the confirmation button by sample manager and a rain event (if enabled, it allows to start the automatic sampling following rain detected) (Figure 5).

TmStamp	FloodWayEvent	ChkDONE	ManualACK_IscoReady	Rain_Event
02/09/2019 13:47	1	0	1	0
02/09/2019 13:48	1	0	1	0
02/09/2019 13:49	1	0	1	0
02/09/2019 13:50	1	0	1	0
02/09/2019 13:51	1	0	1	0
02/09/2019 13:52	1	0	1	0
02/09/2019 13:53	1	0	1	0
03/09/2019 01:47	1	0	1	0
03/09/2019 01:48	1	0	1	0
03/09/2019 01:49	1	0	1	0
03/09/2019 01:50	1	0	1	0
03/09/2019 01:51	1	0	1	0
03/09/2019 01:52	1	0	1	0
03/09/2019 01:53	1	0	1	0
03/09/2019 09:02	1	0	1	0
03/09/2019 09:03	1	0	1	0
03/09/2019 09:06	1	0	1	0
03/09/2019 09:09	1	0	1	0

Figure 5. Extract of sampling trigger from the LOG table of Fano Outfall station.

3.2. LoggerNet

Campbell Scientific's LoggerNet software (Figure 6) is installed on a server (used as centralized base station) at the CNR IRBIM Ancona.

LoggerNet enables automated communication with field sites, scheduled download of data, delivery of new programs or instructions to a site and a set of communications diagnostic tools. The software recovers in real-time raw data stored on the remote dataloggers and saves them in a comma-separated ".dat" text file (each station is associated with a ".dat" file). Raw data is also fed into the WQIS CDB (installed on a DB server) via the LoggerNet Database Software (LNDB).

A Python script (Figure 7) runs in real-time on the server to analyse the consistency of the data and assign a quality flag to each numerical value. After the analysis processes, the script saves the data with a suitable formatting, to ensure interoperability, in specific tables of the WQIS CDB.

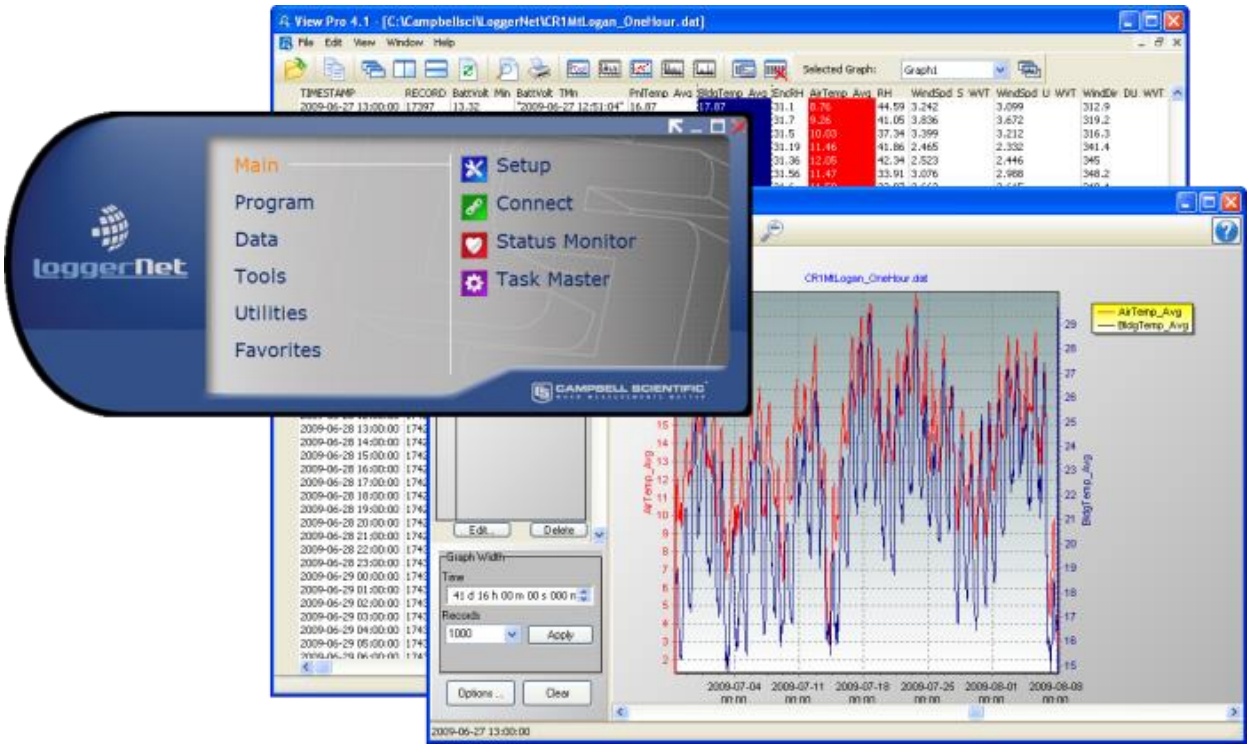

Figure 6. LoggerNET software by Campbell Scientific. This software is used to manage communication and raw data with the dataloggers installed on-site.

```
def read_parameters():

    sql= """select id,name, db, col_tmstamp_name from env_qc.settings_tbl where is_ok=0 and isactive=1 and db='env_qc'"""
    cursor.execute(sql)
    part= cursor.fetchall()
    for p in part:
        try:
            sql="""create table %s.`%s` (id INT(6) UNSIGNED AUTO_INCREMENT PRIMARY KEY, %s DATETIME UNIQUE)"""%(p['db'],p['name'],p['col_tmstamp_name'])
            cursor.execute(sql)
            sql="""update env_qc.settings_tbl set is_ok=1 where id=%s"""%(p['id'])
            cursor.execute(sql)
            conn.commit()
        except:
            pass

    sql_par="""select s.id as id,
                t.db as db_from,
                t.name as tbl_from,
                t.col_tmstamp_name as tm_from,
                tt.db as db_to,
```

Figure 7. Part of the data processing script developed by CNR staff.

3.3. Grafana service

Grafana is open-source visualization and analytics software. It allows you to query, visualize, alert on, and explore your metrics no matter where they are stored. It provides you with tools to turn your time-series database (TSDB) data into graphs and visualizations.

The Grafana service, in addition to the web data presentation, was programmed to generate the alerts envisaged by the alert tool. Alerts have four main components:

- **Alerting rule** - One or more query and/or expression, a condition, the frequency of evaluation, and the (optional) duration that a condition must be met before creating an alert.
- **Contact point** - A channel for sending notifications when the conditions of an alerting rule are met.
- **Notification policy** - A set of matching and grouping criteria used to determine where, and how frequently, to send notifications.
- **Silences** - Date and matching criteria used to silence notifications.

For each specific parameter, the alert conditions were generated by programming a series of SQL queries that run at specific intervals (Figure 8).

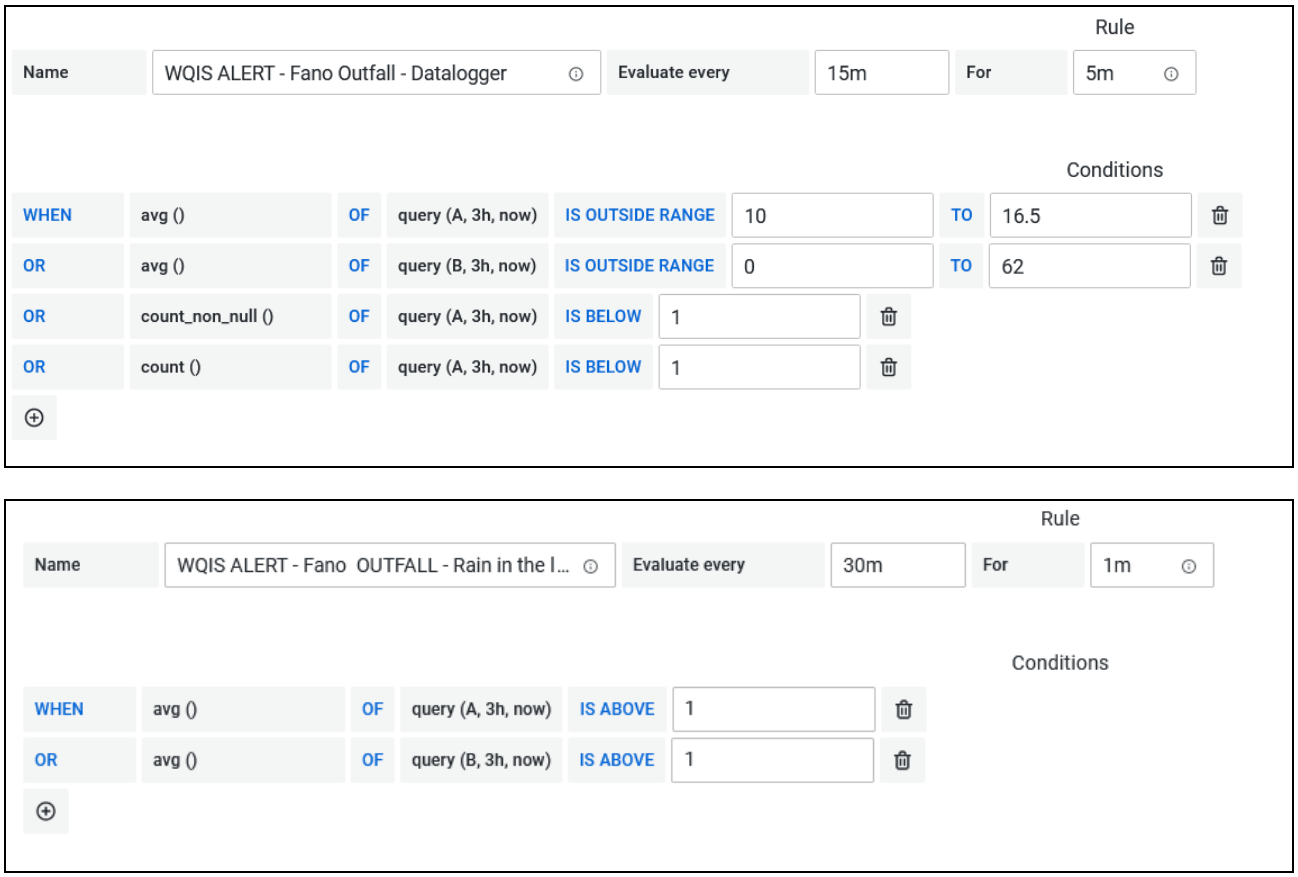

Figure 8. Example of two alert tool queries: checking datalogger parameters(up) and rainfall (down)

Figure 8 (up) shows datalogger parameters: a warning is sent if the input voltage is out 10-16.5V (query 1) or if the temperature isn't between 0°C and 62°C (query 2) or in case of lack of data (count, query 3 and 4).
One or more of these conditions must be maintained for at least 5 minutes before the notice is sent.

Figure 8 (down) concerns the Fano-Outfall rain event. The first query analyses the data collected by the local weather station installed in Fano Arzilla outfall and the second in Santa Maria dell'Arzilla station (provided by the Italian Civil Protection). The system sends an alert if the rain accumulated in the last 30 minutes exceeds 1mm.

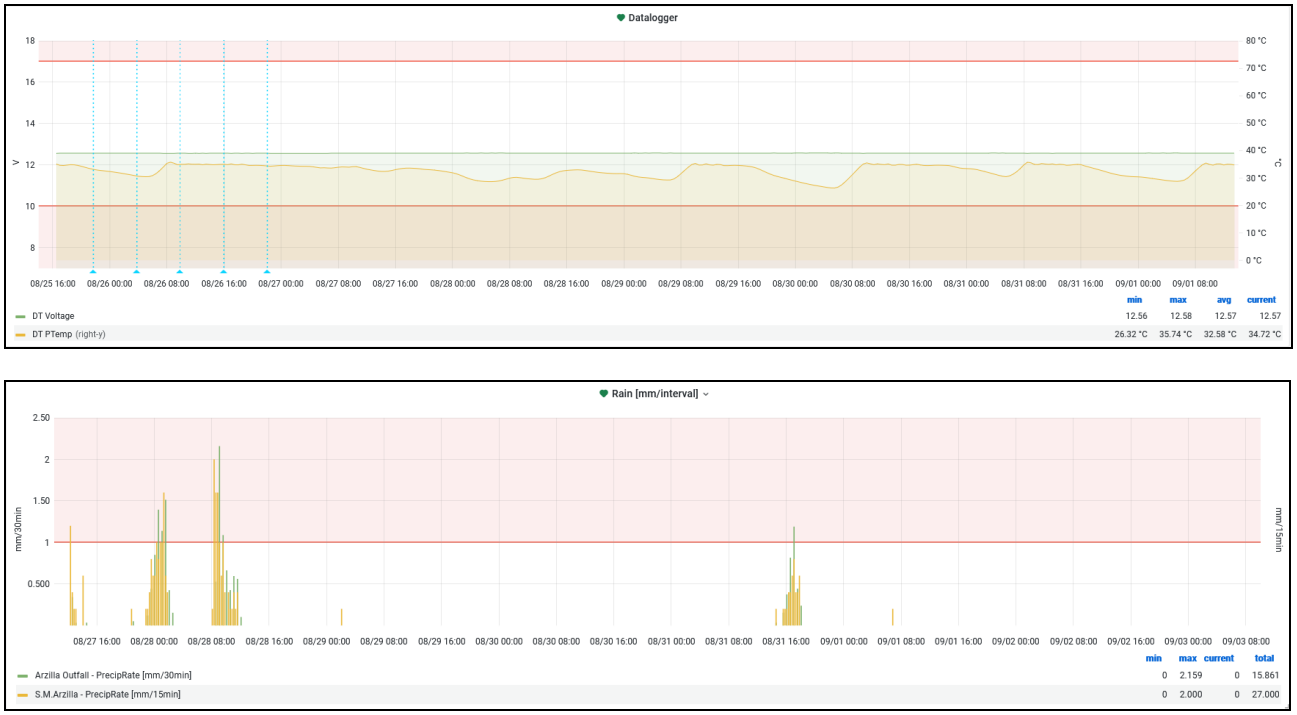

Figure 9. The graph above shows the voltage and temperature values of the CR1000X datalogger. The two red lines represent the minimum and maximum thresholds of the Alert Tool system that sends a Power Anomaly warning if the voltage goes out of the range 10-16.5V. The graph below shows the rain threshold set at 1mm/30min. If the rain that falls in the last 30 minutes exceeds 1mm, a specific alert is sent.

If the pre-set thresholds (Figure 9) are exceeded, the system sends an email (Figure 10) and/or Telegram notification (Figure 11) to the pre-selected actors/recipients (as shown in Table 1).

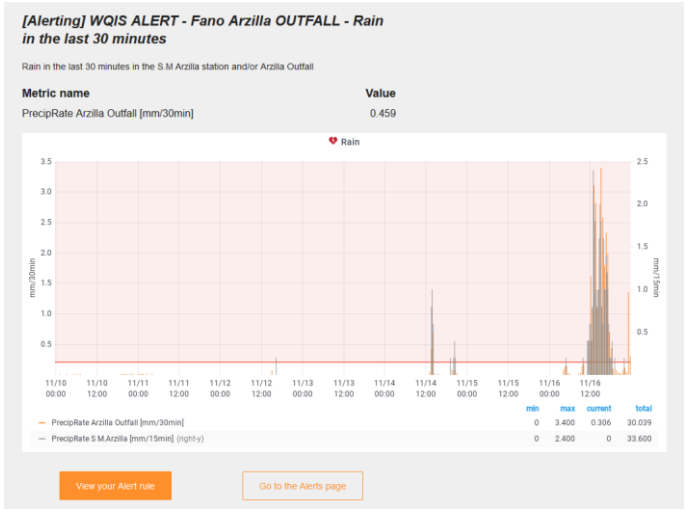

Figure 10. Example of notification: e-mail

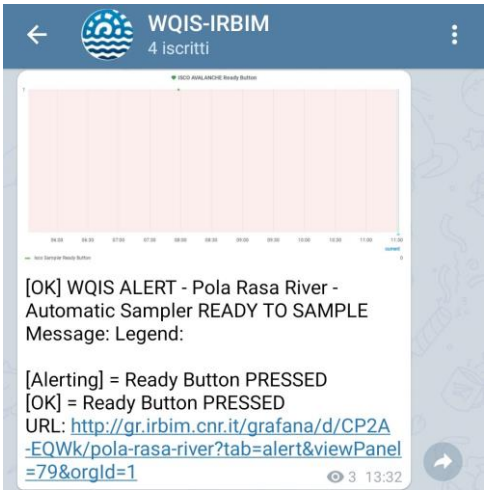

Figure 11. Example of notification channel: Telegram

4. Testing and Implementation

Considering that during the implementation period of this project activity (5.1) all the installations foreseen in project target sites were completed, the Alert Tool was implemented in operating conditions. In this way the system was tested in the field with immediate feedback from the partners involved in the management of the Watercare site.

A table of matching between a general event (precipitation rate, spillover, sampling site start/stop) and actors (stakeholder and public water, scientific, technical and sample manager) who receive the notification through a communication channel (need email or Telegram address) has been created (Table 1).

According to this Events-Actors table, two alert groups notification channels were created:

- the first containing the list of recipients of the alerts linked to the sampling procedures (Figure 12);
- the second group with the list of technicians assigned to hardware management.

Table 1. Events-Actors matching table

EVENTS	FANO Arzilla Out/UP	POLA Rasa River	DUBVRONICK Neretva River	SPLIT Cetina Main	SPLIT Cetina Outfall	PESCARA Pescara River
Rain Trigger	Mauro Marini Pierluigi Penna Fabrizio Moro Antonella Penna Elena Manini Mattia Betti Luigi Bolognini Fabio Ricci Silvia Casabianca Samuela Capellacci	Marija Šikoronja Vedrana Spada	Marija Šikoronja Dolores Grilec	Marija Šikoronja Neven Bujas Mario Ančić Igor Pavelic	Marija Šikoronja Neven Bujas Mario Ančić Igor Pavelic	Roberto D'Andrea Lucia Bergia
Floodway						
River Level						
Sampling Start						
Bottle Progress						
Sampling End						
Ready Button						
No Data	Pierluigi Penna Fabrizio Moro	Pierluigi Penna Fabrizio Moro Alan Blažeković Marija Šikoronja	Pierluigi Penna Fabrizio Moro Alan Blažeković Marija Šikoronja	Pierluigi Penna Fabrizio Moro Alan Blažeković Marija Šikoronja	Pierluigi Penna Fabrizio Moro Alan Blažeković Marija Šikoronja	Pierluigi Penna Fabrizio Moro Roberto D'Andrea
Power Failure						
Power Anomaly						
Fridge Temperature						
Pump Failure						

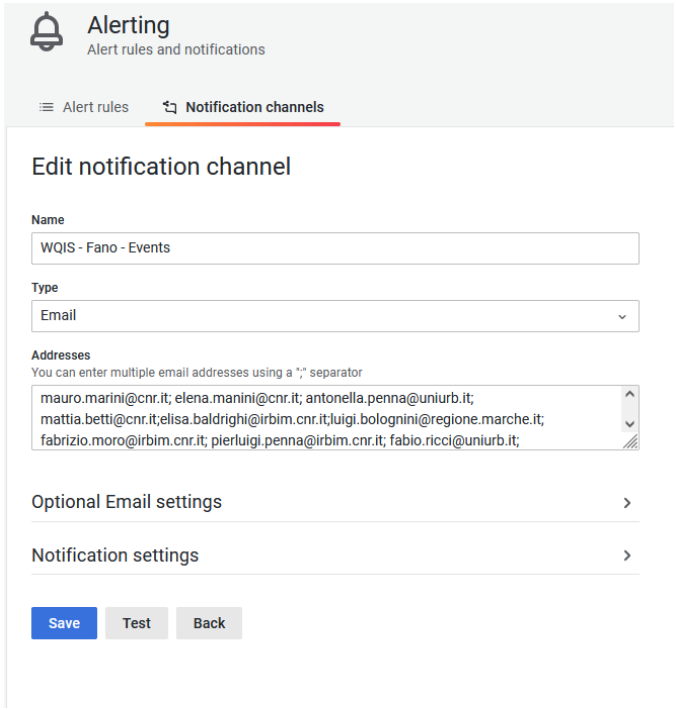

Figure 12. Example of email notification channel setting page.

Here below a description of the events involved in the Alert Tool (Table 1) is provided:

- **Rain trigger**: it activates if system detects rain in the previous half hour.
- **Floodway**: this trigger is based on the real-time information provided by the public water and wastewater service provider (ASET in Fano). It is activated in case of discharge of wastewater in the analysed river.
- **River level**: It is activated if the river level exceeds a pre-set threshold.
- **Sampling Start and Sampling End**: it sends an alert at the start and at the end of the automatic sampling.
- **Bottle Progress**: it allows to know the sampling status; it sends an alert for each new sampling bottle.
- **Ready Button**: it sends an alert when the sample manager presses the button that the bottles have been replaced.

- **No Data:** it reports transmission issues between specific remote station and master station or between sensors and datalogger.
- **Power Failure, Power Anomaly, Pump failure**: it reports hardware anomalies of remote devices.
- **Fridge Temperature**: it is activated in case of anomalies in the automatic sampler fridge temperature.

Once the groups of the alert recipients and the alert queries were created (see section 3.3), all the system functions were tested:

- The alert groups were tested using the Test function (Figure 13) and verifying the confirmation receipts from the actors.

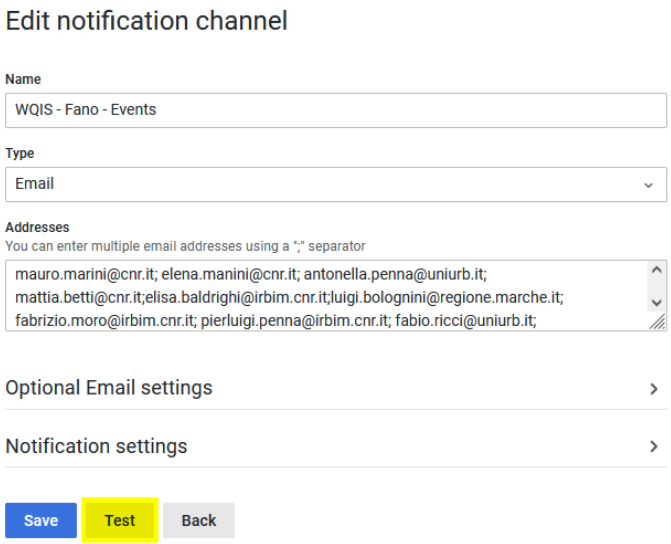

Figure 13. Example of email notification channel setting page. Focus on the Test button.

- The query results (Figure 14) were analysed for each event created using the test function provided by the software (Figure 15).

Figure 14. Debug and test of the alert queries.

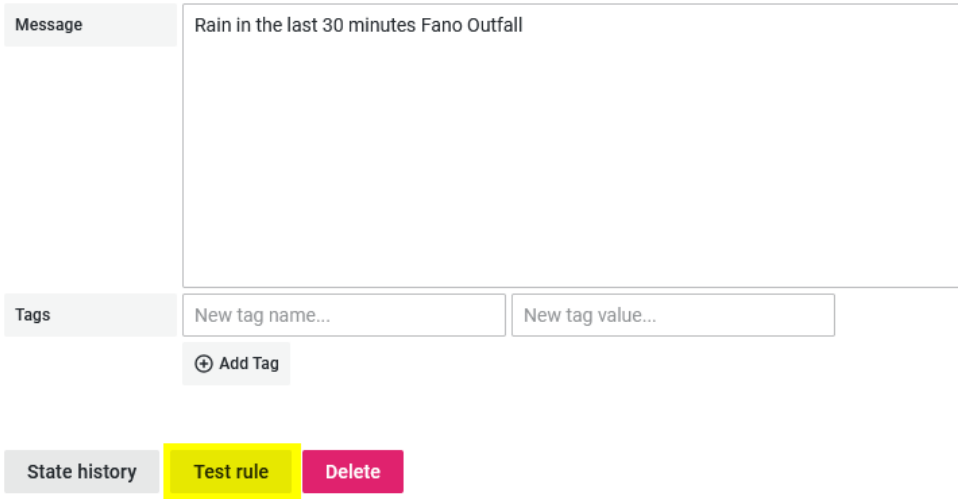

Figure 15. Alert tool. Test rule.

5. Bibliography

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Grafana labs. https://grafana.com/