# Annex 2- REQUIREMENTS OF THE SMART IRRIGATION SYSTEM FOR CUÑA VERDE PARK IN LA LATINA

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## I DESCRIPTION OF THE AREA AND IRRIGATION ELEMENTS WHERE THE SYSTEM WILL BE INSTALLED

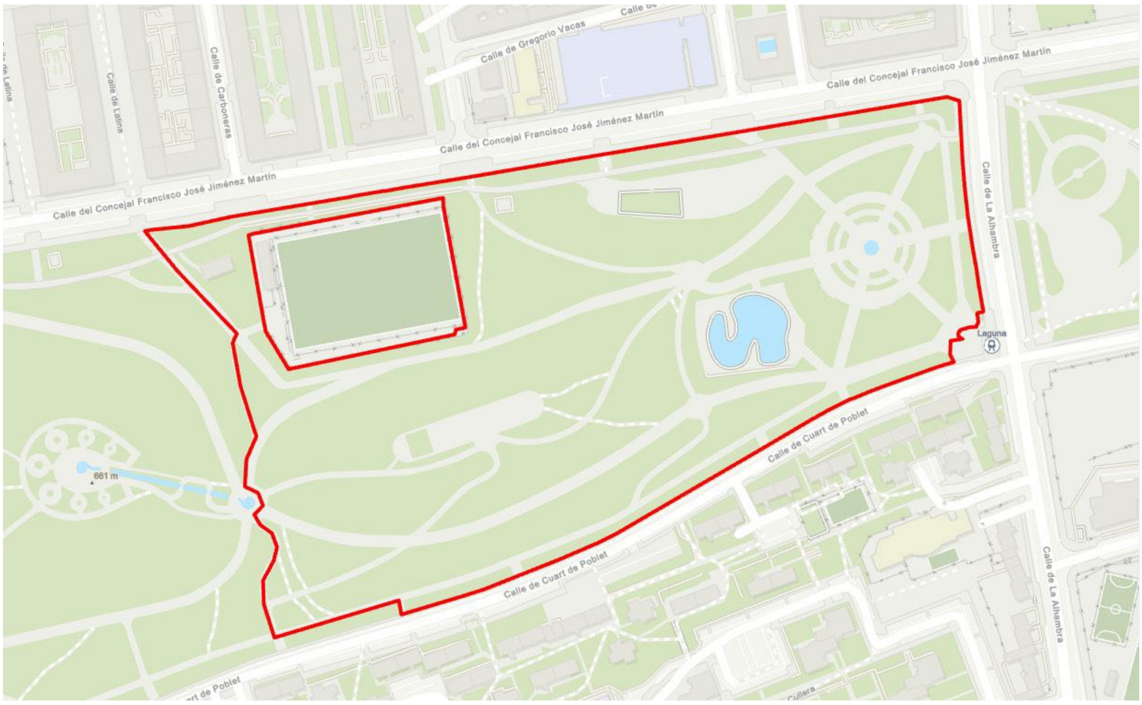
### 1. LOCATION

The selected area for the installation of the smart irrigation system is located within Cuña Verde Park, in the Latina district of Madrid. The park covers a total area of 67.92 hectares.

The specific area chosen for the project spans 8.71 hectares and is bounded by: Concejal Francisco José Jiménez Martín Street to the north, Cuart de Poblet Street to the south, Alhambra Street to the east, and a north-to-south pathway through the park to the west.

Within this designated area, there are five distinct zones:

- Mirador: The highest point of the area. Includes a pergola and a children's play area. Surrounding slopes are natural grasslands with trees.
- Rosaleda: Features circular flower beds planted with roses. Irrigated using a drip irrigation system.
- Lago: An irregularly shaped water feature. Surrounded by shrub masses, irrigated via drip irrigation.
- Perimeter lawns and areas around Rosaleda: Grass areas bordering the park and surrounding the rose garden. Irrigated using sprinklers and diffusers.
- Children's Play Area and Senior Recreation Area: Open unpaved seating area with tree coverage.



## 2. IRRIGATION ELEMENTS

This park features an irrigation network supplied with recycled water. The system consists of polyethylene pipes of various diameters, distributing the available flow across different irrigation sectors.

Below is a description of the main irrigation components:

**Irrigation Sectors:**

The selected project area includes 66 irrigation sectors, categorized as follows:

- Sprinkler irrigation: 28 sectors
- Drip irrigation: 34 sectors
- Diffuser irrigation: 4 sectors

**Valve Boxes.**

A total of 57 valve boxes are distributed throughout the designated area, housing electrovalves, shut-off valves, and autonomous controllers: 45 units are brick-built with metal covers, and 12 units are precast plastic enclosures.

**Electrovalves**.

Each irrigation sector is activated by an electrovalve, which is currently controlled by 9V battery-powered autonomous controllers housed within the valve boxes.

The number of electrovalves corresponds to the number of irrigation sectors:

- Sprinkler irrigation: 28 electrovalves
- Drip irrigation: 34 electrovalves
- Diffuser irrigation: 4 electrovalves

The brand and model of the existing electrovalves — which must be compatible with the controllers/programmers proposed in the new system — are as follows:

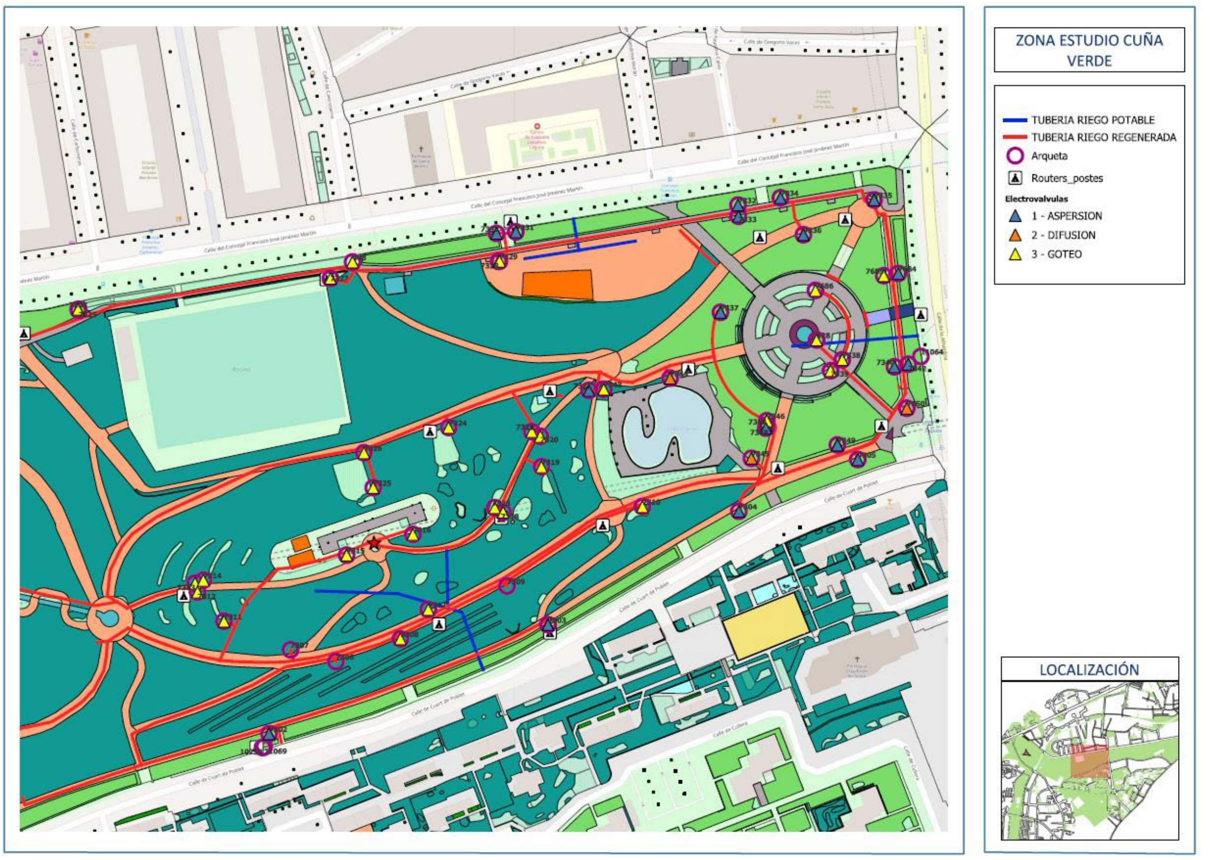
| MODEL | Height x Length x Width |
|---|---|
| RAINBIRD 100-PGA | 7 1⁄4" (18,4 cm) x 5 1⁄2" (14,0 cm) x 3 1⁄4" (8,3 cm) |
| RAINBIRD 150-PGA | 8" (20,3 cm) x 6 3⁄4" (17,2 cm) x 3 1⁄2" (8,9 cm) |
| RAINBIRD 200-PGA | 10" (25,4 cm) x 7 3⁄4" (19,7 cm) x 5" (12,7 cm) |

**Programmers**:

For illustrative purposes, although this information may not be relevant to the designer, the existing standalone programmers (a total of 48 units) are from the brand Solem (you can find information at https://solem-irrigation.com/es/producto/bl-ip/ ):

- SOLEM 1 station: 36
- SOLEM 2 stations: 9
- SOLEM 4 stations: 3

Below is the location of pipes, manholes, and solenoid valves.




The current irrigation system schedules are as follows:

| ID VALVE BOX | Nº DAYS PROGRAMMED IRRIGATION | SPRINKLER IRRIGATION | SPRINKLER IRRIGATION SCHEDULE | DIFFUSION IRRIGATION | DIFFUSION IRRIGATION SCHEDULE | DRIP IRRIGATION | DRIP IRRIGATION SCHEDULE | ELECTROVALVES |
|---|---|---|---|---|---|---|---|---|
| 7335 | 5 | Y | 02:15 - 02:45 | SI | 02:45 - 03:00 | NO | | 2 |
| 7685 | 5 | Y | 01:30 - 02:00 | NO | | Y | 02:00 - 03:00 | 2 |
| 7684 | 5 | Y | 02:00 - 02:20 | NO | | NO | | 1 |
| 7686 | 5 | NO | | NO | | Y | 06:20 - 06:50 | 1 |
| 528 | 5 | NO | | SI | 02:50 - 03:00 | NO | | 1 |
| 7342 | 5 | Y | 02:50 - 03:20 | NO | | NO | | 1 |
| 7340 | 5 | Y | 02:20 - 02:50 | NO | | NO | | 1 |
| 7338 | 5 | NO | | NO | | Y | 06:50 - 07:50 | 1 |
| 7350 | 5 | NO | | NO | | Y | 02:00 - 03:00 | 1 |
| 7339 | 5 | NO | | NO | | Y | 06:20 - 06:50 | 1 |
| 7305 | 5 | Y | 04:00 - 04:30 | NO | | NO | | 1 |
| 7346 | 5 | NO | | NO | | Y | 06:50-07:50 | 1 |
| 7347 | 5 | Y | 04:20 - 04:50 | NO | | NO | | 1 |
| 7348 | 5 | Y | 04:50 - 05:20 | NO | | NO | | 1 |
| 7334 | 5 | Y | 04:30 - 05:00 | NO | | NO | | 1 |
| 7333 | 5 | Y | 01:00 - 01:30 | NO | | NO | | 1 |
| 7332 | 5 | Y | 05:00 - 05:30 | NO | | NO | | 1 |
| 7336 | 5 | Y | 00:00 - 00:30 / 00:30 - 01:00 | NO | | NO | | 2 |
| 7337 | 5 | Y | 05:20 - 05:50 / 05:50 - 06:20 | NO | | NO | | 2 |
| 7303 | 5 | Y | 05:00 - 05:30 / 05:30 - 06:00 | SI | 06:00 - 06:15 | NO | | 3 |
| 7349 | 5 | Y | 03:20 - 03:50 / 03:50 - 04:20 | NO | | Y | 04:20 - 05:20 | 3 |
| 7345 | 5 | NO | | SI | 02:50 - 03:50 | NO | | 1 |
| 7304 | 5 | Y | 04:30 - 05:00 | NO | | NO | | 1 |
| 7344 | 5 | NO | | SI | 02:50 - 3:00 | Y | 03:00 - 04:00 | 2 |
| 7310 | 5 | NO | | NO | | Y | 06:00 - 06:50 | 1 |
| 7319 | 5 | NO | | NO | | Y | 05:00 - 06:00 | 1 |
| 7320 | 5 | NO | | NO | | Y | 06:00 - 07:00 | 1 |
| 7322 | 5 | NO | | NO | | Y | 04:00 - 05:00 | 1 |
| 7318 | 5 | NO | | NO | | Y | 04:00 - 05:00 | 1 |
| 7323 | 5 | NO | | NO | | Y | 04:00 - 05:00 | 1 |
| 7316 | 5 | NO | | NO | | Y | 06:00 - 07:00 | 1 |
| 7308 | 5 | NO | | NO | | NA | | 1 |
| 7315 | 5 | NO | | NO | | Y | 04:00 - 05:00 / 05:00 - 06:00 | 2 |
| 7302 | 5 | Y | 06:00 - 06:30 / | NO | | NO | | 2 |

| ID VALVE BOX | Nº DAYS PROGRAMMED IRRIGATION | SPRINKLER IRRIGATION | SPRINKLER IRRIGATION SCHEDULE | DIFFUSION IRRIGATION | DIFFUSION IRRIGATION SCHEDULE | DRIP IRRIGATION | DRIP IRRIGATION SCHEDULE | ELECTROVALVES |
|---|---|---|---|---|---|---|---|---|
| | | | 06:30 - 07:00 | | | | | |
| 7311 | 5 | NO | | NO | | Y | 04:00 - 05:00 / 05:00 - 06:00 | 2 |
| 7312 | 5 | NO | | NO | | Y | 06:00 - 07:00 | 1 |
| 7313 | 5 | NO | | NO | | Y | 05:00 - 06:00 | 1 |
| 7314 | 5 | NO | | NO | | Y | 05:00 - 06:00 | 1 |
| 7203 | 5 | Y | 06:30 - 07:00 / 07:00 - 07:30 | NO | | NO | | 2 |
| 7330 | 5 | Y | 06:00 - 06:30 | NO | | NO | | 1 |
| 7331 | 5 | Y | 05:30 - 06:30 | NO | | NO | | 1 |
| 7343 | 5 | NO | | NO | | Y | 06:50 - 07:50 | 2 |
| 7321 | 5 | NA | | NO | | NO | | 1 |
| 7329 | 5 | NO | | NO | | Y | 00:00 - 01:00 | 1 |
| 7328 | 5 | NO | | NO | | Y | 01:00 - 02:00 | 1 |
| 488 | 5 | NO | | NO | | Y | 01:00 - 02:00 | 1 |
| 7324 | 5 | NO | | NO | | Y | 04:00 - 05:00 | 1 |

## 3. EXISTING INFRASTRUCTURE FOR COMMUNICATIONS

Within the selected area there is a gardeners' hut with power supply that could eventually, if necessary, be used to locate or power some element.

Similarly, in the selected area there are currently 12 wooden poles (8 meters high) where the communications gateways/concentrators could be installed, if necessary.

The park is in an urban area with excellent coverage from various mobile telephone operators.

In case the solution offered would use WiFi/6LowPan protocols, UPM-Cedint-Madrid City Council would provide and install the hubs and repeaters to create the connectivity mesh.

## 4. FILES WITH GEOREFERENCED INVENTORY OF ELEMENTS

All the elements of the park's current irrigation system are geo-referenced and will be made available to the contractor. A series of files are available with an inventory of all the existing georeferenced equipment, including the location of the different elements where the new intelligent irrigation system devices will have to be installed.

These files, in vector format, have the information corresponding to the entire surface of the Cuña Verde de Latina park (which includes the study area and the rest of the park), in ESRI shapefile format (.shp), which includes the georeferenced graphic representation of the data set together with the attributes contained in a database in dBase Data Base file format (.dbf):

CUÑA VERDE - BOCA DE RIEGO AP

CUÑA VERDE - BOCA DE RIEGO AR

CUÑA VERDE - CASETAS JAR

CUÑA VERDE - CAUDALIMETRO AR

CUÑA VERDE – CONCENTRADOR

CUÑA VERDE - CONTADOR AP

CUÑA VERDE - CONTADOR AR

CUÑA VERDE - CUR NIVEL

CUÑA VERDE - ELECTROVALVULAS AR

CUÑA VERDE - PTO SUMINISTRO

CUÑA VERDE – REJILLAS

CUÑA VERDE – POSTES

CUÑA VERDE - SECTOR RIEGO

CUÑA VERDE - TUBERIA DE RIEGO AP

CUÑA VERDE - TUBERIA DE RIEGO AR

CUÑA VERDE - ZON ESTUDIO

CUÑA VERDE - ZONA VERDE

CUÑA VERDE – ZONIFICACION

CUÑA_VERDE_ARQUETA

The following files are also available in .shp format for the selected study area:

ARQUETAS

BOCA RIEGO AR

CONCENTRADOR

CONTADOR AP

ELECTROVALVULAS AR

REJILLAS

POSTES

SECTOR RIEGO

TUBERIA RIEGO AP

TUBERIA RIEGO AR

# II SYSTEM REQUIREMENTS

## 5. SYSTEM OPERATION

The implemented system must allow to act remotely or locally on the solenoid valves of the different irrigation circuits, to adapt the irrigation to the water needs, as well as to monitor their operation. Specifically, it must allow, among other things:

- Assign to the various solenoid valves a default programming remotely or locally.
- Assign to the various solenoid valves operating instructions over the default programming according to certain city and local weather conditions (general weather forecasts and on-site measurements) or the environment (e.g. cancellation or delay of irrigation in rainy conditions, excessive humidity in the ground).
- Monitor water flow to identify possible system malfunctions or breakdowns.

The system must allow the usual programming for irrigation systems, and at least, programming of start times, duration of irrigation time and irrigation zones in the case of programmers of more than one zone.
At least 2 moisture sensors shall be installed and integrated in the system, distributed as follows: at least one in the drip zone and one in the sprinkler zone.
At least 2 1 ½" flowmeters will be installed on 50mm diameter pipes to maximize the functionalities of the system, recording water consumption and detecting potential leaks or failures in the programmers.
The interaction of the system with a presence detector and a luminaire integrated into Home Assistant, with IoT interfaces, will be tested.

## 6. SOLUTION ARCHITECTURE

### 6.1. Components of the intelligent irrigation system

- Communications infrastructure with Internet connection, via mobile telephony or equivalent, that allows the teleoperation of the different physical devices that control the irrigation. This connectivity can be done by device (for example, with stand-alone IoT devices equipped with NB-IoT mobile telephony transmission or similar, with SIMs to be supplied with the appropriate contracts for the duration of the contract), or by installing meshed networks, in which case there will be a 6LowPAN communications hub connected to the Internet used for the lighting network, deployed by the IoTMADLAb..
- IoT physical devices that control irrigation:
    - Controllers/programmers that operate the solenoid valves that regulate irrigation.
    - Environmental sensors to adapt irrigation to the weather situation (temperature, humidity, rain). In addition, the schedule should be taken into account, including sunrise and sunset times, so that irrigation is carried out at the most appropriate time.
    - Soil moisture sensors to optimize water use based on measured data and not only by hourly scheduling.
    - Flow meters, to measure the volume of water used, and detect losses due, for example, to breakdowns.
    - Other possible IoT devices to be integrated into the system to explore new functionalities for the city
- Information integration platform: IoTMADLab provides the Home Assistant application, but the bid could offer, at thecontractor's expense, another system as long as it is compatible with the architecture defined at https://iotmadlab.en/documents/. This would allow future integrations into the City of Madrid's operating system. Through it, interactions from all physical devices will be integrated, both those included in the offer and the luminaires deployed by IoTMADLab in the area. This will provide a web interface for the system managers, enabling them to remotely parameterize and configure all the irrigation elements with security and perform permanent monitoring with reception of events. Additionally, a read-only user will be set up to allow citizens to view the information of the deployed elements on a map and through lists.

### 6.2. Requirements for the computer system enabling teleoperation

The computer system (Home Assistant or compatible) must allow the following minimum functionalities, provided by a web interface with two-factor authentication:

- Support for the secure enrollment of each physical IoT device, allowing it to be incorporated into the system with security guarantees without intrusions: devices that do not use the established procedure must not be incorporated into the network, and connections with modification capabilities that do not have the security factors established by the CCMAD (Cybersecurity Center of the Madrid City Council), a member of the IoTMADLab cybersecurity teams, will not be allowed.
- Configuration interface for each device, enabling software updates, as well as modifications to device settings or programming. Specifically for irrigation programmers, the interface must allow editing and storing various predefined irrigation schedule configurations in the system. This way, the irrigation system's operational rules can assign these preconfigured programs (no_watering, normal, increase_watering_by_extreme_heat, ...). Additionally, the device must operate autonomously in the event of connectivity loss.
- Monitoring of the connectivity of each device, so that alarms are generated when the loss of effective connectivity with the device has been prolonged for a few minutes. In addition,

these incidents will be correlated to determine if it is an isolated element or if there is a group/area that has been cut off. Devices should be permanently online, and send events autonomously if possible, but in addition the central system will perform polling so that a reliable loss of connectivity (not a false positive) can be determined if a zone is out of communication for more than 30 minutes, except for battery powered elements in which case the refresh rate will change to 24 hours.

- Capability to create groups of devices (e.g. all programmers in the sprinkler irrigation sector) and initiate common operations for all devices in the group (e.g. update programming, putting the same programming on all devices in the group).
- Interface for defining rules with programming logic based on data from environmental sensors and weather forecasts for the area. With this interface, for example, it should be possible to make rules of this type. Below are three examples of possible rules: one to stop irrigation when unnecessary, another to increase it due to excessive heat, and a final rule to set consumption alerts based on data from flow meters:
    - Every [X] hours, retrieve the information from the IoT sensors, as well as the weather forecast, and launch the following rules (the values in square brackets would be configurable values in the interface itself):
        - IF the soil moisture values are greater than [Moisture_threshold] OR the rain forecast in the next [No.] hours is greater than [Rain_forecast_threshold] THEN change the programming of the programmer group [Programmer_group] to programming [Non_watering_programming] OTHERWISE keep in the programmer group [Programmer_group] programming [Normal_programming]
        - IF the soil moisture values are lower than [Moisture_threshold] AND the current temperature is higher than [Temperature_threshold] AND the rain forecast in the next [No.] hours is lower than [Rain_forecast_threshold] THEN change the programming of the programmer group [Programmer_group] to programming [Program_increase_irrigation_by_extreme_heat] OTHERWISE keep in the programmer group [Programmer_group] the programming [Normal_programming].
        - IF the value of the flowmeter [Flowmeter_ID] in the period [measurement_period] is greater than [Flowmeter_threshold] THEN send_alert_possible_leakage [e-mail, Flowmeter_ID, value].
    - Rules definition interface with programming logic to be able to interact with IoT nodes for presence detection and luminaire management allowing to launch the following type of rules (the values in square brackets would be configurable values in the interface itself):
        - IF the value of [Presence_Detector_ID] is greater than [Presence_detection_threshold] THEN change the scheduling of the [Scheduler_Programmer_Group] to scheduling [Scheduling_delay_watering_temporarily].
        - IF the value of the [Programmer_ID] is equal to [open] THEN activate the luminaire [Luminaire_ID] with the value [Flashing_watering_light] otherwise activate the luminaire [Luminaire_ID] with the value [Off]
    - Seasonal configurations and exceptional situations: there are annual periods in which irrigation does not take place, or if it does take place it is in very different conditions to the usual irrigation period. In addition, there may be circumstances (celebration of events) that should be easily managed, with a prioritized programming that does not imply having to deprogram the usual activity.
        - The default behavior of the sensors in the event of loss of connectivity will be equivalent to the behavior of the programmed irrigation systems

in each station, and will therefore be updated periodically.

- Statistics and indicators interface: The system will collect all the activity and will allow to exploit the following minimum information:
    - Updated inventory of all IoT devices, grouped by type of sensor, showing its status (if it responds properly or not, and, in case of not responding, date and time of its last connection) and its current values (software version, battery level, last data provided by the sensor). A summary list grouped by type of device shall be included, indicating the number of devices of each type that present any anomaly. Each device will be located on a map during installation, as this is a standard feature of this type of platform.
    - Downloadable history with the data of each sensor, identifying each one and associating the measurement with its date and time. It will offer groupings by hour, day, week and month.

### 6.3. Technical requirements for hardware and software of the intelligent irrigation system elements

All IoT devices that are part of the irrigation system shall be wirelessly configurable, both locally and remotely via the Internet.

The indications of the IoTMadLab reference architecture published at [https://iotmadlab.es/wp-content/uploads/2025/01/IoTMADLab-IoT-reference-architecture.pdf](https://iotmadlab.es/wp-content/uploads/2025/01/IoTMADLab-IoT-reference-architecture.pdf)

### 6.4. Some difficulties encountered in the past with remote management systems

In order to guide the participants in the design of the system, the initial existing system is described and some problems identified in the use of remote management irrigation systems in the past are listed below. The bid should propose solutions that respond to or alleviate these known circumstances.

In this park, a remote management system for solenoid valves via radio was installed in 2017. In this system, once the configuration and irrigation schedules have been entered into the management software, they are transmitted from the server to the concentrators via GPRS. The concentrators transmit the irrigation schedules to the remote units located in the valve boxes either directly or using the repeaters if they are far away. This communication is done via radio.

The field components of the system are:

- Concentrator or Master: It receives orders from the server via GPRS and sends them to the repeaters via radio. Powered by photovoltaic panels.
- Router or Repeater: It amplifies and distributes the radio signal sent by the concentrator to reach the different programmers throughout the urban environment.
- Secondary or Remote Unit: similar to irrigation controllers, watertight and powered by 9V batteries. For 1, 2 or 4 stations. They are responsible for operating the solenoid that will open and close the solenoid valve based on the established programming.

In this park, the masters and routers were placed at elevated points (wooden poles, trees and structures present in the park).

During the 6 years of operation of this system, multiple incidences appeared that forced the installation of autonomous programmers, thus abandoning the remotely managed system.

The most relevant incidents with the radio remote management system are described below:

- Communication failures between elements (concentrators, router and secondary).
    - These connection failures are mostly due to interferences or reduction of the radio signal intensity due to the presence of obstacles that prevent the radio

signal from reaching with sufficient intensity. The usual obstacles are manhole covers, or the presence of vegetation, which produces an absorption of the radio signal, hindering the stability of the overall coverage.

- There were also communication failures of remote units or programmers in manholes submerged in water (sometimes the manholes are filled with rain or irrigation water).

- Rapid consumption of the batteries of the remote units in the pit (secondary) and in some routers powered by 9V batteries.
- Equipment failures: repeaters or routers, concentrators or receivers (secondary).
- Vandalism: theft of remote units (secondaries) installed within the manholes.
- Excessive cost of replacing routers and secondaries.

# II INSTALLATION, TESTING AND MAINTENANCE

## 7. INSTALLATION AND MAINTENANCE OF EQUIPMENT

The equipment will have to be supplied within the deadlines to be determined in the negotiated tender contract, which must be compatible with the European program GovTech4All: Orientatively before April 15, 2025. Prior to this date, it will be able to collaborate with IoTMADLab in the configuration of the devices in that laboratory, in order to obtain the compatibility reports provided for in IoTMADLab.es.

The installation of this equipment will be at the expense of the Madrid City Council, which will provide the necessary material and human resources through the current contract for maintenance of green areas. The participation of the company that wins this tender will be limited to providing the necessary training, generating the documentation with the installation, maintenance and replacement instructions, and supervising the deployment. It is necessary to value the offer in this aspect, in that it tries that this installation does not suppose excessive or unreasonable requirements and is compatible with the required deadlines: It will work so that the installation is concluded during the month of April of 2025 as a guideline date.

The testing, programming and commissioning of the supplied equipment on the platform, as well as configuring interactions between types of devices, defining groupings, setting up monitoring and programming alarm, will be the responsibility of the winning company. This company will collaborate with IoTMADLab on the devices deployed by the them (luminaires, gateways and presence sensors). Individual tests can begin at the IoTMADLab as soon as the devices are available, but the acceptance tests of the elements deployed in the park already integrated in the management platform must be completed before the end of May 2025.

The physical maintenance of this equipment will be carried out on behalf of the Madrid City Council, based on the documented indications and advice of the successful contractor. A manual for the use of this equipment must be provided, and a communication channel will be available for second level support during working hours (Monday to Friday from 9:00 to 17:00) for the resolution of incidents. To speed up operations, the winner of the tender will deliver to the Madrid City Council an amount of 5% of the total equipment installed, with a minimum of one per type, as replacement and reserve material. In this way it will be possible to replace the elements that present incidences while they are being reconfigured or repaired. The management of warranties for damaged equipment will be the responsibility of the successful bidder, who must collect it from the municipal facilities.

## 8. TESTING

The dates on which the operational tests and the pilot tests themselves will be carried out will be included in the contract, although, as a guideline, they will be before June 2025.