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DESIGN AND DRAFTING OF A NEW WASTE-WATER TREATMENT PLANT IN BEGUR (GIRONA, SPAIN).

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“Earth was originally allotted a finite amount of water — we have no more or no less than that original allotment today. It logically follows that, to sustain life as we know it, we must do everything we can to preserve and protect our water supply. We also must purify and reuse the water we presently waste (i.e., wastewater).”

Frank R. Spellman.

Vull agrair sincerament l’ajut que m’ha aportat el meu tutor al llarg d’aquest camí, no només en l’execució d’aquest projecte, sinó també durant tots aquests anys a la universitat, a poder créixer en l’àmbit professional i a desenvolupar un pensament més crític.

També dono les gràcies a Enghydra. Enginyeria i Serveis, on he realitzat les pràctiques, per permetre’m descobrir el sector hidràulic i conèixer més a fons el món del tractament d’aigües, gràcies per fer-me partícip del vostre dia a dia i deixar-me formar part d’aquesta petita-gran família.

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Per últim, agrair als meus pares i a la meva germana, perquè no hagués arribat on soc ara si no fos pel seu suport incondicional, sempre han estat al meu costat, ajudant-me en els moments difícils i celebrant també els bons. M’han acompanyat en tot moment i han sabut estar-hi quan més ho necessitava.

CONTENTS

SUMMARY

This work presents the design of a new Wastewater Treatment Plant (WWTP) for the municipality of Begur (Girona, Spain), adapted to strong seasonal variations due to tourism. The plant has a design capacity of 3,000 PE (population equivalent), with flows ranging from 20,89 m³/h in low season to 38,58 m³/h in peak season. The proposed treatment scheme includes pretreatment and a biological process based on a Membrane Bioreactor, with effluent discharged into the marine environment via a submarine outfall. Sludge is treated through thickening and a Planted Drying Bed system, enabling its reuse as compost for agriculture.

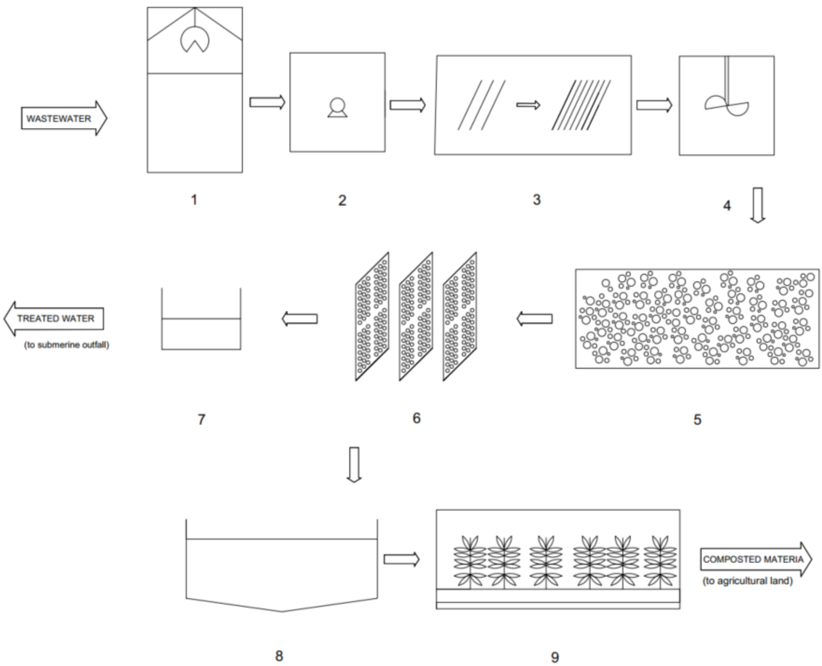


Figure 1 Process Flow Diagram of the Proposed Wastewater Treatment Plant (WWTP)
(1 – coarse chamber, 2 – inlet pumping station, 3 – coarse and fines screening, 4 – equalization tank, 5 – biological reactor, 6 – ultrafiltration membranes system, 7 – presentation chamber, 8 – thickener, 9 – bed drying system)

The study defines the design basis, evaluates alternatives, selects the most suitable technologies, and ensures compliance with environmental regulations and the applicable discharge standards set by the relevant authorities. The final design ensures technical efficiency, environmental sustainability, and adaptability to seasonal fluctuations.

Keywords: Wastewater treatment, sanitation, WWTP, treatment plant, membrane bioreactor (MBR), Planted Drying Bed, seasonality, submarine outfall, Begur.

RESUM

Aquest projecte presenta el disseny d'una nova Estació Depuradora d'Aigües Residuals (EDAR) per al municipi de Begur (Girona), adaptada a les fortes variacions estacionals provocades pel turisme. La planta està dimensionada per a 3,000 habitants equivalents, amb cabals que oscil·len entre els 20,89 m³/h a l'hivern i els 38,58 m³/h a l'estiu. El tractament proposat inclou un pretractament i un procés biològic basat en un Reactor Biològic de Membranes, amb abocament al medi marí a través d'un emissari submarí. Els fangs són tractats mitjançant un espessidor i un sistema de rizocompostatge, que permet el seu ús com a compost agrícola.

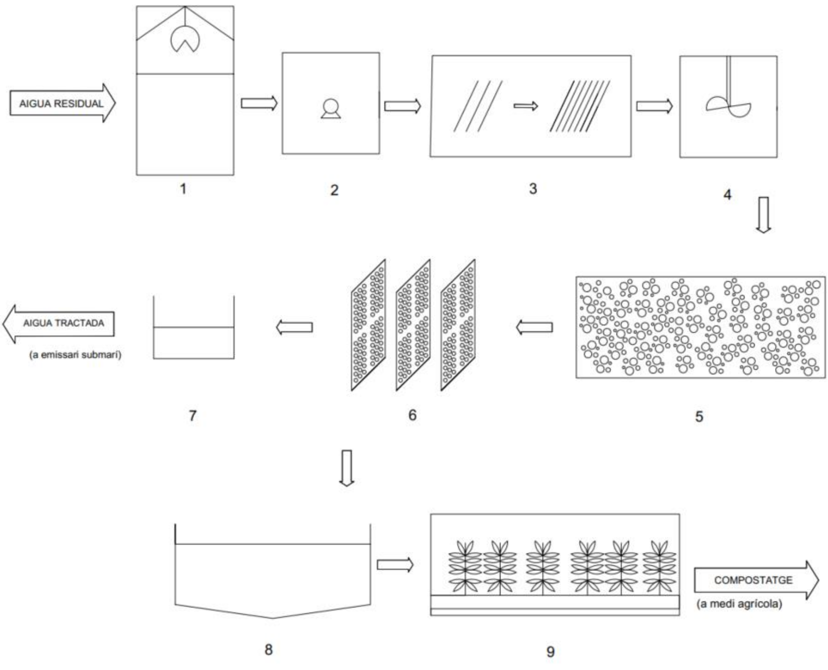


Figure 2 Diagrama de Procés de l'Estació Depuradora d'Aigües Residuals (EDAR) projectada
(1 – pou de gruixuts, 2 – bombament de capçalera, 3 – desbast de gruixuts i fins, 4 – tancs d'homogeneïtzació, 5 – reactor biològic, 6 – membranes d'ultrafiltració, 7 – arqueta de presentació, 8 - espessidor, 9 – sistema rizocompostatge)

L'estudi defineix la base de disseny, avalua alternatives, selecciona les tecnologies més adequades i garanteix el compliment de la normativa ambiental i dels estàndards de vessament establerts per les autoritats competents. El disseny final assegura l'eficiència tècnica, la sostenibilitat ambiental i l'adaptabilitat a les fluctuacions estacionals.

Paraules claus: Tractament d'aigües residuals, sanejament, EDAR, planta de tractament, reactor biològic de membranes (MBR), rizocompostatge, estacionalitat, emissari submarí, Begur.

SUSTAINABLE DEVELOPMENT GOALS

The Sustainable Development Goals (SDGs) of the United Nations [27] recognize water as an essential resource for sustainable development and equality. In this context, SDG 6 focuses on ensuring the availability and sustainable management of water and sanitation for all. This goal is fundamental, but it also interacts transversally with other targets, highlighting how integrated water management can transform communities, foster equality, and protect the planet.

The lack of access to clean water and sanitation perpetuates structural inequalities and limits development opportunities, especially in vulnerable communities, which directly connects to SDG 1, no poverty. Water treatment plants are a key solution, as they improve hygiene conditions, reduce the incidence of disease, and free up resources that can be directed toward productive activities. These improvements also impact education, aligning with SDG 4, quality education. Schools with access to clean water and adequate sanitation provide safer environments, particularly supporting attendance for girls and young women.

In this sense, water treatment also contributes to gender equality, SDG 5. By reducing the burden of fetching water—a responsibility often placed on women and girls—new opportunities for education and economic participation are created. Furthermore, the development and implementation of water treatment plants foster sustainable economic growth, aligning with SDG 8. Sectors such as agriculture, industry, and tourism directly benefit from secure and sustainable water management, driving both local and global economies.

Water treatment is also a critical infrastructure within the framework of SDG 9, industry, innovation, and infrastructure. Beyond ensuring access to safe water, these facilities are an example of technological innovation, adopting more efficient and sustainable processes to reduce environmental impact. This also resonates with cities and communities, SDG 11, where responsible water management improves urban living conditions, reduces pollution, and fosters healthier, more liveable spaces.

The reuse of treated water exemplifies the principles of responsible consumption and production (SDG 12), preventing the waste of water resources and optimizing their use in critical sectors. At the same time, water treatment contributes directly to climate action (SDG 13) by mitigating the effects of climate change, protecting aquatic ecosystems, and facilitating adaptation to water scarcity.

From an environmental perspective, this process plays a crucial role in preserving aquatic and terrestrial ecosystems. Related to SDG 14, life below water, it prevents the discharge of pollutants into water bodies, protecting marine and coastal habitats. Similarly, it ensures the sustainability of terrestrial ecosystems such as wetlands and marshlands, as outlined in SDG 15, promoting an ecological balance is essential for the planet's future.

The implementation of water treatment plants is a clear example of how a concrete action can have transversal and lasting benefits, both socially and environmentally. This technology not only ensures access to a basic resource but also transforms water into a renewable resource for agricultural, industrial, and urban uses.

This project, which emphasizes planet conservation and equality among people, aims to reflect on the necessity of responsible and collective water management. Its intention is to raise awareness of the positive impact of guaranteeing this universal right on global and planetary health. Ultimately, only by understanding the essential role of water treatment and sanitation systems and acting with commitment can we achieve a sustainable, fair, and empathetic transformation for all future generations.

1. INTRODUCTION

1.1. BACKGROUND

Although water is often perceived as an abundant resource, it is, in fact, a limited and valuable commodity. Wastewater treatment refers to a set of physical, chemical, and biological processes used to remove contaminants from domestic, industrial, or other types of wastewater.

A typical Wastewater Treatment Plant (WWTP) eliminates solids, reduces organic matter and pollutants, and restores dissolved oxygen levels. Solids such as sand, textiles, or wood are removed mechanically, while microorganisms degrade organic matter and contaminants. These microorganisms are subsequently separated from the treated water. Maintaining adequate oxygen levels is essential to support aquatic ecosystems.

In regions with high seasonal population density and water stress, such as the Costa Brava, wastewater treatment becomes critical. Increased tourism and limited water resources can lead to pollution and pressure on existing infrastructure. This study examines various wastewater treatment technologies applicable to such contexts, focusing on efficient, sustainable solutions that meet environmental discharge standards and protect marine ecosystems.

1.2. AIM PROJECT

In recent years, tourism has increased significantly in the Costa Brava, especially in municipalities such as Palamós. As a result, the Palamós WWTP is approaching its maximum treatment capacity, which could lead to serious challenges in the near future.

The Consorci d’Aigües Costa Brava Girona (CACBG) has planned a full renovation of the Palamós WWTP [3]. Since its commissioning in 1985, no major upgrades have been made. The plant shows signs of deterioration in structures, equipment, and installations. Furthermore, its proximity to urban areas creates additional environmental and operational issues.

The plant currently treats wastewater from Palamós, Palafrugell, Calonge, Vall-llobrega, Mont-ras, and Begur [4]. According to CACBG reports, the facility suffers from structural pathologies. The existing elements do not meet the technical standards required for safe rehabilitation, especially in terms of structural reinforcement.

For this reason, this project proposes building a new WWTP in one of the municipalities currently served by the Palamós plant [5]. This new installation would relieve pressure on the main facility and contribute to decentralizing the system.

- The proposed solution would offer multiple benefits:
- Reduces future capacity demands on the Palamós WWTP.
- Prevents overconcentration of wastewater in a single location.
- Decreases emissions due to shorter transport distances.
- Improves seasonal adaptability in high-tourism periods.
- Increases system autonomy and resilience.
- Integrates modern, more efficient technologies.
- Acts as a backup facility in case of failures.
- Minimizes treatment disruptions and load loss.

Begur has been selected as the site for the new WWTP. This choice is based on two main factors: it is the furthest municipality from Palamós and experiences the highest-pressure loss in the current pumping network.

Below are the main characteristics of the municipality of Begur:

Table 1 Characteristics of Begur [6]

Parameter	Value	Units
Region	Baix Empordà	-
Population (2024)	4,177 (winter) 7715 (summer)	habitants
Surface area	20,66	km^2
Density	204,6	habitants/km^2
Altitude	200	m

1.3. PARTS OF A WWTP

The main stages and components of the WWTP that will be considered during the design process are described in the following sections. Each unit plays a specific role in reducing contaminants and preparing the water for discharge or reuse. This section follows the standard structure of a conventional treatment train, from influent entry to final effluent and sludge management.

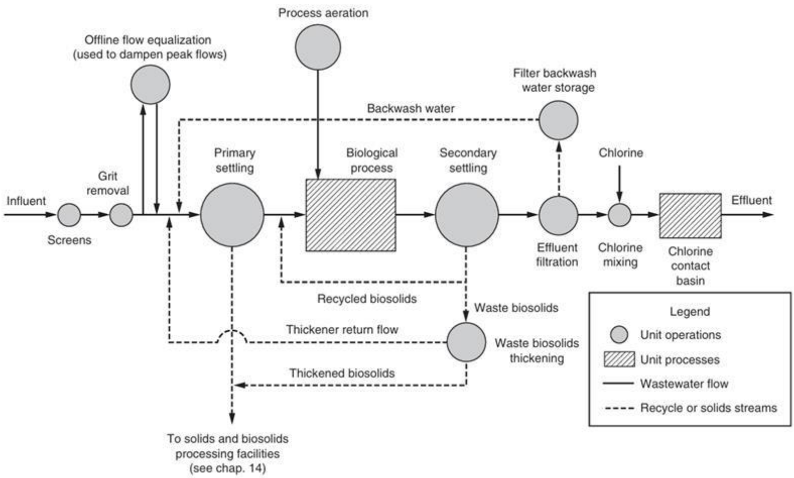


Figure 3 Location of physical unit operations in a conventional wastewater treatment plant flow diagram [1]

A bypass system allows water to be diverted away from part of the treatment process, typically used during maintenance or when inflow exceeds the plant's capacity. It can be applied across various stages of the treatment process [1].

1.3.1. Influent Work and Pretreatment

This initial stage includes all units that prepare raw wastewater for treatment. It removes large solids and grit to protect downstream processes. The main elements include the inlet structure, pumping station, and pretreatment units such as screens, grit, and grease removal systems. These units ensure proper hydraulic and mechanical conditions before primary treatment.

1.3.2. Inlet Work

Although civil engineering is outside the scope of this project, it is essential to describe the preliminary works required at any WWTP. Wastewater, conveyed by gravity or pumping, first enters an inlet structure designed to remove materials (e.g., wipes, large solids) that could hinder pretreatment. Flow measurement is also performed at this stage to support plant operation.

The inlet must include an overflow connected to the general bypass to divert excess flow beyond design limits. To reduce solid and grit discharge during rainfall events, a stormwater tank may be installed.

1.3.3. Pumping Station

A pumping station lifts incoming wastewater to feed the pretreatment units and ensure gravity flow throughout the process, minimizing energy use.

1.3.4. Pretreatment

Pretreatment involves mechanical and physical operations to remove coarse solids, grit, and grease that could interfere with treatment or increase maintenance. These phases depend on incoming flow, treatment type, and population served. Common pretreatment stages include screening, grit and grease removal. Also a flow measurament and sampling box use to be located in this stage.

In some cases, grit removal may be omitted with fine screens, though this can cause wear or clogging downstream. Grease removal may also be skipped if primary treatment is sufficient and grease content is low [1].

A. Screening

The coarse solids pit receives wastewater, allowing larger solids (stones, wood, etc.) to settle. These solids are removed using bar screens or sieves and conveyed via screw or belt conveyors. Bar screens consist of parallel bars placed in front of the flow with uniform spacing; sieves are made of perforated plates or metal mesh with uniform openings. Bar screens typically have wider openings than sieves and are classified based on bar spacing [10]:

- Coarse screen: bar spacing from 20 to 60 mm
- Fine screen: bar spacing from 6 to 12 mm

Bar screens are also classified by cleaning method:

- Manually cleaned: equipped with a perforated basket to collect solids
- Mechanically cleaned: incorporate a scraper that automatically cleans periodically

Waste is discharged onto conveyors and sent to containers. Compression systems often reduce volume and remove excess water before disposal. Sieves used include static, self-cleaning, and rotary screens, with openings from 1 to 6 mm.

B. Grit removal

This stage removes dense particles (typically >0.2 mm diameter [1]) to prevent settling in channels, pipelines, and units.

C. Grease removal

Removes fats and floating substances lighter than water. Units may be:

- Static, a tank with a deflector wall
- Aerated, where air is injected to break down emulsified fats and improve flotation.

D. Combined grit and grease removal

These processes are often combined and aerated, with air injected from the bottom to separate fats that float in a quiescent zone. The mobile-bridge grit and grease separator is the most used system.

Flow Measurement and Sampling Box

Flow measurement is essential for WWTP management. According to Order ARM/1312/2009 [11], a system must be installed at the outlet. Flow measurement methods include:

- Open channels (free-surface flow), using rectangular/triangular weirs or Parshall flume
- Pressurized pipes, using electromagnetic, ultrasonic, or turbine flow meters.

1.3.5. Primary Treatment

After pretreatment, primary treatment removes settleable solids and part of the organic load using physical separation processes. This step reduces the burden on biological units and enhances overall performance. The section describes components such as equalization tanks, primary settlers, and Imhoff tanks used in smaller installations.

Equalization Tank

Used to address flow variations, the tank provides a constant flow rate to downstream processes while homogenizing pollutant loads to improve performance and reduce treatment facility size and cost. It stores excess water and regulates flow rate, temperature, and contaminant concentration. It typically includes mixing mechanisms (pumps or agitators) to ensure uniform wastewater characteristics.

Primary Settlers

Sedimentation removes settleable solids and floating material, reducing suspended solids content by 50–70% and BOD by 25–40% [1]. Primary settlers can be rectangular or circular tanks, using scrapers or screws to collect settled sludge.

Imhoff Tank

A combined sedimentation and digestion tank typically used in decentralized systems and small communities. It consists of an upper sedimentation zone and a lower digestion chamber separated to prevent gas and sludge mixing.

1.3.6. Secondary Treatment

Secondary treatment, also known as biological treatment, focuses on eliminating dissolved organic matter and nutrients through microbial activity [1]. This section presents both extensive (e.g., wetlands, lagoons) and intensive (e.g., activated sludge, MBR) systems.

Extensive technologies are based on natural processes, require larger land areas, and operate with minimal energy input, making them suitable for small populations and rural settings. In contrast, intensive technologies are compact, highly controlled systems that require greater energy and operational resources but provide higher treatment efficiency in less space.

A comparative analysis of intensive alternatives is included in Appendix 1. Alternatives Study.

Extensive Technologies:

- Constructed wetlands
- Intermittent sand filters
- Infiltration-percolation
- Peat filters
- Waste stabilisation ponds (lagoons)

Intensives Technologies:

- Activated Sludge System (ASS) (fig.4)
- Membrane Bioreactor (MBR) (fig.5)
- Rotating Biological Contactors (RBC) (fig.6)
- Trickling Filter (TF) (fig.7)

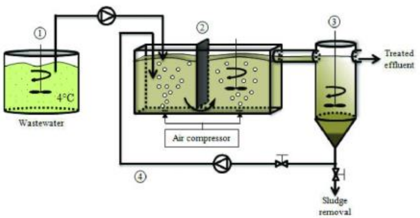


Figure 4 Activated Sludge System diagram [12]

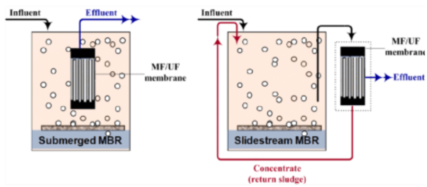


Figure 5 Membrane Bioreactor Schema [13]

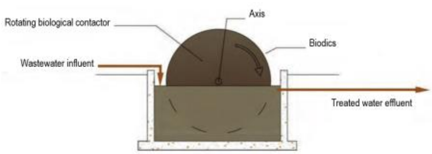


Figure 6 Rotating Biological Contactor diagram [14]

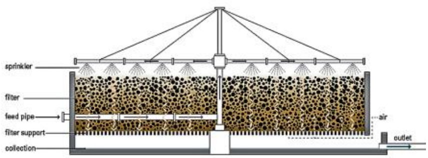


Figure 7 Trickling Filter diagram [15]

Cleaning Treatment

Regular cleaning is required to maintain membrane lifespan and system efficiency. ASS cleaning targets aeration tanks and clarifiers, using mechanical and chemical methods. RBC and TF require periodic removal of excess biofilm and scaling. MBR membranes are cleaned in situ; more intensive cleaning may be required in case of fouling [13].

1.3.7. Tertiary Treatment

Tertiary treatment is required when the effluent must comply with stricter discharge or reuse standards. It includes processes such as filtration, disinfection, nutrient removal, and advanced systems like reverse osmosis. The main objective is to ensure that the effluent meets the more stringent parameters required for safe discharge or reuse.

The most conventional methods involve physicochemical treatments such as adsorption, and disinfection processes including chlorination or ozonation. These technologies are essential for water reclamation, especially in environmentally sensitive areas, although they can entail higher operational and investment costs.

1.3.8. Destination / applications of treated water

Once treated, effluent can be discharged or reused. This section outlines the possible destinations and their quality requirements, according to applicable Spanish and European legislation [9] [11] [31].

- Discharge into water bodies: rivers, lakes, or seas
- Surface water discharge: stricter standards in sensitive ecosystems
- Marine water discharge: less strict due to dilution
- Infiltration into subsoil (aquifer recharge): stricter quality required
- Direct reuse: irrigation or industrial use (Royal Decree 1620/2007 [28])
- Reuse in food industries: requires highest quality standards

1.3.9. Sludges treatment

Sludges concentrate removed pollutants and require complex treatment and disposal. They are classified as:

- Primary: From primary settlers, rich in organics
- Secondary: From biological reactors, high moisture

Stabilization reduces odours and improves handling. Options include unstabilized sludge transfer or onsite stabilization through drying beds or wetlands.

1.3.10. Reuses of sludge

Once treated and stabilised, sludge can be reused following strict quality and safety requirements. The most common use is in agriculture as a soil conditioner, due to its high organic and nutrient content. Other applications include land reclamation, forestry, and landscaping.

In large WWTPs, dried sludge may also be incinerated for energy recovery. More experimental uses involve incorporating sludge into construction materials, though these require additional controls. All reuse pathways must comply with Royal Decree 506/2013 [17].

2. OBJECTIVES

The main goal of this project is to design a new decentralized wastewater treatment plant (WWTP) for the municipality of Begur, capable of effectively treating urban wastewater and reducing the pollutant load before discharging the treated water into the environment—particularly in ecologically sensitive areas such as the Costa Brava coastline. The design must also be adaptable to the significant seasonal variations in population, ensuring reliable operation during both low and peak demand periods.

The specific objectives of the project are:

1. Characterization of the influent wastewater in terms of flow rate, pollutant load, and seasonal variability.
2. Selection of the most appropriate treatment processes and determination of the optimal location for the new WWTP.
3. Sizing of the plant to accommodate both average and peak load conditions.
4. Definition of the required equipment, instrumentation, and valving systems for proper operation and control.
5. Estimation of the total budget for the construction and implementation of the treatment plant.

The proposed design must comply with current environmental regulations and safety standards, specify the characteristics of the treated effluent to be discharged into the environment, and describe all relevant processes, equipment, and instrumentation. Special attention will be given to ensuring that the plant is capable of handling the substantial seasonal fluctuations in water and sludge loads typical of tourist-driven population changes.

3. METHODOLOGY

The development of this project has been structured following a technical and sequential methodology, with the objective of ensuring consistency between the initial data, the treatment options analysed, and the final adopted solution. The steps followed are described below:

1. **Influent characterisation:** Based on population and pollutant loads (Chapter 4), average, peak and maximum flows and influent quality parameters were defined.
2. **Alternative assessment:** Chapter 5 evaluates water and sludge treatment options for both the water and sludge treatment lines, using technical, economic, environmental, and social criteria.
3. **Design and sizing:** Based on the defined flows and pollutant loads, treatment units were dimensioned using empirical formulas and standard calculation models, mainly following the criteria from Metcalf & Eddy [1] (Appendix 3. Design Equipment Process).
4. **Instrumentation and control:** An automated control architecture was proposed, adapted to seasonal variations, including sensors, PLCs, and SCADA to optimise the overall performance (Chapter 9).
5. **Integration and planning:** the final design was completed with the technical justification of the chosen solution, the global budget, and the development of layout drawings (PFD and P&ID) (Chapters 6, 11, and 12 respectively).

The detailed sizing calculations are presented in Appendix 3. Design Equipment Process and have been summarised in the main body of the report to comply with the project's length requirements.

4. PRINCIPAL INFORMATION AND DESIGN BASIS

For the design of the wastewater treatment plant (WWTP), it is essential to define key parameters such as the project scope, expected flow rates, and the types of pollutants, in order to select the most suitable treatment technology. This project accounts for significant seasonal differences, distinguishing between the peak season (summer, with the highest flows) and the low season (winter, spring, and autumn).

4.1. POPULATION

Begur, located in the Baix Empordà region of Girona, experiences strong seasonality due to tourism. The population nearly triples during the summer months. According to a demographic study [6], the municipality has 4,177 permanent residents and reaches up to 7,715 people in the peak season (including 3,538 seasonal residents)[6]. Although projections indicate a stable or slightly declining permanent population, the current population figures are used for design purposes, ensuring the plant can handle peak demands.

4.2. DESIGN FLOW

Accurate determination of the design flow rate is essential for establishing the WWTP's treatment capacity and ensuring efficient, cost-effective performance. Flow rates can be measured (recommended, using a flow measurement chamber) or estimated based on population and per capita water consumption [1].

For this project, both seasonal and daily variations are taken into account. Weekly variations are considered negligible. During the summer, higher population and increased water consumption significantly raise the hydraulic and pollutant load.

Parasitic water (infiltration and groundwater) also varies seasonally: wet season - higher infiltration, dry season - minimal infiltration. The plant's inlet is already oversized to handle these fluctuations, so no additional treatment for parasitic water is needed at this stage.

4.2.1. Design Flow Calculation

Water consumption is estimated at 150 L/person day [1], including domestic, industrial, and commercial use. Assuming a return coefficient of 80% [1], the mean daily flow rate is calculated using the following formula:

$$\bar{Q}\left[\frac{m^3}{d}\right] = H[hab]\cdot C\left[\frac{L}{hab\cdot d}\right]\cdot 0{,}8 \qquad (1)$$

Where:

- $\bar{Q}$ = average flow
- H = population
- C = water consumption
- 0,8 = return coefficient [1]

4.2.2. Peak and Maximum Flow

In addition to average flow, two operational parameters are considered [18]:

- Maximum flow = 4 × average flow
- Peak flow = 2 × average flow

These values reflect the plant's ability to maintain stable performance under both continuous high load and short-term inflow surges (e.g., rain events) [18].

4.2.3. Population Equivalent (PE)

Although PE is usually calculated using BOD_5 load (1 PE = 60 g BOD_5/d [29]), in this case it is derived from water consumption and design flow, due to the availability of real operational data. The formula is:

$$PE[hab.] = \frac{\bar{Q}\ [m^3/h]}{C\ \left[\frac{L}{hab\cdot d}\right]} \quad (2)$$

Where:

- PE = population equivalent
- $\bar{Q}$ = average flow
- C = water consumption

4.2.4. Design Flow Results

Table 2 Flow data

	Units	Low Season	Peak Season
Medium flow rate ($\bar{Q}$)	m^3/d	501,24	925,80
(1 m^3/d = 0,0417 m^3/h)	m^3/h	20,89	38,58
Maximum flow rate ($4\bar{Q}$)	m^3/h	83,54	153,30
Peak flow rate ($2\bar{Q}$)	m^3/h	41,77	77,15
Population Equivalent	PE	3342	6172

4.3. INFLUENT POLLUTION CHARGES

The wastewater treated at the WWTP primarily originates from domestic consumption and urban runoff. Pollution loads exhibit significant seasonal variability, closely linked to changes in flow rates. During the low season, pollutant concentrations and loads are reduced due to several factors:

- Increased industrial and commercial activity raises organic and chemical pollutants.
- Tourist-driven seasonal population growth increases wastewater volume and load.
- Higher temperatures accelerate biological processes and organic matter breakdown.

Based on operational data from the existing WWTP, an adjustment factor F = 0,8 [30] is applied to low season pollutant values, reflecting an approximate 20% reduction in contaminant loads compared to the peak season.

Table 4 shows influent flow and pollutant load data for low and peak seasons, based on monitoring reports and technical guidelines from the Agència Catalana de l'Aigua (ACA, 2021) [31], reflecting typical seasonal variations in Catalan wastewater treatment plants.

Table 3 Flow quality input charges [31]

Properties	Units	Low Season	Peak Season
Chemical Oxygen Demand (COD)	mg/l	480	600
Biological Oxygen Demand (BOD_5)	mg/l	240	300
Total Suspended Solids (TSS)	mg/l	200	250
Total Kjeldahl Nitrogen (TKN)	mg/l	40	50
Phosphorus (P)	mg/l	8	10

4.4. QUALITY REQUIREMENTS OF TREATED EFFLUENTS

Effluent quality must comply with the EU Water Framework Directive (2000/60/EC) [8], as implemented by Spanish and Catalan legislation, which aims to protect water bodies and achieve good ecological and chemical status. Since the effluent discharges into a marine environment, extensive nitrogen removal and tertiary treatment are not required in accordance with Directive 91/676/EEC [9]. Nitrogen removal will be limited to the pre-treatment stage without additional dedicated processes.

The WWTP effluent must meet the following seasonal quality requirements:

Table 4 Flow quality output charges [8]

	Units	Value	% minimum reduction [1]
Chemical Oxygen Demand (COD)	mg/l	125	> 70
Biological Oxygen Demand (BOD_5)	mg/l	25	> 75
Total Suspended Solids (TSS)	mg/l	35	> 80
Total Kjeldahl Nitrogen (TKN)	mg/l	50	--
Phosphorus (P)	mg/l	10	--

In addition to water discharge, treated sludge must also comply with legal standards before being reused or disposed of. According to Royal Decree 506/2013 on the use of sewage sludge in agriculture [17], only stabilised and hygienised sludge can be applied to soil. The sludge must meet quality criteria regarding organic matter, moisture, and contaminant levels, particularly heavy metals.

Table 5 Requirements for the Environmental Application of Sludge as Compost [17]

Parameter	Units	Value
Total Organic Matter	%	< 35
Maximum Moisture	%	40
Carbon/Nitrogen	-	> 20
Impurities	-	None
Granulometry	90% of particles must pass through a 25 mm sieve	

These criteria ensure the safe reuse of biosolids, protect soil and crop quality, and comply with national regulations on environmental protection.

5. ALTERNATIVES STUDY

To select the most suitable treatment process for the plant, several alternative studies were carried out, evaluating multiple criteria. The plant must meet the needs of a coastal population of up to 3,342 PE during the low season and 6,172 PE in the peak season, with average flow rates of 20,88 m³/h and 38,58 m³/h, respectively. The treatment process must include preliminary and biological stages to reduce BOD_5, COD, and TSS concentrations to comply with regulatory standards.

5.1. WASTEWATER TREATMENT ALTERNATIVES

It is considered appropriate to focus the selection of alternatives on intensive treatment systems, given the space constraints of the study area and the need to ensure high purification efficiency. Four technological options have been evaluated:

- Alternative 1: Activated Sludge Process (ASS)
- Alternative 2: Rotating Biological Contactors (CBR)
- Alternative 3: Trickling Filter (TF)
- Alternative 4: Membrane Bioreactor (MBR)

The evaluation of these alternatives has been carried out using a multi-criteria approach based on four main aspects:

- **Technical criteria:** Includes factors such as effluent quality, surface area requirements, adaptability to flow/load variations, complexity of operation and maintenance, sludge production, need for aeration, and process stability.
- **Economic criteria:** Considers both capital investment and operation and maintenance (O&M) costs.
- **Environmental criteria:** Evaluates the degree of integration of each system into the surrounding landscape and its overall environmental impact.

- **Social criteria:** Assesses the potential for odour and noise generation, especially relevant given the proximity of the WWTP to urban and touristic areas.

A detailed breakdown of each criterion and scoring method is included in Appendix 1. Alternative Study.

The comparative results of each alternative are summarised below:

Table 6 Comparative criteria table results

Comparative analysis	ASS	RBC	TF	MBR
Technical factor	25	34	31	41
Economic factor	6	7	5	3
Environmental factor	3	4	4	4
Social factor	6	7	7	7
TOTAL	**40**	**52**	**47**	**55**
Weighted total	**13,15**	**17,35**	**15,35**	**18,55**

Although MBR is not the most favourable option in terms of cost, economic criteria are not prioritized in this project. Therefore, other factors—such as technical performance, environmental sustainability, and social impact—are considered more relevant. MBR, RBC, and TF offer similar benefits in terms of environmental and social factors due to the high-quality treatment they provide.

As a result, Alternative 4, based on Membrane Bioreactor (MBR) technology, is considered the most advantageous overall. MBR significantly reduces pathogen concentrations, requires less maintenance, and operates with minimal supervision. In addition, MBR offers several further advantages compared to the other treatment technologies:

It facilitates technical management within the plant, allowing for easy adjustment of treated air, sludge purge, and recirculation.

- It eliminates bacteria and viruses without the need for additional disinfection stages.
- It occupies less space, as it eliminates the need for secondary clarifiers.
- It is easier to operate and requires fewer personnel.
- Its modular design allows for easy expansion and increased recycling capacity.
- It produces less sludge than conventional systems.

In conclusion, despite higher investment costs, MBR provides the highest treatment quality, lowest maintenance demands, and greater environmental and social benefits, making it the preferred solution.

5.2. SLUDGE TREATMENT ALTERNATIVES

Since the treated water is discharged into the sewer system and does not require additional treatment, the main challenge in this project lies in the management and treatment of excess sludge. The volume of sludge generated exceeds the capacity of a conventional thickener, requiring a significant reduction in volume. Transporting the sludge to another wastewater treatment plant is not viable due to the high associated costs. Therefore, an alternative analysis was carried out to determine the most suitable sludge treatment process.

Although the overall methodology used to evaluate the sludge treatment alternatives is similar to that applied in the selection of the wastewater treatment options — involving a multi-criteria analysis based on technical, economic, environmental, and social factors — the specific criteria differ to better reflect the unique challenges and requirements of sludge treatment. This is due to the particular nature of sludge management, which focuses on volume reduction, odour control, physical and chemical characteristics, and sustainable disposal methods. Hence, while the evaluation framework remains consistent, the criteria are adapted to ensure a relevant and accurate assessment tailored to sludge treatment.

The two options considered are:

- **Alternative 1: Dehydration Sludges by Centrifuge (CTF):** This method uses mechanical centrifugation to rapidly separate water from the sludge, achieving high levels of dehydration and volume reduction through high-speed rotation.
- **Alternative 2: Planted Drying Bed (PDB):** This passive system combines sludge drying and composting through a gravel-based bed planted with vegetation. The roots of the plants enhance sludge stabilization and promote the natural degradation of organic matter.

Below is the comparative evaluation based on qualitative scores (1 – Poor, 3 – Good, 5 – Excellent). For detailed data, refer to Appendix 1: Alternatives Study.

Table 7 Sludge treatment comparation

Parameter	PDB	CTF
Space requirement	3	5
Investment costs	5	1
Maintenance cost and spare parts	3	3
Generation of odours and noises	5	1
Dehydration capacity	3	5
Weighted TOTAL	**3,7**	**3,3**

Given the results, the recommended option is the Planted Drying Bed (PDB), which integrates traditional sludge drying and composting with natural plant growth. The system uses plant roots to stimulate the decomposition of organic matter and convert sludge into compost, enhancing soil quality. This sustainable method minimizes energy consumption and operational costs by relying on natural biological processes. Furthermore, it reduces environmental impact and facilitates final disposal without requiring chemical or mechanical interventions.

5.3. LOCATIONS ALTERNATIVES

Although site selection is beyond this project's direct scope, some key factors should be considered if a full study is undertaken:

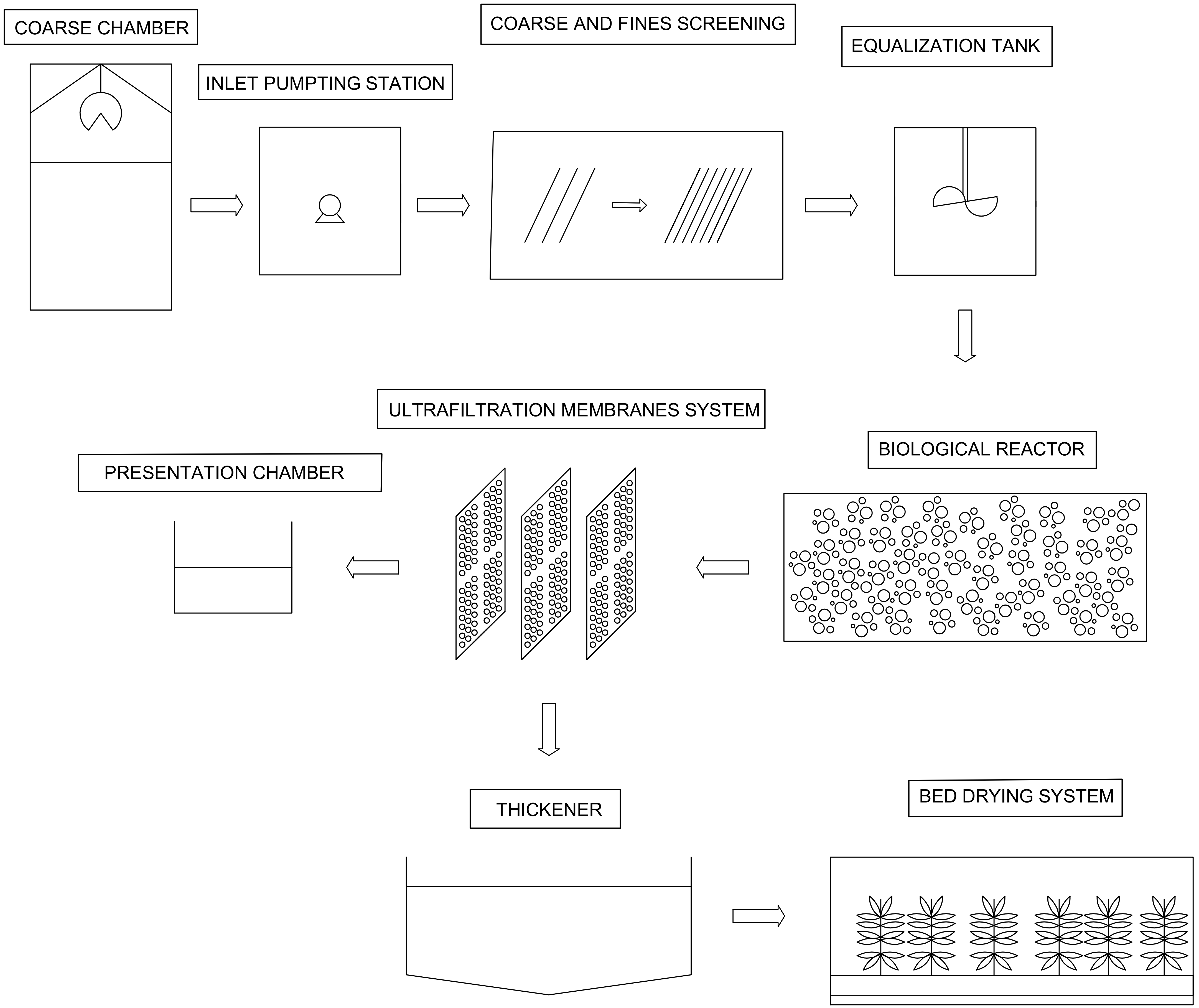
- Accessibility, including collector line length and earthworks impact.
- Economic factors, especially plot ownership, favouring public land to ease acquisition.
- Environmental sensitivity to protect habitats, flood zones, and land use.
- Urban proximity to minimize odour and noise nuisances.

A tentative location has been proposed based on site visits to optimize design, detailed further in Appendix 2. Location WWTP. A full assessment will be needed to finalize the plant site.

6. ADOPTED SOLUTION

The following section describes the different parts of the wastewater treatment process.

The Process Flow Diagram (PFD) is presented below to provide an initial overview of the proposed solution before its detailed explanation.



UNIVERSITAT DE BARCELONA · Grau en Enginyeria Química	AUTHOR: CRISTINA CANO MORET	PROJECT TITLE: DESIGN AND DRAFTING OF A NEW WASTE-WATER TREATMENT PLANT IN BEGUR.	SCALES: NONE · Original DIN A3 scale	DATE: JUNE 2025	TÍTOL DEL PLÀNOL: Process Flow Diagram (PFD)	Nº PLAN: 02 · SHEET: 1 OF 1

As it is said, this chapter describes the WWTP implemented work process. For more detailed information on the equipment, refer to Chapter 7. Equipment and Instrumentation: Design and Nomenclature, Appendix 6: Technical Sheets; and for Control and Automation refer to Section 8. Control and Automation and Section 11.3. Piping and Instrumentation Diagrams (P&ID).

6.1. WATER LINE

The water line starts with a coarse screening chamber featuring both self-cleaning and manual screens, followed by an inlet pumping station. After pretreatment, the water moves into an equalization tank before undergoing biological treatment in a membrane bioreactor. Finally, the treated effluent is collected and discharged through a submarine outfall.

6.1.1. Influent Work

Prior to pretreatment, the design includes a coarse screen chamber and an inlet pumping station.

→ **Thick waste chamber**

At the plant inlet, a civil works shaft is constructed and equipped with a bivalve grab operated by an automatic hoist for coarse solids removal. Inside the same shaft, a coarse screening system with two channels is installed.

The main channel includes a self-cleaning bar screen that removes large debris and discharges it into a container via a screw overflow screen. The bypass channel features a manual bar screen to allow flow diversion during maintenance or main screen failure. This bypass screen has a 30 mm bar spacing to retain solids during diversion.

Both channels are fitted with automatic inlet and outlet gates to control flow and enable switching. The self-cleaning screen provides essential pre-filtration, protecting downstream pumps by removing debris before it reaches the pumping station, complementing the pretreatment screens. A container is placed next to the shaft to collect extracted solids.

A radar sensor installed in the coarse chamber measures influent flow and sends data to the SCADA (Supervisory Control and Data Acquisition) system. Additionally, a high-level sensor (LSH) monitors water levels in the bypass channel.

Table 8 Coarse chamber characteristics

Proprieties	Units	Values
Extraction system	-	Bivalve clamshell + host
Volume	m^3	25
Surface	m^2	6,3
Depth	m	4,0
Useful Height	m	1,5
Instrumentation	-	1 LIT (matching the inlet pipe diameter)
Coarse channel characteristics		
System	-	Self-cleaning screen
Screen aperture	mm	30
Adopted effective height	m	0,5
Total unitary channel surface	m^2	0,04
Extraction system	-	Direct to container with conveyor screw
Bypass channel characteristics		
System	-	Manual screen
Screen aperture	mm	30
Adopted effective height	m	0,5
Total unitary channel surface	m^2	0,04
Extraction system	-	Grase collection basket
Instrumentation	-	1 LSH

→ **Inlet Pumping Station**

Following the coarse screening system, the inlet pumping station is constructed. It includes a chamber with three submersible pumps that lift raw wastewater to a head of 10 mWC, enabling gravity flow through subsequent treatment stages. Each pump has a check valve to prevent backflow and a gate valve for isolation during maintenance.

To manage peak flows, such as during rain events, an overflow system within the same well diverts excess flow (up to $0.25\overline{Q}$) to the receiving water body. This flow is filtered and classified as screened water using a manual bar screen with a 10 mm opening.

A hoist is installed to facilitate pump removal during maintenance. In parallel, a bypass channel with an automatic inlet gate allows direct diversion to the pretreatment stage when needed.

Five float switches (LS) monitor water levels and regulate pump operation via a PLC [21], which communicates with the SCADA system. A flow indicating transmitter (FIT) and a level indicating transmitter (LIT) are also installed to monitor flow rate and water level, respectively. The FIT is mounted on removable rollers for easy maintenance. An additional float switch is installed in the bypass channel for flow level monitoring.

Table 9 Inlet pumping station characteristics

Proprieties	Units	Values
Pumping system	-	Submersible pumps + hoist
Nº of pumps (+standby)	ut.	2 (+1)
Pumping chamber volume	m^3	12,0
Instrumentation	6 LS (LS, LSH, LSHH, LSL), 1 LIT, 1 FIT (+RD)	
Valves configuration	3 VCM0, 3 VRB0	
Coarse overflow screening system		
System	-	Automatic screening grid
Channel cross-section	m^2	Rectangular
Nº of screens	ut.	1
Screen aperture	mm	10
Adopted effective height	m	0,5
Total unitary channel surface	m^2	0,04
Solids extraction system	-	Direct to container with conveyor screw

6.1.2. Pretreatment

→ Screening system

Filtration is performed through a coarse and fine screening system with three channels. The two main channels include a mechanized coarse screen followed by a fine screen, connected via a screw conveyor that transports solids to a compaction unit discharging into a container. The third, bypass channel is equipped with a manual screen that directs solids to a grease collection basket.

Automatic gates at each channel's inlet and outlet regulate flow and allow isolation when needed.

To monitor performance, a level indicating transmitter (LIT) is installed in the main channel to measure incoming flow, and a float switch (LS) is installed in the bypass channel to detect high-flow conditions. If elevated flow is detected, standby screens are activated. A solenoid valve is also included to enable periodic cleaning of the fine screens.

Table 10 Coarse and fines screening characteristics

Proprieties	Units	Low Season	Peak Season
System	-	Automatic screening grid	
Channel cross-section	m^2	Rectangular	
Nº of channels	ut.	1	2
Nº of screens per channel	ut.	1 coarse screen + 1 fine screen	
Instrumentation	-	1 LID, 1 LSH	
Coarse screening			
Screen aperture	mm	10	
Adopted effective height	m	0,5	
Total unitary channel surface	m^2	0,04	
Solids extraction system	-	Direct to container with conveyor screw	
Fine screening			
Screen aperture	mm	8	
Adopted effective height	m	0,5	
Total unitary channel surface	m^2	0,07	
Solids extraction	-	Screw conveyor for residues to compactor	
Valves	-	1 solenoid valve	
Bypass channel			
System	-	Manual coarse screen with guide rails	
Screen aperture	mm	50	
Length	m	0,8	
Width	m	0,8	

6.1.3. Primary Treatment

At this stage, a civil works homogenization tank is designed.

→ **Equalization tank**

The homogenization tank is equipped with two vertical agitators at opposite ends to maintain a uniform mixture and prevent dead zones. Three submersible pumps transfer equalized water to the biological treatment stage when gravity flow is insufficient.

An elevated central channel serves as a bypass, allowing direct diversion to biological treatment during maintenance, cleaning, or equipment failure. At this stage, the water has been screened but does not yet meet discharge standards; it can be released as screened water via an emergency overflow if necessary.

Five float switches (LS) inside the tank monitor water levels and control pump operation via valves managed by a PLC (see Section 9. Control and Automation), which sends data to the SCADA system. An additional float switch in the bypass channel monitors flow there. At the tank outlet, a flow indicating transmitter (FIT) monitors the flow of pre-treated water entering the biological reactor. The FIT data is sent to SCADA and is mounted on removable rollers for easy maintenance and reinstallation.

Table 11 Equalization tank characteristics

Proprieties	Units	Low Season	Peak Season
$\bar{Q}$	m^3/h	20,89	38,58
BOD_5	mg/L	480	600
Geometry system	-	Rectangular tank	
Surface	m^2	100	
Depth	m	3,0	
Volume	m^3	300	
Instrumentation	-	5 LS (LS, LSH, LSHH, LSL), 1 LIT	
Agitation system			
System configuration	-	Vertical helix agitators	
Nº of agitators	ut.	2	
Submersibles pumps	ut.	3 (2+1)	
Outlet equipment			
Instrumentation	-	1 FIT (+RD)	
Valves	-	3 VCM	

6.1.4. Secondary Treatment

The biological treatment employs a conventional aerobic activated sludge process integrated into a Membrane Bioreactor (MBR) system. Screened and homogenized wastewater enters a fully aerated biological reactor, where microorganisms aerobically degrade organic pollutants. Aeration supplies the necessary oxygen to sustain microbial activity and maintain optimal biomass levels.

After biological treatment, the mixed liquor passes to membrane filtration units for solid-liquid separation. The membranes retain suspended solids and biomass, permitting only treated water to pass, thus eliminating the need for secondary clarification and improving effluent quality.

→ **Biological Reactor**

The biological reactor, a civil-engineering structure, is equipped with vertical agitators to maintain biomass movement and support oxygenation. Oxygen is supplied via a blower through a fine-bubble diffuser grid with flexible connectors to minimize air inflow impact and maintain flow stability.

Inside the reactor, two pairs of submersible pumps are installed: two for excess sludge purging and two for conveying treated wastewater (permeate) to the membrane system. All pumps have their corresponding operating valves. A bypass channel allows flow diversion during maintenance or failure, ensuring water reaches the downstream effluent collection chamber.

Instrumentation includes four level switches (LS) for pump regulation based on flow demand, managed by a PLC linked to the SCADA system. A radar level sensor monitors reactor water level. Additionally, sensors for dissolved oxygen, temperature (20–25 °C), and redox (pH) monitor biological activity and maintain optimal operating conditions.

Table 12 Biological Reactor characteristics

Proprieties	Units	Value
Geometry system	-	Rectangular tank
Adopted volume	m^3	510
HRT	h	13,22
Instrumentation	4 LS (LS, LSH, LSHH, LSL), 1 AIT, 1 TIT, 1 ORP, 1 LIT	
Aeration and agitation system		
Nº of blowers	-	2 Blowers (+ 2 MNG)
Diffuser system	-	1 Diffuser grid
Valves	-	2 VPP
Agitation system	-	2 Vertical helix agitators
Pumping system		
Type	-	Submersible pumps
Nº of pumps	ut.	2 (sludge purge) + 2 (wastewater)
Valves	-	2 VRB + 2 VCM

→ **Membranes system**

The system consists of two main zones: one housing the ultrafiltration membrane units and an adjacent area with chemical cleaning tanks. It is designed to operate under two seasonal flow conditions—low and peak season—handling flow rates from 20.89 to 38.58 m^3/h. The modular configuration allows flexible operation: six membrane modules run during peak flow, while only four are active in low flow, keeping two on standby for maintenance rotation.

Each membrane tank has submersible pumps that drive permeate through the membranes in an outside-to-inside flow pattern, retaining suspended solids and contaminants. Air is injected by blowers to clean membrane surfaces and prevent fouling from grease and organic matter.

A pressure sensor monitors transmembrane pressure (TMP), sending data to the SCADA via PLC, enabling automatic pump adjustments and triggering cleaning cycles to avoid clogging, optimise energy use, and extend membrane life. Knife gate valves control the inflow, while butterfly valves regulate air distribution.

Membranes are cleaned through automatic backwashing triggered by fouling detection. During this cycle, sodium hypochlorite and citric acid are dosed from internal tanks to remove deposits and restore permeability. Two chemical storage tanks with level sensors ensure stable supply.

Sludge management includes two submersible pumps, operating valves, four float switches (LS), and a flow indicating transmitter (FIT), complemented by valves and a regulating device (RD). The same setup applies to the reactor recirculation line.

At the effluent collection chamber, a control system with one FIT, three motorised valves (VCM), and a regulating device ensures accurate treated water flow measurement—critical for discharge control and billing.

No additional ultrafiltration modules are installed beyond the six configured units, as two standby modules already provide operational redundancy. This setup ensures continued service during maintenance or failure without requiring further reserve units. Adding more modules would increase capital and space requirements, which is not justified under the current design flows and operating conditions.

Table 13 Membrane System Characteristics

Proprieties	Units	High season	Low season
System	-	Rectangular tank	
Nº of tanks in use	ut.	3 tanks in operation	2 tanks in operation
Depth	m	3,5	
Unitary surfaces	m^2	18,0	
Unitary volume	m^3	63,0	
Valves	-	8 VPP, 6 VGM	
Instrumentation	-	6 PT	
Membrane modules distribution			
Necessary Surface	m^2	1050	1930
Nº of installed trains per chamber	ut.	2	2
Total installed modules	ut.	4	6
Total installed membrane area	m^2	4200	11580
Aeration system			
Nº of blowers	-	2 Blowers (+ 2 MNG)	
Diffuser system	-	6 Diffuser grid (+ 6 MNG)	
Diffuser type	-	Fine bubble diffuser (< 2 mm)	
Airflow per blower	Nm^3/h	894	
Chemical cleaning system			
Treated water pumping system	-	1 permeate submersible pump	
Cleaning pumping system	-	2 submersibles pump	
Nº of tanks	ut.	2	
Configuration tanks		Sodium hypochlorite tank + Citric acid tank	
Valves	-	2 VBM	
Instrumentation	-	3 LSH, 3 LSL	
Maintenance cleaning			
Typical frequency	-	Daily or automatic cycle	
Sodium hypochlorite concentration	mg/L	125	
Citric acid concentration	mg/L	2.000	
Recovery cleaning			
Typical frequency	-	Monthly to annually, as needed	
Sodium hypochlorite concentration	mg/L	1.000	
Citric acid concentration	mg/L	20.000	
Outler equipment to effluent collection chamber			
Valves	-	1 FIT (+ 1 RD)	
Instrumentation	-	3 VCM	

6.1.5. Effluent Collection Chamber

The effluent collection chamber is a civil structure with an ORP sensor monitoring oxidation-reduction potential to ensure treated water quality before discharge. A level indicating transmitter (LIT) measures water level to maintain volume and regulate discharge flow reliably.

Table 14 Effluent collection chamber characteristics

Properties	Units	Values
System	-	Civil work effluent collection chamber
Type	-	Square geometry
Depth	m	3,00
Surface	m^2	25,00
Volume	m^3	75,00
Instrumentation	-	1 ORP, 1 LIT

6.1.6. Discharge of the Treated Water

Treated water from the membrane system flows to the effluent collection chamber, then through a collector to a submarine outfall for marine discharge. The bypass is installed downstream of the sampling chamber to prevent contamination of the treated water zone. The sampling chamber must be isolated to ensure only properly treated water is analyzed.

6.2. SLUDGE LINE

Sludge pretreatment includes a thickener and a Planted Drying Bed System that directs sludge to a storage chamber. After the required storage period, the sludge is sent to a plant with a comprehensive treatment system for further processing.

6.2.1. Sludge Production

Sludge generated in the MBR biological treatment is 91.43 kg TSS/d in low season and 211.08 kg TSS/d in peak season, equivalent to 9.14 m^3 and 21.11 m^3 at 10% concentration [1]. Part of this sludge is recirculated to maintain active biomass concentration using screw pumps controlled by a level float and probe. Excess sludge is purged to prevent biomass overload, ensuring treatment efficiency. Purged sludge is sent for dehydration and final disposal.

Table 15 Sludge Recirculation Pumps Characteristics

Proprieties	Units	Values
Pumping type	-	Submersible pumps
Nº of recirculation pumps	ut.	2
Nº of purge pumps	ut.	2
Instrumentation	-	8 LS (LS, LSH, LSHH, LSL)
Valves	-	4 VCM, 4 VRB

6.2.2. Sludge Thickening

The purged sludge is sent to a gravity thickener that separates solids by sedimentation, concentrating them at the tank bottom and separating water. This reduces sludge water content before dehydration, preventing system saturation. The thickener has multiple water outlets at different levels to control solids-water separation effectively.

Two pumps, similar to the recirculation and purge pumps, extract leachate—the liquid generated by percolation—for treatment at the main pumping station.

Three level switches (LS) monitor sludge levels, and a PLC uses this data to operate the leachate pumps via the SCADA system. A radar sensor also controls the liquid level to ensure precise extraction regulation.

Table 16 Sludge Thickener Dimensions

Proprieties	Units	Values
System	-	Gravity thickener with rotator arm
Diameter	m	4,00
Total height (cylindrical + conical)	m	4,00
Total volume	m^3	50,00
Instrumentation	-	3 LS (LS, LSH, LSL), 1 LIT
Leachates pumping system		
Pumping system	-	Submersibles pumps
Valves	-	2 VRB, 2 VCM
Instrumentation	-	4 LS (LS, LSH, LSHH, LSL)

6.2.3. Planted Drying Bed System

After thickening, sludge is transported by helicoidal pumps to the Planted Drying Beds (PDS), where composting occurs via interaction with plant roots.

The sludge is placed in concrete boxes designed to optimize water absorption by the plants. Water filters through the substrate and is absorbed by roots, while solids dry gradually. The beds have two length options to adapt to seasonal variations: limited space in low season, full surface in peak season.

Once dehydration and stabilization are complete, the composted sludge is removed approximately once per year and analyzed for compliance with environmental regulations for agricultural use.

Every two beds share sensors monitoring dissolved oxygen (AIT), temperature (TIT), and humidity (RH). Data from 12 sensors is collected by a PLC and sent to the SCADA system. Extraction is mechanical, using a light backhoe or mini-loader, taking care not to damage drainage or plants. Substrate and vegetation are replenished as needed to maintain system function.

The composted material is transported to authorized temporary storage or directly to agricultural fields, following Catalan organic waste management regulations and ARC guidelines [26].

Table 17 Planted Drying System Characteristics

Proprieties	**Units**	**Low Season**	**Peak Season**
Surface loading for design	kg TSS/m^2/year	40	40
Required surface area	m^2	1285	2967
Nº of needed cells	ut.	4	8
Construction method	-	Concrete boxes	
		Cells dimensions	
Width	m	7,00	
Length	m	55,00	
Depth	m	2,20	
		Extraction system	
Composting production	m^3/year	53,9	
Transport to storage	-	Light backhoe	
Type of temporary storage	-	Container	
Storage volume	m^3	40	
Storage area	-	Covered fixed concrete storage facility	

In addition to dewatering, the planted drying bed contributes to pathogen inactivation through natural composting mechanisms. Factors such as exposure to solar radiation, oxygenation, and biological activity promote hygienisation of the stabilised sludge, improving its sanitary quality for potential agricultural reuse.

6.3. CONTAMINANT REMOVAL PERFORMANCE AND EFFLUENT QUALITY

The effectiveness of the adopted treatment solution is reflected in the plant's ability to significantly reduce the pollutant load of the influent. The following table summarises the estimated removal efficiency for key contaminants, along with the expected concentrations in the final effluent. These values are based on standard design assumptions and typical performance data for the selected technologies (pre-treatment, MBR, and sludge treatment).

Table 18 Contaminant removal summary

Treatment Stage	Parameter	Influent (mg/L)	Effluent (mg/L)	Removal Efficiency (%)
Pre-treatment	TSS	250	200	20%
	BOD_5	300	270	10%
	COD	600	570	5%
	TN	60	60	~0%
	TP	10	10	~0%
Biological reactor (MBR)	TSS	200	<10	>95%
	BOD_5	270	<10	>95%
	COD	570	75	85–90%
	TN	60	30–35	40–60%
	TP	10	7–8	20–30%
Membrane filtration	TSS	<10	<5	~100%
	BOD_5	<10	<5	~100%
	COD	75	<60	>95%
	TN	30–35	20–25	50–70%
	TP	7–8	4	40–60%
Sludge treatment (PDB)	Pathogens	High	Inactivated (compost)	>99.99%

7. EQUIPMENT AND INSTRUMENTATION: DESIGN AND NOMENCLATURE

7.1. CALCULATION METHODOLOGY

This section summarizes the core principles and approaches used to size and design the treatment plant components. Detailed computational developments and data are provided in Appendix 3. Design Equipment Process for reference.

The design adheres to the methodologies outlined in Metcalf & Eddy (2014) [1] and other references [32], [33], and [34], complemented by relevant local and international standards. Different design flow rates are considered for each treatment stage to accurately reflect operational conditions ($\bar{Q}$, Q_{max}. Q_{peak}).

Key parameters such as hydraulic retention times, volume requirements, pressure drops, and equipment dimensions have been calculated using standard engineering formulas and best practices. Safety factors have been incorporated to ensure robust and reliable plant operation under variable conditions.

- Summary of Main Calculations:
- Flow rate determination based on population equivalent and influent characteristics.
- Reactor and tank volumes derived from hydraulic retention time requirements.
- Pressure loss estimates calculated for piping and fittings to size pumps and valves.
- Equipment sizing driven by process parameters, including flow, load, and physical constraints.

All input data, calculation formulas, assumptions, and final sizing results are presented in detail in Appendix 3. Design Equipment Process for transparency and reproducibility.

7.2. EQUIPMENT AND INSTRUMENTATION NOMENCLATURE

As established by the ACA format [20] all equipment, instruments, and valves [24] in this project will be referenced according to this coding system (there is an example below).

Table 19 Process classification

Process	Subprocess	Description
AE	01	Coarse waste chamber
	02	Inlet pumping station
	03	Screening system
	04	Overflow bypass peak flow arrival
PR	01	Screening
	02	Overflow bypass peak flow arrival
DP	01	Equalization tank
	02	Tank's outlet to biological
TS	01	Biological reactor
	02	Membrane system
	03	Recirculation to biological
	04	Purge to thickener
	05	Chemical cleaning system
	06	Overflow bypass secondary peak flow
AT	01	Treated water outlet
EF	01	Gravity thickening
	02	Thickened sludges
	03	Leachate pumping
DE	01	Planted drying bed system
	02	Compost storage

Table 20 Example of a reference

WWTP	Process	Subprocess	Equipment	Number of units
DBEG-A2 (BEGUR)	AE	01	CB00	001

Appendix 5: List of Equipment, Instrumentation, and Valves contains the inventory of all equipment, instrumentation, and valves installed at the plant. For more detailed information, please refer to Appendix 6: Technical Specification Sheets.

8. CONTROL AND AUTOMATION

The proposed automation strategy ensures a dynamic response to seasonal fluctuations, guarantees equipment safety, and optimizes energy consumption through the intelligent operation of pumps and aeration systems. In addition, the SCADA system [21] provides centralized supervision, facilitating both operational management and predictive maintenance.

Consequently, an instrumentation network has been designed to monitor and control the various plant processes, along with a control architecture based on local PLCs connected to a central SCADA system [21]. The function of each instrumentation element and its role within the overall control system are described below [21]. For detailed information on the instrumentation network, refer to Chapter 6. Adopted Solution or see the project Plans.

8.1. INSTRUMENTATION AND SENSORS

The instrumentation system of the plant includes a variety of sensors and transmitters designed to continuously monitor key physical and chemical parameters. These instruments provide essential data for maintaining optimal operational conditions, ensuring safety, and supporting automatic control functions throughout the treatment process.

The following sections describe the main devices used for level measurement, flow monitoring, pressure detection, and critical environmental parameters such as temperature, dissolved oxygen, pH, and humidity.

8.1.1. Level Transmitters (LIT)

They continuously measure the liquid level in channels, tanks, and reactors, providing an accurate representation of water volume at each stage of the process. These instruments are essential at key locations such as the pumping well, inlet pumping station, equalization tank, biological reactor, and sludge thickener [21].

8.1.2. Level Switches (LS, LSH, LSHH, LSL)

These are on-off type sensors that trigger control actions when specific liquid levels are reached. Their typical configuration follows the logic below:

- LSHH (Safety): emergency shutdown or alarm at critically high level.
- LSH (Maximum): activates draining pumps or other preventive actions.
- LS (Run): starts pumps that are on standby.
- LSL (Minimum): stops pumps to prevent dry running.

This set of float switches is integrated into the pump control system, ensuring safe and automatic operation based on liquid levels.

8.1.3. Flow Transmitters (FIT)

Installed at key points such as the outlets of the inlet pumping station, equalization tank, membrane system, and treated water inspection chamber, they measure both instantaneous and cumulative flow. It is essential for adapting plant operations to actual hydraulic load conditions.

8.1.4. Pressure Sensors (PT)

They measure the pressure inside the membrane modules to detect potential clogging or operational anomalies.

8.1.5. Temperature, Dissolved Oxygen, pH, and Humidity Sensors

These devices continuously monitor fundamental physical and chemical parameters that influence biological treatment performance and sludge stabilization. Oxygen and temperature control in the MBR and PDB system are crucial for supporting efficient microbial metabolism.

8.2. CONTROL ARCHITECTURE

The plant is equipped with multiple local PLCs, each responsible for managing a specific group of equipment (e.g., pumps, sensors, valves) [21]. These PLCs locally process data and control actuators such as pumps, valves, and aeration systems. All local units are interconnected via an industrial communication network to a central SCADA system [21], which provides comprehensive monitoring, control, and data visualization for the entire facility [18] [21]. The main functional control units are outlined below, grouped according to process type and the corresponding instrumentation.

8.2.1. Inlet Pumping Station Set

This unit comprises several submersible pumps installed in the inlet well of the WWTP. Their operation is controlled by a set of level sensors (LS) [18] [21], configured as follows:

- LSL0 (minimum level): disables all pumps to prevent dry running.
- LS00 and LS00 (run 1 and run 2): sequentially activate one or two pumps depending on the water level and hydraulic load.
- LSH0 (maximum level): activates all available pumps to rapidly evacuate excess water.
- LSHH (safety level): triggers a critical alarm and may activate an automatic bypass to the overflow channel.

A local PLC reads the input from these sensors [21], automatically manages pump operation, and transmits status information to the SCADA system [21]. Additionally, the system includes a level transmitter (LIT0) for continuous monitoring and optional proportional control, and a flow transmitter (FIT0) on the discharge line to measure the pumped flow.

8.2.2. Equalization Tank Pump Set (and similar pump sets)

This system operates similarly to the lift pump set and is applied to the equalization tank as well as other pumping zones, such as sludge recirculation, purge, leachate, and chemical cleaning systems. The float logic remains consistent across all these applications: LSL0 (Minimum), LS00 (Run), LSH0 (Maximum), and LSHH (Safety) [18].

Each pump set is equipped with a dedicated PLC that controls pump operation, including sequencing, alternation, and redundancy, and is connected to the SCADA system [21] for supervision. In some cases, a level transmitter (LIT0) is also installed to enhance control precision and allow flow regulation based on target setpoints.

8.2.3. Float set in bypass channel

In overflow or bypass channels, both at the inlet and outlet, a high-level float (LSH0) is installed. This float serves a critical function [18]:

- When the water level exceeds the channel limit, it activates a relay that can open a bypass valve, trigger an alarm, or divert flow to the emergency channel.

Although simple, this system is essential to prevent flooding or damage during exceptional flow conditions such as heavy rainfall or mechanical failure.

8.2.4. Radar level measurement (for channels and tanks

Level transmitters (LIT0), typically employing radar or ultrasonic technology, provide continuous measurement of water levels in channels, chambers, and tanks [18]. Their primary functions include:

- Continuous level visualization on the SCADA system [21].
- Activation of control actions (e.g., pumps, valves) based on configured setpoints.
- Indirect flow calculation when combined with hydraulic formulas in open channels.

In the inlet or settling basin channels, these transmitters complement float sensors [21], offering improved accuracy and enabling earlier detection of changes in flow conditions.

8.2.5. Flow Meter Set at the Outlet of Each Treatment Stage (FIT0)

At the outlet of each main stage (pumping, primary treatment, secondary treatment, final inspection), flow transmitters (FIT0) are installed. This set serves to [18]:

- Obtain continuous records of the flow treated at each stage.
- Detect imbalances, losses, or recirculated flows.
- Perform water balance of the plant (input vs output).
- Generate data for operation reports and performance calculations.

The flow meters send signals to the SCADA [21] via local PLCs and allow alarm generation if flow goes beyond the expected limits.

8.2.6. Dissolved Oxygen, Temperature, and pH Sensor Set (Biological Reactor)

The biological reactor is equipped with essential analytical instrumentation:

- AIT0 (Dissolved Oxygen)
- TIT0 (Temperature)
- ORP0 (pH / redox potential)
- RH00 (Humidity Recorder)
- PT (Pressure Transmitter).

This set of instrumentation is connected to a dedicated Programmable Logic Controller (PLC), which is responsible for several key control functions [18]. These include regulating aeration through valve actuation based on predefined oxygen setpoints, monitoring process parameters such as temperature and pH to enable adaptive control strategies or activate alarm protocols, and transmitting real-time operational data to the SCADA system for visualisation, monitoring, and historical data logging [21].

This control scheme is crucial to maintain biological process efficiency and prevent issues such as overactivity or oxygen deficiency. The following table summarizes the defined sensor values for this project:

Table 21 Range values for project sensors [21]

Sensor	Typical Range [1]	Comment
AIT0	1,5 – 3,0 mg/L	Aeration control of biological reactor
	> 1,0 mg/L	Aeration control of PDB system
TIT0	15 – 35 ºC 5 – 35 ºC	In the biological reactor, it affects bacterial activity. In planted drying beds, it is evaluated within a typical environmental range.
ORP0	+50 a +200 mV	Not essential in this project as the study does not consider nitrification or other critical redox reactions (sensor used as an informative instrument).
RH00	40% - 60 %	Planted beds: irrigation and resting management.
PT00	0,1 bar – 0,7 bar	Transmembrane pressure for fouling detection.

8.2.7. Other Integrated Instrumentation Sets

In addition to the main instrumentation, specific sensors are integrated into key units to enhance process control [21]. Pressure transmitters (PT) in the membranes monitor transmembrane pressure, indicating clogging and cleaning needs. In the planted drying beds, humidity and oxygen sensors (RH, AIT, TIT) optimise sludge dehydration and regulate irrigation cycles. Level indicators (LIT) in the thickener control sludge purging based on accumulation. Each functional zone is managed by a dedicated PLC, all connected to the SCADA system via industrial Ethernet or fieldbus protocols (e.g., MODBUS, Profinet) [21].

9. PIPING

In the design of a Wastewater Treatment Plant (WWTP), defining the hydraulic regimes within pipelines is essential, as these influence material selection and equipment sizing. Two main flow types are considered: free-surface flow and pressurised flow. Gravity pipelines operate partially full, with the liquid surface exposed to atmospheric pressure and flow driven solely by elevation differences. In contrast, pressurised conduits are completely filled, with flow induced by internal pressure from elevation differences or by external energy sources such as pumps.

Given the preliminary nature of this project, the system's simplicity, and the relatively short lengths of the pipelines, no advanced hydraulic analysis (e.g., numerical simulation) has been carried out. Instead, the following section outlines the basic hydraulic sizing procedure, using standard methods appropriate for this design phase.

The methodology is based on classical hydraulic principles, including Bernoulli's energy conservation equation [25], the Darcy–Weisbach formula for pressurised flow [22], and Manning's equation for open-channel flow [22]. These are established approaches widely used in wastewater engineering, as outlined in CEDEX's Guía de diseño hidráulico de conducciones and other technical guidelines [23].

Due to the preliminary scope of this project, the full mathematical sizing procedure is not applied at this stage. Further details are provided in Appendix 4, which includes the complete methodology applicable in similar cases.

9.1. CONDUIT MATERIALS

The selection of conduit materials is a critical aspect in the design of wastewater infrastructure, as it directly influences the durability, safety, and overall performance of the plant's pipeline network.

Various technical factors must be considered, including flow conditions, pressure requirements, mechanical resistance, environmental exposure, and cost-effectiveness. Based on these criteria and established design guidelines [23], several materials have been evaluated for suitability within different sections of the plant. The following table summarizes the rationale behind the acceptance or rejection of each material, guiding the choice of HDPE for most buried pipelines and stainless steel for exposed or easily accessible sections.

Table 22 Material Suitability for the Plant

Material	Reasons [23]
Concrete	Discarded due to flow and pressure conditions
PVC	Discarded for pressurized and exposed sections
HDPE	Adopted for most buried pipelines in the project
GRP	Discarded due to mechanical requirements and the plant's moderate flow
Stainless steel	Adopted for exposed or directly accessible sections
Ductile iron	Discarded due to cost and oversizing

HDPE is lightweight, flexible, corrosion-resistant, and durable (up to 50 years); ideal for buried gravity and pressurized pipelines up to 500 mm. HDPE [23] is used as the primary material for buried pipelines, while AISI 316L stainless steel is specified for exposed or harsh environments.

9.2. DESIGN FLOWS

The design flows for each season in the WWTP are summarized in the following table:

Table 23 Flows design

	Units	Low season	Peak season
Max. pretreatment flow, Qmax ($4\bar{Q}$)	m^3/h	83,54	153,30
Peak flow, Qp ($2\bar{Q}$)	m^3/h	41,77	77,15
Average flow ($\bar{Q}$)	m^3/h	20,89	38,58

9.3. PIPELINE MATERIALS AND DIMENSIONS

Pressurized pipelines (water and sludge) are designed using HDPE PN 10, selected for optimal diameter ranges, ease of installation, and wastewater suitability [23].

Table 24 Conductions dimensions

	Nominal diameter	Pressure
Pressurized water line	DN160	PN10
Gravity water line	DN400	PN6
Sludge line	DN160	PN10

9.4. HYDRAULIC SIZING AND VELOCITY RANGES

Pipeline sizing follows the Catalan Water Agency's *Manual of Good Practices* [22]. For the peak season, flow velocities in pressurized conduits range from 0,5 to 2,5 m/s. During the low season, velocities fall slightly below the minimum but remain sufficient to prevent sedimentation. Head losses are within acceptable limits, ensuring energy-efficient design.

Pipeline velocity characterization

To select nominal diameter (DN), design flow velocities for each pipeline type are [23]:

- Pressurized wastewater lines: 0,6 to 2,5 m/s
- Sludge lines: 0,8 to 1,5 m/s (to avoid sedimentation)

Pressurized Water Pipeline Velocities

Velocity calculations for various DN values (HDPE PN10 pipes) [22]:

Table 25 Velocity according to DN for peak and low season

DN (mm)	Interior DN approx. (mm)	Surface (m^2)	v (high season) (m/s)	v (low season) (m/s)
DN 63	~53 mm	0,00221	19,28	10,49
DN 90	~79 mm	0,0049	8,69	4,73
DN 110	~95 mm	0,0071	6,00	3,27
DN 125	~110 mm	0,0095	4,48	2,44
DN 160	~140 mm	0,0154	2,77	1,50

DN 160 mm supports the peak summer flow at approximately 2,77 m/s (slightly above the recommended maximum, but acceptable for short distances), and the winter flow at 1,50 m/s (ideal). Therefore, DN 160 is optimal across the full flow range.

For gravity water lines, DN 400 mm is proposed to maintain a flow velocity between 0,6 and 1.5 m/s, preventing sedimentation and ensuring efficient gravity-driven transport.

9.5. SLUDGE PIPELINE

Sludge flow rates are low and vary with treatment processes. Maintaining flow velocity between 0,8 and 2,0 m/s prevents solids settling and ensures stable hydraulics [22].

HDPE PN10 DN 160 mm pipe is proposed for sludge, achieving velocities of 0,86 m/s (low season) and 1,99 m/s (high season) at 8 kg/m³ concentration, minimizing sedimentation, wear, and ensuring stable flow.

10. PROJECT BUDGET

In hydraulic infrastructure projects, a detailed budget is essential to evaluate the scope, ensure technical and financial feasibility, and comply with administrative requirements. It forms the basis for tendering, awarding, and project monitoring.

In this academic case, given its non-executive nature and the absence of a submission to public or private authorities, a fully detailed budget was not developed. The aim is to understand its overall structure and main components.

Cost references are based on real WWTP projects [18] and the BEDEC construction database [26].

Table 26 Project Budget

Properties	Value (€)
Civil works	138.000,00 €
Mechanical equipment	416.200,00 €
Instrumentation	60.000,00 €
Valves	37.450,00 €
Piping	60.000,00 €
Total PEM (excluding IVA)	**711.650,00 €**
General contractor expenses (13% of PEM)	92.514,50 €
Health and safety (1% of PEM)	7.116,50 €
Waste management (0,5% of PEM)	3.558,25 €
Total base tender amount	**1.526.489,25 €**
IVA (21%)	320.562,74 €
Total budget (including IVA)	**1.847.051,99 €**
Project uncertainty (±30%)	554.115,60 €
Final budget (with uncertainty)	**1.847.051,99 ± 5542115,60**

The Budget for Material Execution (PEM) is approximately **€711,650.00** [18][26], covering direct costs for civil works, mechanical equipment, instrumentation, valves, and piping.

General contractor expenses include:

- Health and safety, typically 1–3% of the PEM [26], estimated at **€7,116.50**
- Waste management, often 0.5–1.5% [26], calculated at **€3,558.25**

These components make up the Total Base Tender, amounting to **€1,525,489.25**. Adding the current VAT rate of 21% [18] (**€320,562.74**), the final budget including taxes totals **€1,847,051.99.**

Although this is an approximate estimate, it should be noted that real project development would consider many additional factors. However, as this is a basic engineering study, some have been omitted. To account for potential deviations, an uncertainty margin of ±30% [18] has been applied, resulting in a variability of **±€554,115.60.**

11. PLANS

The following drawings are attached to this report:

11.1. SITUATION AND LOCATION PLAN

The following drawings provide a visual overview of the WWTP's geographic context and precise site layout.

- The location plan situates the project within the municipality of Begur and its surroundings.
- The site plan defines the exact positioning of the facilities within the selected plot.

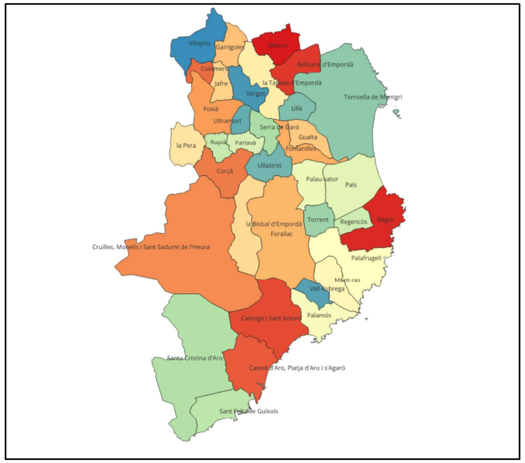
These plans support the project's territorial integration and inform access, construction, and service planning.

11.2. PROCESS FLOW DIAGRAM (PFD)

The process diagram illustrates the main treatment stages and the direction of flow: inlet works (coarse screening chamber, inlet pumping station), pretreatment (screens), primary treatment (equalisation tank), secondary treatment (MBR), sludge treatment (thickener, Belt Drying System), and final discharge or disposal. Blocks or icons represent each treatment unit, and lines indicate flow paths and connections.

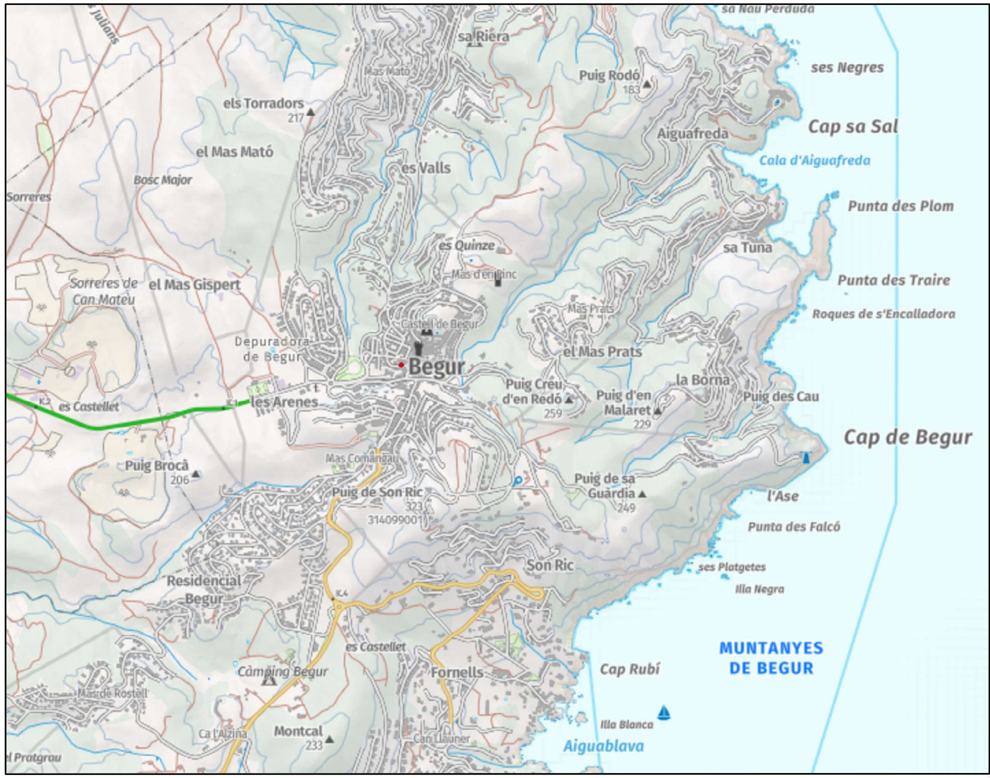
11.3. PIPING AND INSTRUMENTATION DIAGRAMS (P&ID)

The Piping & Instrumentation Diagram (PID) provides technical detail on pipes, valves, pumps, and instrumentation (flow meters, pressure gauges, level sensors, pH probes, etc.) and their interconnections. It is used to design the piping network, specify equipment, and define plant control and safety logic.

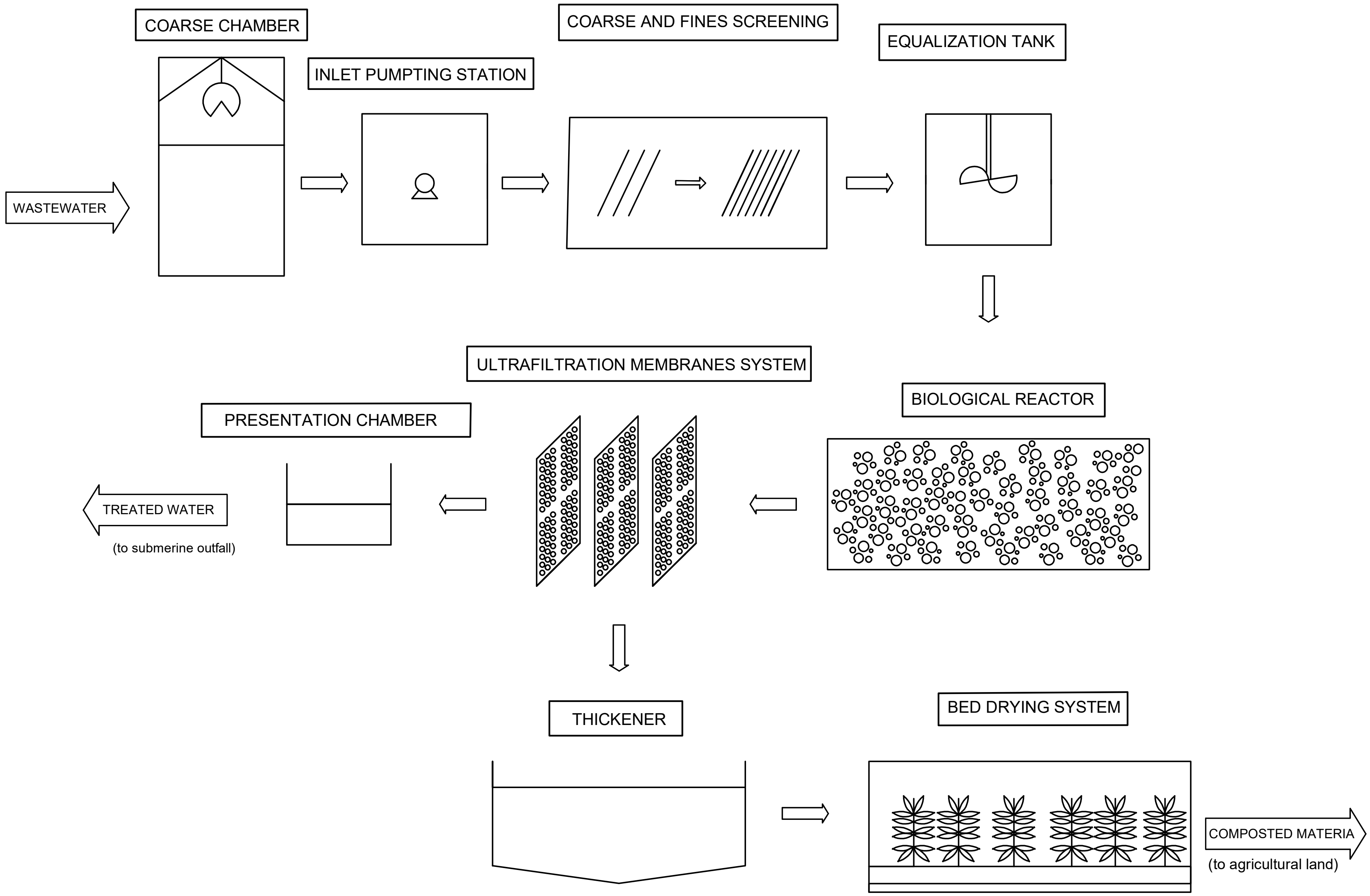


PLANS PROJECT LIST

PLANS	SHEETS
1. SITUATION AND LOCATION	1
2. FLOW DIAGRAM	1
3. PIPPING AND INSTRUMENTATION DIAGRAM	3

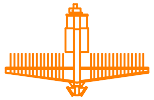
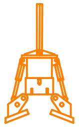
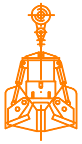
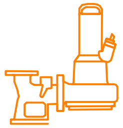
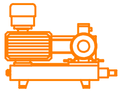
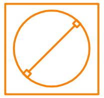
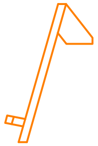
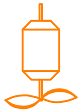
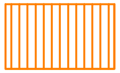
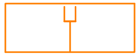
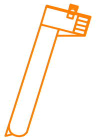
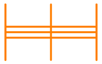


UNIVERSITAT DE BARCELONA · Grau en Enginyeria Química	AUTHOR: CRISTINA CANO MORET	PROJECT TITLE: DESIGN AND DRAFTING OF A NEW WASTE-WATER TREATMENT PLANT IN BEGUR.	SCALES: NONE Original DIN A3 scale	DATE: JUNE 2025	TÍTOL DEL PLÀNOL: Situation and location	Nº PLAN: 01 SHEET: 1 OF 1



UNIVERSITAT DE BARCELONA Grau en Enginyeria Química	AUTHOR: CRISTINA CANO MORET	PROJECT TITLE: DESIGN AND DRAFTING OF A NEW WASTE-WATER TREATMENT PLANT IN BEGUR.	SCALES: NONE Original DIN A3 scale	DATE: JUNE 2025	TÍTOL DEL PLÀNOL: Process Flow Diagram (PFD)	Nº PLAN: 02 SHEET: 1 OF 1

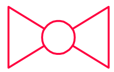
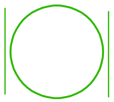
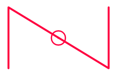
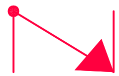
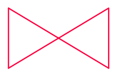
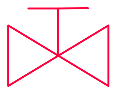
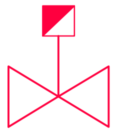
EQUIPMENT

	Automatic channel gate (CPCM)		Grease collection basket (CGE0)		Rotating scraper arm (BRR0)
	Backhoe (RECP)		Helicoidal screw pump (BCGH)		Selfcleaning screen - Automatic coarse screen (RXA0)
	Bivalve clamshell with hoist (CB00,PL00)		Hoist (PL00)		Submergible pump (BS00)
	Blower (BUF0)		Hoses (MNG0)		Tansfer pump (BTS0)
	Compacting press (PSC0)		Manual screen (RX0M)		Vertical helix agitator (AG00)
	Container (CT00)		Membrane module (MMB0)		Waste conveyor screw (CGT0)
	Diffuser grid (DABF)		Membrane tank (DPMB)		
	Fine screen (TMDB)		Removable rollers (RD00)		

COLOR CODE

(orange)	Equipment
(green)	Instrumentation
(red)	Valves

UNIVERSITAT DE BARCELONA / Grau en Enginyeria Química	AUTHOR: CRISTINA CANO MORET	PROJECT TITLE: DESIGN AND DRAFTING OF A NEW WASTE-WATER TREATMENT PLANT IN BEGUR.	SCALES: NONE Original DIN A3 scale	DATE: JUNE 2025	TÍTOL DEL PLÀNOL: Legend (Plan 4)	Nº PLAN: 03 SHEET: 1 OF 2

INSTRUMENTATION				VALVES	
	Level Indicating Transmitter (LIT)	AIT	Analytical Indicator Transmitter (AIT)		Ball valve (VBM0)
	Flow Indicating Transmitter (FIT)	TIT	Temperatura Indicator Transmitter (TIT)		Butterfly valve (VPP0)
LS	Level Switch (LS)	ORP	Oxidation-Reduction Potential (ORP)		Check valve (VRB0)
LSH	Level Switch High (LSH)	RH	Relative Humidity (RH)		Gate valve (VCM0)
LSHH	Level Switch High-High (LSHH)	MAP0	Manometric Air Pressure (MAP)		Knife gate valve (VGM0)
LSL	Level Switch Low (LSL)	PLC	Programmable Logic Controller (PLC)		Solenoid valve (VSN0)
	Pressure Transmitter (PT)	SCADA	Supervisory Control and Data Acquisition (SCADA)		

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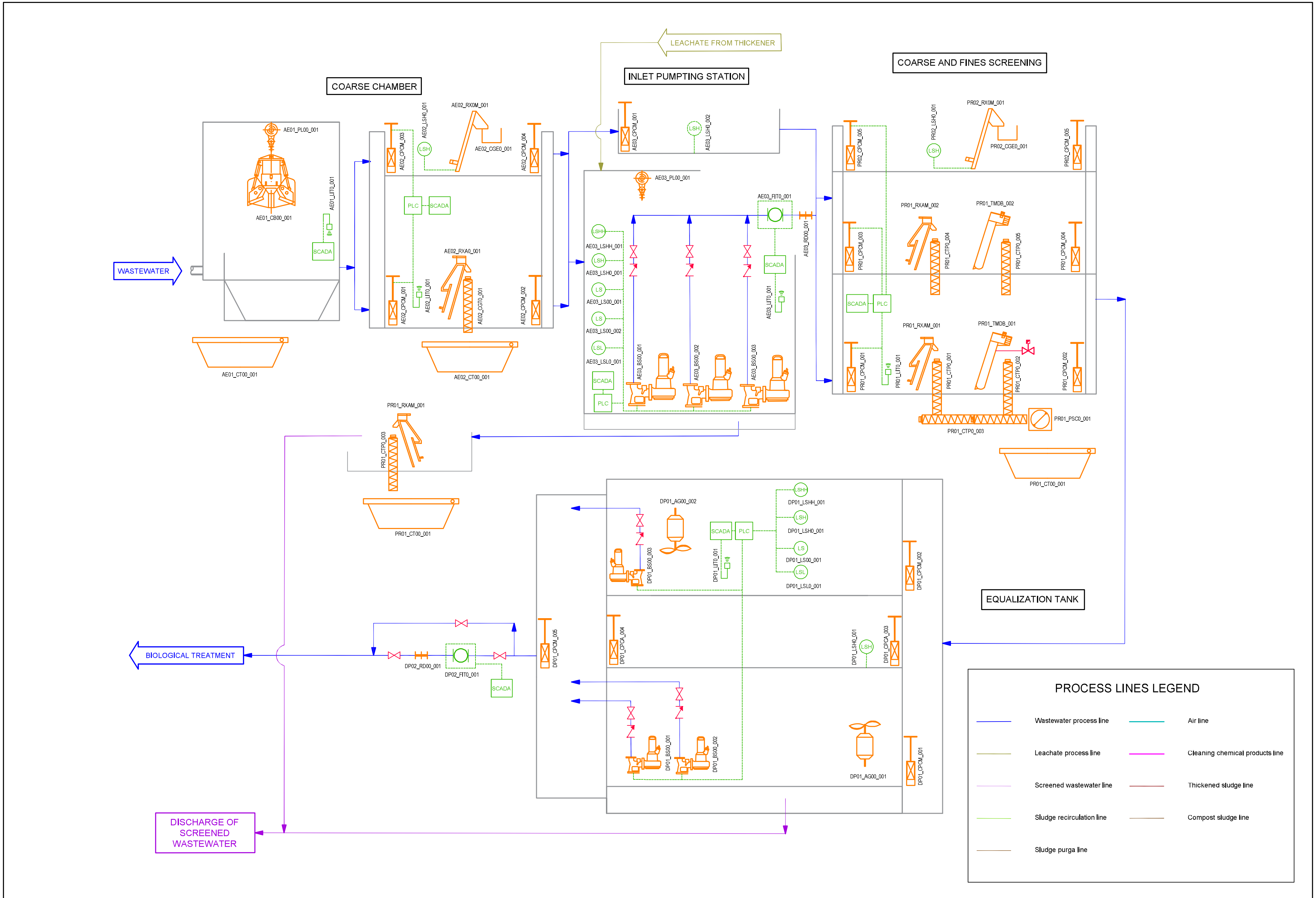

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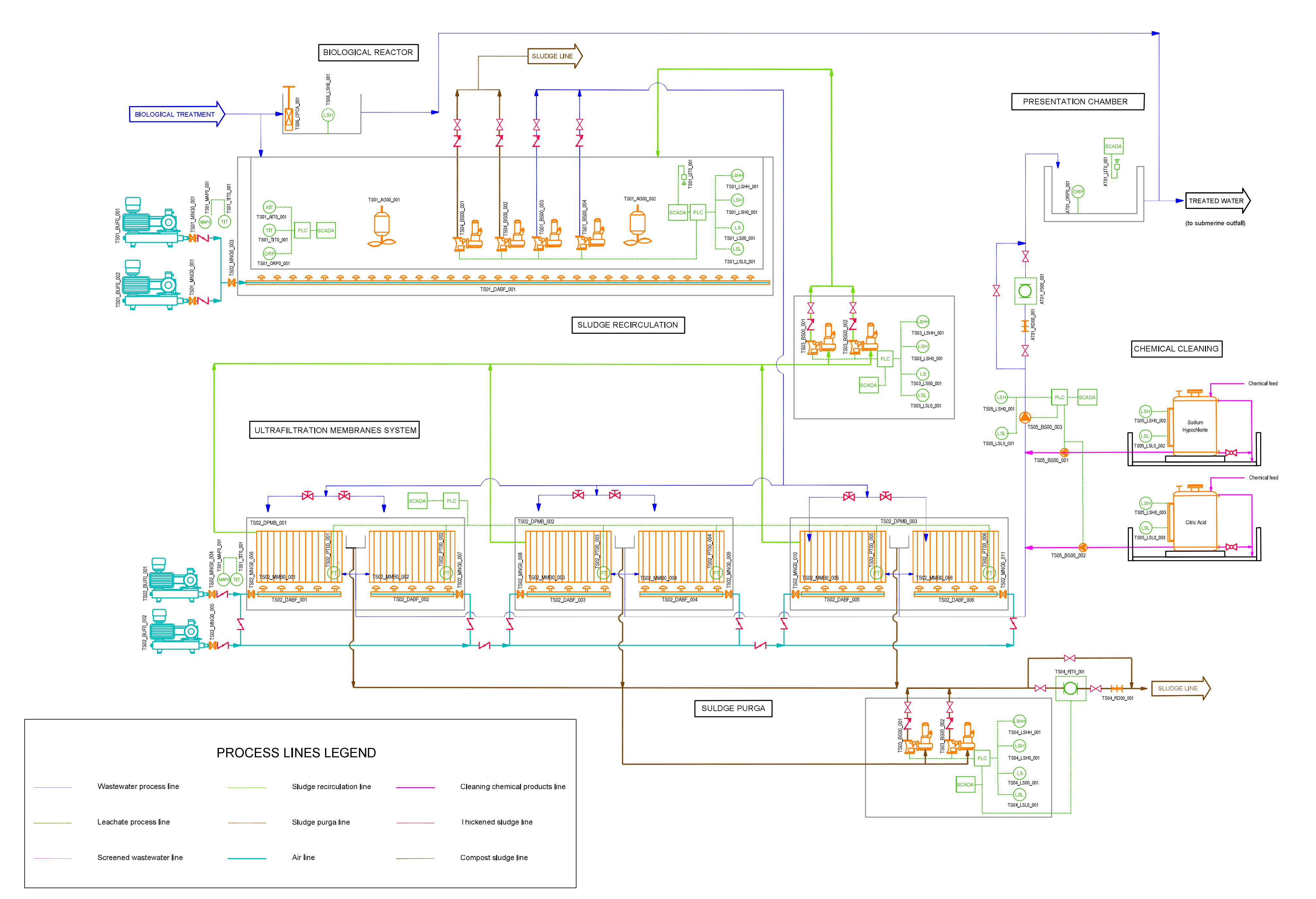

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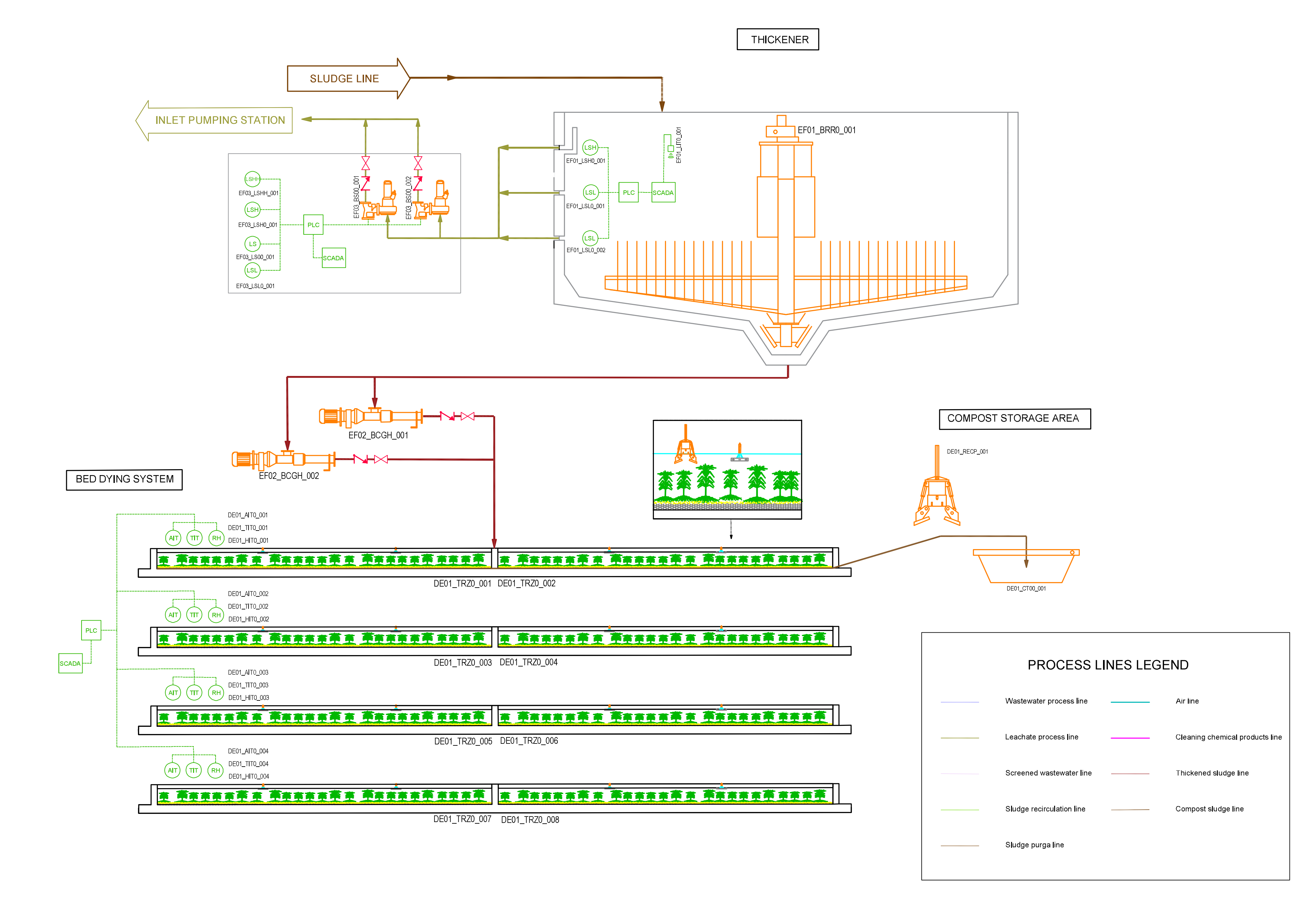

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12. SEASONAL OPERATION STRATEGY

One of the most critical design aspects of the WWTP in Begur is its capacity to adapt to strong seasonal variations in population and, consequently, wastewater inflow. During summer months, the influx of tourists significantly increases hydraulic and organic loads, whereas during the rest of the year, flow and pollutant levels remain relatively low. This fluctuation presents technical, operational, and energy management challenges that have been addressed through a flexible and scalable design [1] [19].

12.1. IMPACT OF SEASONALITY ON WWTP OPERATION

Seasonal variability affects:

- Hydraulic load: daily flow nearly doubles during peak season [30]
- Organic and nutrient load: increased wastewater production leads to higher concentrations of BOD_5, COD, TN, and TP [1]
- Energy consumption: more aeration and pumping required during summer [13]
- Maintenance scheduling: more stress on equipment during peak periods [19]
- Sludge production: higher generation in summer, require adapted removal cycles [5]

Failing to manage these fluctuations may result in:

- Overloaded treatment units [1]
- Increased risk of membrane clogging or process inefficiencies [13]
- Poor effluent quality, potentially violating discharge standards [8] [31]

12.2. ADAPTIVE OPERATION STRATEGY

To address these challenges, the WWTP has been designed with a seasonally adaptive operating plan, structured in three phases [13] [19]:

Low-Season Operation (Autumn–Spring)

Flow range: approx. 20.89 m^3/h

- Activated equipment:
  - 4 membrane modules operating
  - 2 modules on standby (preserved and rotated)
- Minimum aeration and pumping rates
- Energy strategy: low-power operation, prioritising efficiency
- Sludge handling: limited sludge production; extended residence time in thickener [1]
- Maintenance: ideal period for preventive actions, tank cleaning and chemical restocking

Transition Phase (Spring and Early Autumn)

- Flow range: gradually increasing or decreasing
- Actions:
  - Progressive activation of membrane modules
  - Adjustment of blower speeds and pump frequencies via SCADA [21]
  - Recirculation loops adjusted to optimise nitrogen removal [1]
- Monitoring: intensified SCADA control to adapt in real time to incoming loads[21]

Peak Season Operation (Summer)

- Flow range: up to 38.58 m^3/h
- Activated equipment:
  - All 6 membrane modules active
  - Maximum aeration and recirculation to maintain performance [1] [2]
  - Increased backwash and CIP frequency based on TMP monitoring
- Sludge handling: increased purge frequency and drying bed use [1] [5]
- Operational redundancy: standby pumps and level sensors fully activated[21]
- Chemical dosing: adapted for increased fouling risk [24]

12.3. ROLE OF SCADA IN SEASONAL MANAGEMENT

The plant's SCADA system plays a fundamental role in:

- Monitoring flow, TMP, sludge level and oxygen demand in real time [21]
- Automatically adjusting pump and blower speeds based on load[21]
- Triggering cleaning and maintenance cycles [21]
- Ensuring operational stability despite external variability [2] [21]

12.4. BENEFITS

By incorporating a seasonally flexible design, the WWTP in Begur ensures:

- Compliance with effluent quality standards year-round [8] [31]
- Efficient energy use and reduced operating costs in low season [13]
- Operational resilience during high-load summer periods [30]
- Improved equipment lifespan through controlled stress and preventive maintenance [19]

13. CONCLUSIONS

The proposed decentralized WWTP for Begur is based on a thorough characterization of the influent wastewater, revealing strong seasonal fluctuations in both flow and pollutant load due to tourism. To address this, a Membrane Bioreactor (MBR) system was selected for its high effluent quality, compact footprint, and robustness to load variations, making it ideal for Begur's limited space and changing population.

For sludge treatment, Planted Drying Beds (PDBs) were chosen as a low-energy, low-maintenance solution aligned with circular economy principles and cost efficiency.

A key strength of the design is its adaptive operation strategy, which adjusts equipment, energy use, and sludge management across three seasonal phases. The SCADA system enables real-time control and optimization, ensuring consistent performance throughout the year—even during summer peaks.

The plant layout, modular and automated, supports future scalability, operational resilience, and environmental integration. Despite a higher initial investment, the solution is economically viable due to its low operational costs and extended equipment lifespan.

In summary, the design fully meets the project's objectives—technically sound, economically balanced, and environmentally responsible—and offers a replicable model for other coastal towns facing similar seasonal and spatial challenges.

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15. ACRONYMS

AIT	Analytical Indicating Transmitter
ASP	Activated Sludge Process
BOD	Biochemical Oxygen Demand
C	Water Consumption
CACBGI	Consorci d'Aigües Costa Brava Girona
COD	Chemical Oxygen Demand
FIT	Flow Indication Transmitter
HRT	Hydraulic Retention Time
MBR	Membrane Bioreactor
LIT	Level Indication Transmitter
LS	Level Switch
ORP	Oxidation-Reduction Potential
P	Phosphorus
PDB	Planted Drying Bed
PE	Population Equivalent
PFD	Process Flow Diagram
PLC	Programmable Logic Controller
P&ID	Piping and Instrumentation Diagram
RBC	Rotator Biological Contactors
RH	Relative Humidity
SCADA	Supervisory Control and Data Acquisition
SDG	Sustainable Development Goals
SRT	Solids Retention Time
TIT	Temperature Indicating Transmitter
TMP	Transmembrane pressure
TF	Trickling Filter
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids
WWTP	Wastewater Treatment Plant

APPENDICES

APPENDIX 1: ALTERNATIVE STUDY

The study of alternatives for purification processes is focused on determining the type of biological treatment to be projected. It is essential to choose the most appropriate wastewater process and then design the process units of the water line and the sludge line. To support this decision, a comparative analysis of several technologies was carried out based on technical, environmental, and economic criteria. The key aspects of this analysis, including the options considered and the rationale behind the final selection, are summarised in this Appendix.

→ TREATMENT ALTERNATIVES OF PROCESS

Generally, two types of secondary wastewater treatment are distinguished: extensive (wetlands in vertical, horizontal or hybrid flow, lagoon systems, filters of peat, etc) and the intensive ones (prolonged aeration, bacterial beds, rotating biological contactors, sequential reactors, etc).

Extensive treatments require large areas of land, of the order of 2,5 to 5 m2/P.E.. In the case of Begur, where a maximum load of 3.000 P.E is estimated.

Therefore, it is considered appropriate to focus the alternatives on intensive treatments and adjust the solution to the surface.

The proposed alternatives are listed below:

- Alternative 1: Activated Sludge System (ASS)
- Alternative 2: Rotating Biological Contactors (CBR)
- Alternative 3: Trickling Filter (TF)
- Alternative 4: Membrane Bioreactor (MBR)

ALTERNATIVE 1: Activated Sludge System (ASS)

Activated sludge process is a common method for wastewater treatment. It is an oxygen-dependent biological process that serves to convert soluble organic matter to solid biomass, which can be removed by gravity or filtration.

Activated sludge (definition): the solids formed when microorganisms are used to treat wastewater using the activated sludge treatment process. It includes organisms, accumulated food materials, and waste products from the aerobic decomposition process.

The process schema is as follows:

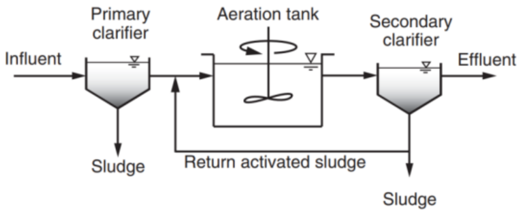


Figure 8 Activated sludge process (Tchobanoglous et al., 2003).

A key element in the system is the secondary clarifier (or secondary settler), which allows the separation of the treated water from the biological sludge. The settled sludge is partly recirculated back to the aeration tank to maintain an adequate concentration of microorganisms (MLSS), which is crucial for ensuring stable biological activity. The excess sludge is removed for further treatment. This recirculation loop is a fundamental feature of the process, enabling efficient nutrient removal and system stability.

After, is resumed the advantages and disadvantages:

Table 27 Advantages and Disadvantages of ASS.

Advantages	Disadvantages
Low surface requirements for implementation.	Professional and complex maintenance and continued
Possibility of achieving high total nitrogen removal yields.	Important energetic consumption
Flexibility, since its operating parameters can be controlled.	High exploitation costs
The sludge generated in the process is stabilized.	Sensible to hydraulic overcharges
Low level of odours.	Sludge production
	High noises generation

ALTERNATIVE 2: Rotating Biological Contactors (CBR)

The Rotating Biological Contactor is a system of water purification treatment consisting of batteries of discs various materials placed in parallel that they are submerging sequentially and partially (40%) in a tank through which water circulates treat.

On the support it adheres and develops an active biomass from wastewater, and which performs the effect system debugger.

Power consumption is low; If the whole is balanced, it is essential for spin it slowly. Depending on the model and manufacturer it can be estimated at less than 2.5 w/h. The low energy supplied results in a low noise level and in low maintenance cost. The environmental impact is also low.

The process schema is as follows:

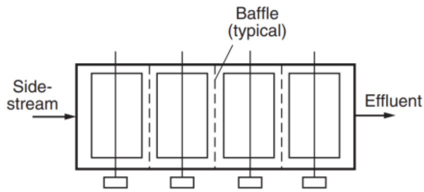


Figure 9 Rotating Biological Contactors Process (CBRs) (Tchobanoglous et al., 2003).

After, is resumed the advantages and disadvantages:

Table 28 Advantages and Disadvantages of CBR.

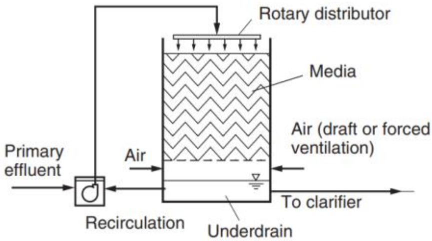
Advantages	Disadvantages
Land requirement relatively small	Difficult scale-up
Easy construction and expansion	Slow process start-up
Compact design with separate compartments	Adequate primary treatment and secondary clarifier required
Simple process control and monitoring	Limited process flexibility
Low operating and maintenance cost	
No requirement of sludge recirculation	

ALTERNATIVE 3: Trickling Filter (TF)

Trickling filters are based on the principle that if settled wastewater was passed over rock surfaces, slime grew on the rocks and the water became cleaner. Now it uses this principle with plastic media instead of rocks.

Trickling filters are widely used for the treatment of domestic and industrial wastes. The process is a fixed film biological treatment method designed to remove BOD and suspended solids.

A disadvantage of trickling filters is air pollution becomes bad odours. Currently for trickling process, there are new systems that replace stones, although at a higher cost, but increasing the contact surface very considerable.



The process schema is as follows:

Figure 10 Trickling filter process (TF) (Tchobanoglous et al., 2003).

After, is resumed the advantages and disadvantages:

Table 29 Advantages and Disadvantages of TF.

Advantages	Disadvantages
Less energy required	Odour production
Simpler operation with no issues of mixed liquor inventory control and sludge wasting	Production of an effluent with a higher suspended solids concentration (than ASS)
No problems of bulking sludge in secondary clarifiers	Poor effluent quality in terms of BOD and TSS concentration
Better sludge thickening properties	Uncontrolled solids sloughing events
Less equipment maintenance needs	Greater sensitivity to lower temperatures

ALTERNATIVE 4: Membrane Bioreactor (MBR)

The MBR (Membrane Bioreactor) is a biological treatment system combined with filtration membranes, replacing traditional secondary settling in a wastewater treatment plant.

The biological reactor operates like a conventional activated sludge process, where microorganisms break down organic matter and nutrients. Instead of a secondary clarifier, membranes (microfiltration or ultrafiltration) are used to separate solids from the clarified water.

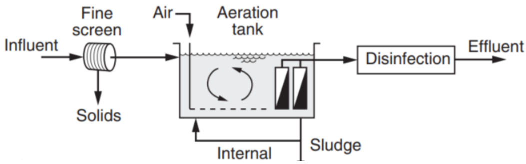


Figure 11 Membrane Bioreactor (MBR) (Tchobanoglous et al. 2003).

The filtered water contains very few suspended solids and has a very low pollutant load. Excess sludge is periodically removed for treatment and disposal.

Membranes are classified based on their filtration capacity. In membrane bioreactors, we have: Microfiltration (MF) and Ultrafiltration (UF).

Table 30 Microfiltration and Ultrafiltration Membranes Characteristics

Microfiltration (MF) (0,1 – 0,4 μm)	**Ultrafiltration (UF) (0,01 – 0,1 μm)**
Sufficient to separate activated sludge from treated water.	Eliminates bacteria and some viruses.
Reduces suspended solids (TSS) and organic matter	Provides better effluent quality than microfiltration, but not essential in your case
Lower energy consumption compared to ultrafiltration	May require more cleaning to prevent clogging.
More resistant to fouling	Uncontrolled solids sloughing events

Therefore, if more economical and efficient other options for discharge, the microfiltration membrane is the best choice. On the other hand, if the goal is to achieve a higher quality effluent for potential water reuse, ultrafiltration membranes are the better option.

Comparative analysis

To choose the wastewater treatment system, it is necessary to carry out a comprehensive multi-criteria study of alternatives, in which the advantages and disadvantages of each of the different proposed solutions are assessed.

This comparative analysis defines a series of critical and conditioning factors that can be grouped into four aspects:

- Technical criteria
- Economic criteria
- Environmental Criteria
- Social Criteria

These criteria will have a different weighting in the analysis according to the importance attributed to them:

Technicians	40%
Economy	40%
Environmental	15%
Social	5%
Total	**100%**

Each criterial will be broken down into different sub-criteria which are evaluated in the sections below. Then, in the conclusions section, the values of each criterion are taken (sum of the different subcriteria) and the weighting factor is applied to determine the final value of each alternative.

Technical criteria

Flow quality

The main objective of the purification treatment is to achieve the highest pollutant removal performance and, therefore, the highest quality of the effluent discharged into the receiving environment. All the proposed alternatives present a high performance of organic matter removal.

The efficiency of the treatment is evaluated below based on its performance. A coefficient from 1 to 4 is applied:

Performance > 95%	5
Performance 85 – 95 %	4
Performance 80 – 90 %	3

Performance 75 – 80 % 2

Performance < 75 % 1

Table 31 Score of flow quality factor.

Alternatives	BOD_5%	TSS %	COD %	TKN %	SCORE
ASS	80-90	85-95	85-95	80-90	14
CBR	85-95	85-95	85-95	80-90	15
TF	80-90	80-90	85-95	75-80	12
MBR	> 95%	> 95%	85-95	85-95	18

Necessary space

The surface required for the implementation of the WWTP is closely linked to the type of purification process. All processes correspond to the so-called intensive technologies, therefore, their occupation of land surface is reduced and very similar to each other, although the MBR and TF require more space than is needed in the other alternatives.

Larger occupation area: 1

Medium occupation area: 3

Smaller occupation area: 5

Table 32 Score of necessary space factor.

Alternatives	Surface	SCORE
ASS	Larger	1
CBR	Medium	3
TF	Larger	1
MBR	Smaller	5

Wastewater aeration

In this section, the efficiency in terms of aeration will be assessed. In the case of ASS and MBR, the contribution of oxygen is needed to ensure the aeration of the residual water. In the case of RBC, the supply of oxygen occurs naturally when they are rotated. In accordance with the previous point, in the case of CBR and TF, an aeration system is not required to achieve the appropriate conditions:

Need for aeration: 1

No need for aeration: 3

Table 33 Score of wastewater aeration factor.

Alternatives	Aeration	SCORE
ASS	Yes	1
CBR	No	3
TF	No	3
MBR	Yes	1

Charge variety behave

In a population like Begur, significant load variations can occur throughout the day, it is therefore important that the biological process can adapt to these variations. However, although the four (4) proposed processes present considerable versatility in the face of these variations, the ASS system and MBR present greater flexibility for seasonal variations in flows and polluted loads, as is the case study.

Highly adaptable biological treatment: 5

Adaptable biological treatment: 3

Badly adaptable biological treatment: 1

Table 34 Score of charge variety behave factor.

Alternatives	Ability to adapt to variations	SCORE
ASS	Badly Adaptable	1
CBR	Badly Adaptable	1
TF	Adaptable	3
MBR	Highly adaptable	5

Complexity of execution and maintenance

The complexity of plant maintenance and operation is a key factor in the technology selection process. CBRs have a relatively simple operational function, like the bacterial bed, the ASS system being a process of greater functional complexity due to the temporal programming and control of the process. Regarding the maintenance of the equipment, CBRs require greater control due to the possible wear and tear of the same.

The evaluation of the ease of operation and maintenance of the equipment is:

Simple - low: 5

Average: 3

Complex – high: 1

Table 35 Score of complexity of execution and maintenance factor.

Alternatives	Functional Simplicity	Maintenance	SCORE
ASS	Complex	High	2
CBR	Average	Average	6
TF	Simple	Low	10
MBR	Average	Average	6

Sludge production

Sludge generation is a key factor, as its characteristics determine the appropriate treatment method, removal frequency, and handling strategy. CBR systems feature a multipurpose tank with three chambers where primary settling occurs — a process not present in the other proposed alternatives, which rely solely on secondary settling. However, sludge production in CBRs is lower than in conventional activated sludge or extended aeration systems. In both these systems, the outgoing sludge is already well stabilised due to its high sludge age, eliminating the need for additional stabilisation processes.

Low sludge production: 5

Average sludge production: 3

High sludge production: 1

Table 36 Score of sludge production factor.

Alternatives	Sludge production	SCORE
ASS	Low	1
CBR	Average	3
TF	Average	3
MBR	High	5

Efficiency

The wastewater treated in the designed WWTP is primarily domestic, with no industrial discharges or nutrient removal requirements. The energy consumption of low-intensity systems, such as CBRs or trickling filters, is significantly lower than that of activated sludge plants, due to minimal oxygen input. Among activated sludge systems, energy use varies, with prolonged aeration requiring higher oxygen supply because of the greater biomass concentration.

In bacterial beds, however, it is important to consider the need for pumps to recirculate treated water and dilute the influent before entering the filter.

Greater efficiency: 5

Average efficiency: 3

Lower efficiency: 1

Table 37 Score of process stability factor.

Alternatives	Efficiency	SCORE
ASS	Lower efficiency	1
CBR	Average	3
TF	Average	3
MBR	Grater	5

Next, the balance of the assessment is carried out according to technical criteria:

Table 38 Resume of technical criteria results.

Technical criteria	ASS	CBR	TF	MBR
Flow quality	12	14	12	16
Necessary space	1	3	1	5
Wastewater aeration	1	3	3	1
Charge variety behave	1	3	3	5
Complexity and maintenance	2	10	10	6
Sludge production	1	3	3	5
Efficiency	1	3	3	5
TOTAL	**23**	**37**	**33**	**37**

As it sees at *Table 38* Resume of technical criteria results., from a technical point of view, CBRs is the best solution followed by the trickling filter.

Economic criteria

The economic criteria are divided into operation/exploitation costs and inversion costs.

Operation and exploitation costs

The operating cost of the plant is mainly associated with the personnel required for the operation of the WWTP, equipment maintenance, administration costs, energy consumption, waste production and reagent consumption. CBRs present a higher cost of equipment maintenance and ASS a considerable cost about energy consumption. The score for the operation and exploitation cost of the plant is:

Very low cost:	5
Low cost:	4
Average cost:	3
High cost:	2
Very high cost:	1

Table 39 Score of exploitation costs.

Alternatives	Costs	SCORE
ASS	Average	3
CBR	Low	4
TF	Average	3
MBR	Very high	1

Inversion costs

The initial investment has an important weight in the whole and is a function of multiple variables. The type of purification treatment and the process units represent a variable of great importance in the construction cost. A higher implementation cost is determined in the treatment of CBRs, due to the higher cost represented by the equipment. The score based on the initial investment.

Very low cost:	5
Low cost:	4
Average cost:	3
High cost:	2
Very high cost:	1

Table 40 Score of inversion costs factor.

Alternatives	Civil work	Equipment	SCORE
ASS	Average	Average	6
CBR	High	Very high	3
TF	Average	High	5
MBR	Very low	High	7

The balance of the assessment carried out according to technical criteria is explained below:

Table 41 Resume of economic criteria results.

Economic criteria	ASS	CBR	TF	MBR
Operation and exploitation cost	3	4	3	1
Inversion cost	6	3	5	7
TOTAL	**9**	**7**	**8**	**8**

From an economic point of view, alternative 2 and 3 are both economically adequate, the best option could be CBR or TFK.

Environmental criteria

Landscape integration

Both in the case of the ASS and the CBR, most of the elements of the process are usually buried and therefore have little visual impact. On the other hand, TF are not usually buried due to the problems associated with the ventilation itself and therefore they can have quite a visual impact due to the height of the beds.

Depending on the integration of each process in the environment, the treatment is evaluated from 1 to 5:

Very high integration: 5
High integration: 4
Average integration: 3
Low integration: 2
Very low integration: 1

Table 42 Score of landscape integration factor.

Alternatives	Landscape integration	SCORE
ASS	Average	3
RBC	High	4
TF	Average	3
MBR	Very low	5

Social criteria

Regarding the social criteria, the production of bad smells and noises from each alternative.

Smell generation

The generation of unpleasant odour is an important factor to consider for the choice of technology, mainly if the WWTP is located close to urban centres, as is the case study.

The treatment of CBRs should not present problems due to odour given that the biological process takes place in covered tanks, although this process requires a multipurpose tank, where the solids are decanted, among other functions of the tank, this being the possible focus of smells

The score based on the probability of generating odour is:

Very Low Probability:	5
Low probability:	4
Average probability:	3
High probability:	2
Very high probability:	1

Table 43 Score of smell generation factor.

Alternatives	Smell generation	SCORE
ASS	High	2
RBC	Average	3
TF	Average	3
MBR	Very Low	5

Noise generation

The generation of noise is associated with the operation of electromechanical equipment. In the treatment system with CBRs, electromechanical equipment of reduced power is available, the generation of noise being reduced.

Regarding SBR, they require artificial oxygen supply equipment such as blowers, of high power, although the noise they generate is mitigated by soundproofing cabins and buildings.

The score based on the probability of generating noise is:

Very Low Probability:	5
Low probability:	4
Average probability:	3
High probability:	2
Very high probability:	1

Table 44 Score of noise generation factor.

Alternatives	Noise generation	SCORE
ASS	High	2
CBR	Low	4
TF	Average	3
MBR	Low	4

The balance of the assessment carried out according to social criteria is explained below:

Table 45 Resume of social criteria results.

Social criteria	ASS	RBC	TF	MBR
Smell generation	2	3	3	5
Noise generation	2	4	3	4
TOTAL	**4**	**76**	**7**	**9**

From a social point of view, all the alternatives are similar to each other's, not only CBR and TFK are the best, but also ASS has high potential.

→ SLUDGE ALTERNATIVE OF PROCESS

For the management of the sludge generated in the purification process of the WWTP and considering the treatment capacity of the plant, two possible solutions have been considered:

- Centrifuge (CTF)

- Planted drying bed (PDB)

- Thickener has been ruled out because the plot does not have the space requirements that the technology and transport facilities has been required.

This comparative analysis defines a series of critical and conditioning factors that can be grouped into five aspects:

- Dehydration capacity
- Space requirement
- Investment costs
- Maintenance costs
- Generation of noises and odour

These criteria will have a different weighting in the analysis according to the importance attributed to them:

Dehydration capacity	25%
Space requirement	25%
Investment costs	20%
Maintenance cost	15%
Generation of noises and odour	15%
Total	**100%**

Each criterial will be broken down into different sub-criteria which are evaluated in the sections below (the same as the previous study). Then, in the conclusions section, the values of each criterion are taken (sum of the different subcriteria) and the weighting factor is applied to determine the final value of each alternative.

Dehydration capacity

The goal of sludge treatment is to reduce its volume by dehydrating it. This can be done more efficiently with a centrifuge; although the PDB system generates less dehydrated sludge or takes much longer to produce sludge of the same quality as the centrifuge, it is also a good treatment for agricultural application.

Additionally, it should be considered which option has the best visual environmental effect, depending on the location of the WWTP.

Space requirement

For the design of a good WWTP, it is important to consider the dimensions of the treatment process and the impact that its development will have. In the case of PDB, the system consists of a space where the different plants will be distributed, and little else; with the centrifuge, it must be noted that, in addition to the main operational equipment, a building must be constructed to house it, as well as to implement the necessary instrumentation and valves.

Investment cost

Both treatments require significant investment costs; however, the PDB system requires a lower initial investment. The system with the centrifuge also includes the building and the corresponding piping and valves, which results in higher investment and execution costs.

Maintenance cost

Maintenance costs are an important factor to consider, but in this case, they are negligible since both processes have low maintenance requirements.

Generation of noises and odour

In this case, the centrifuge generates more noise than the PDB system (which produces no noise). As for odours, there is no significant generation, but the centrifuge, being in an enclosed space, may produce some odours (such as hydrogen sulfide or VOCs).

Comparative

The score is based on:

Little positive:	1
Positive:	3
Very positive:	5

Below is a comparative table with both possible technologies.

Table 46. Possible sludge process.

Parameter	RZC	CTF
Space requirement	3	5
Investment costs	5	2
Maintenance costs and spare parts	2	2
Generation of odours and noises	5	2
Dehydration capacity	4	5
TOTAL	**19**	**16**
Weighted total	**3,8**	**3,5**

APPENDIX 2: LOCATION WWTP

The selection of an appropriate location for the wastewater treatment plant is a crucial aspect of the design process, as it directly affects technical feasibility, construction and operating costs, and environmental and social integration. Although an exhaustive site selection study is beyond the scope of this project, several alternatives are proposed and evaluated based on general planning criteria. These include technical, economic, environmental, and socio-territorial aspects commonly used in WWTP design. The analysis provides a comparative overview to highlight the implications of each location and to justify the need for such an evaluation in future project phases. Three locations are proposed to implement the treatment plant:

- **Alternative 1:** On the plot with cadastral reference 6549101EG1464N0001UU, located on the left bank of the municipality. The former WWTP (which has become obsolete and only serves about a third of the population) is located there, and the collector system that discharges into it is already in place.
- **Alternative 2:** On the plot with cadastral reference 6653101EG1465N0001RQ, located on the outskirts of Begur, to the north of the town.
- **Alternative 3:** On the plot with cadastral reference 7654120EG1475S0001QD, also located on the outskirts of the municipality, to the northeast.

In this case, since the scope of the project does not include an exhaustive study of the choice of plot location and its corresponding justification, the main criteria to consider when choosing the most suitable location for a water treatment plant under the given conditions will be outlined. However, no specific plot will be justified.

Below is an orthophoto showing the layout of the three possible plots.

Figure 12 WWTP possible locations

Technical criteria

Accessibility

It is important to consider the accessibility conditions of each proposed plot, as well as the necessary requirements to ensure access both during the construction phase and when the plant is operational. The presence of an access road to the plot designated for the WWTP is a significant advantage, as it reduces execution time, since the construction of the plant is not dependent on the construction of the access road.

Length of the collector line

The need to lay a collector line to the WWTP plot implies excavation, earthworks, and building materials costs. Therefore, the proximity of the plot to existing infrastructure is positively evaluated.

Earthworks

Depending on the needs of each location, earthworks will be carried out for the treatment plant itself, the incoming collector, and the access road. The greater the amount of earth movement, the higher the construction and economic costs will be.

Impact on third parties

This involves greater complexity in the execution of the works, as well as higher construction costs, due to the need to replace affected services and compensate third parties, if applicable.

Economic criteria

Investment and operation costs

The location of the WWTP can have a significant impact on costs:

- A difference in elevation between the current discharge points and the plot may require a new pumping station, resulting in higher costs.
- A plot that lacks good accessibility would require the construction of a new access road, which would incur construction costs and private compensation.

Environmental criteria

Impact on habitats and protected species

It is essential to consider whether the location of the WWTP would affect natural habitats or protected species. The presence of protected wildlife or flora species in the area may limit location options or require mitigation measures, such as the creation of protected areas or the implementation of operational practices that do not interfere with natural habitats. Preliminary environmental studies should be conducted to identify possible impacts and establish protection measures.

Impact on protected natural areas and other areas of environmental relevance

In this case, the WWTP should be located away from areas that are part of environmental protection networks, such as Natural Parks, ZEPA (Special Protection Areas for Birds), or SCI (Sites of Community Importance). The location should minimize impact on biodiversity and local ecosystems. Another aspect to consider is the distance to natural areas of interest, to avoid degrading the environmental quality of these spaces.

Flood risk

Vulnerability to flooding is a critical factor for the safety of the WWTP. Areas near rivers, streams, or flood zones should be avoided. A hydrogeological study should be conducted to analyze nearby streams and rivers, as well as climate change scenarios that could increase flood risks in the future. Additionally, engineering measures can be implemented to protect the infrastructure from potential flooding.

Impact on land use

The location of the WWTP should take into account the current land uses in the area (urban, agricultural, tourist, etc.) and their potential incompatibilities with such an installation.

For example, if the area has a significant tourist use, conflicts may arise due to visual impact, odours, or noise. Additionally, areas with high agricultural or production value should be avoided. In this sense, it would be ideal to select a location where the land use is less prone to conflicts with other human activities.

Socio-territorial criteria

Proximity to urban center

The distance between the urban center and the WWTP should be considered, given the odours and noise generation that a treatment plant may cause.

APPENDIX 3: DESIGN EQUIPMENT PROCESS

In the design of a WWTP, the type of flow considered depends on the specific function and section of the plant. Different flow rates are used in design calculations to ensure the facility operates efficiently under various conditions:

- Average flow ($\bar{Q}$), basic treatment processes and sizing parts that operate continuously.
- Maximum flow (Qmax.), systems that must withstand flow increases or peaks.
- Peak flow (Qp), specific process for exceptional events (as biological treatment)

All formulas and calculation procedures used in this section are based on *Metcalf & Eddy (2014),* Wastewater Engineering: Treatment and Resource Recovery, McGraw-Hill [1]. Information not sourced from Metcalf has been properly indicated in the corresponding section.

1. WATER LINE

1.1. Coarse well

→ **Volume and useful Surface of the chamber**

Formula:

- Volume [m³] = Longitude [m] × Width [m] × Depth [m] (3)
- Surface [m²] = Longitude [m] × Width [m] (4)

For both seasons, the volume and surface area of the chamber are the same. If it fixed volume on 25 m^3 and depth on 4,0 m [1], the surface is:

$$Surface = \frac{Volume\ [m^3]}{Profundity\ [m]} = \frac{25\ m^3}{4,0\ m} = 6,3\ m^2$$

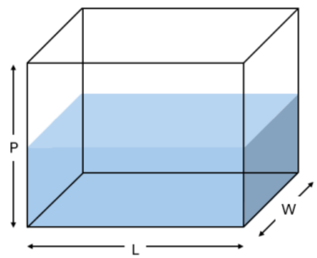


Figure 13 Coarse well geometry (own work)

→ **Hydraulic Retention Time (HRT)**

Retention time is calculated based on the chambers volume and the maximum flow rate (Qmax.) for each period. The maximum flow rate is based on a security factor (F = 10) [1].

Formula: HRT [h] = Volume [m^3] x Maximum Flow rate [m^3/h]. (5)

Retention times will vary depending on whether it's low or peak season, because with the same space, in peak season will be more fluent that cause a minor retention time.

$$HRT = \frac{Volume[m^3]}{Q\ [m^3/h] \cdot F} = \frac{25\ m^3}{20{,}89\ m^3/h \cdot 10} = 0{,}12\ h = 7{,}2\ min$$

Doing the same procedure for peak season with a 38,58 m^3/h it led to 3,9 min.

→ **Head loss (h_L) of the chamber**

Head loss is a crucial factor that should be estimated for both operational periods, as it directly affects the hydraulic performance and energy efficiency of the system. Excessive head loss can lead to increased pumping requirements, reduced flow rates, and potential operational inefficiencies. Head loss calculations will vary depending on the flow conditions, screen obstruction, and geometry (for more information on the head loss calculation process, refer to Section 10 of the present project) [1].

Formula: h_L [m] = Head Loss Coefficient [m] x (Velocity [m]) ^{2} / 2 x gravity [m/s^2] (6)

Where:

- K: head loss coefficient (depending on geometry and obstruction's screen)
    - Clean and well-designed grate, K = 0,2 - 0,5
    - Partially obstructed grate, K = 0,8 - 1,5
- v (m/s): water's velocity between bars (1 m/s) for both seasons
- g (m/s^2): gravity acceleration (9.8 m/s^2)

$$h_L = K \cdot \frac{v^2\ [m/s]}{2 \cdot g\ [m/s^2]} = 0{,}35 \cdot \frac{1^2\ m/s}{2 \cdot 9{,}8\ m/s^2} = 0{,}02m = 20cm$$

→ **Self-cleaning screen**

Formula: S [m^2] = Maximum flow [m^3/h] / Velocity [m/s] (7)

$$S = \frac{Qmax\ [m^3/h]}{v\ [m/s]} = \frac{154{,}3\ m^3/h}{1\ m/s} = 0{,}023\ m^2$$

In this case the maximum flow rate is chosen for the self-cleaning screen as systems that must withstand flow increases or peaks.

1.2. Inlet pumping station

→ Geometry design of the pumping chamber

The fundamental parameters for defining a pumping chamber are the influent flow rate and the start-up frequency of the pumps. To avoid thermal overload of the motors, the pumps must not be started too frequently within a given time period.

Since the selection of the pumps is based on handling the maximum influent flow rate—which is subject to daily fluctuations—a storage volume, known as the useful volume, must be provided in the pumping chamber. This prevents excessively frequent pump start-ups and protects the equipment.

The useful volume is calculated using the following equation, as proposed in the Manual para el Proyectista by ABS [17]:

$$V_1 = k \cdot \frac{0{,}9 \cdot Q}{Z} \quad (8)$$

Where:

- V_1 (m^3), useful volume of the pumping well
- Q (m^3/h), influent flow rate to the pump
- Z (starts/hour): number of allowed pump starts per hour (set to 6)
- k (-): correction factor depending on the pump operating scheme

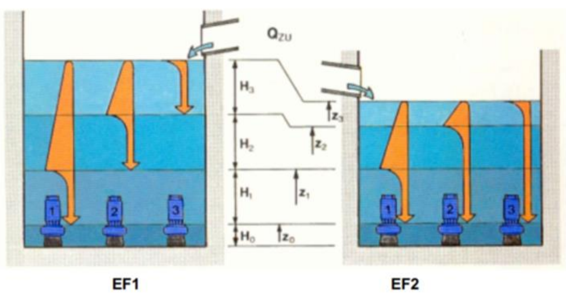


Figure 14 Pump Operating Scheme in the Pumping Well

EF1: Pumps start sequentially as water levels rise and stop in reverse order as levels drop. In this case, k = 1.

EF2: Pumps start like in EF1, but all stop at the same time when first pump's stop level is reached. In this case, k depends on the number of pumps:

Table 47 Corrector factor values

Number of pumps	K	Number of pumps	K
1	1	5	0,188
2	0,392	6	0,167
3	0,264	7	0,152
4	0,216	8	0,140

Since in the case of EF1 the useful volume of the pumping well is greater than in EF2, for safety reasons the system is designed to operate under EF1, with staggered starts and stops.

Using the peak-season flow rate, fixing the number of starts at 6 per hour, and assuming a correction factor of k = 1, the calculated useful volume (V_1) is 1.60 m³. Once the useful volume is defined and the pumps are selected, the total volume of the chamber is obtained by adding the dead volume (i.e., the volume below the minimum water level). Applying a 35% safety factor results in a total chamber volume of 2.2 m³.

→ **Manometric head of a pump**

As this document focuses on the preliminary design of the pumping system and considering the simplicity and short length of the discharge pipeline, a detailed hydraulic analysis has not been carried out. Instead, a conservative and commonly used approach is adopted for the pre-design phase, based on the sum of the key components (H_G, H_L, H_P) [18]:

- H_G (geodetic heigh), heigh difference between water intake level and discharge point
- H_L, (loses heigh), head losses due to friction in pipes, fittings and valves
- H_P (pressure heigh), minimum pressure head required to ensure correct functioning of the discharge system

Formula: $H_M = H_G$ [m] + H_L [m] + H_P [mWC] (9)

Where:

- H_G (geodetic heigh), adopted value: 7,00 m (habitual range: 5 – 10 m)
- H_L, (loses heigh), estimated as 15% of the geodetic head:

$$H_{losses} = 15\ \% \cdot H_{geodetic} = 1{,}05\ m$$

- H_P (pressure heigh), adopted value: 2,00 m (habitual range: 1 – 2 mWC)

Result: $H_m = H_G + H_L + H_P = 7\ m + 15\ \% \cdot 7\ m + 2\ m = 10{,}05\ mWC$

Result: $H_m = H_G + H_L + H_P = 7\ m + 15\ \% \cdot 7\ m + 2\ m = 10{,}05\ mWC$

1.3. Coarse screening

→ Removal efficiencies and effluent concentrations

During the inlet works and pretreatment stage, there is no substantial removal of pollutant loads in terms of mass. Instead, the process primarily targets the separation of suspended solids, leading to an approximate 10 % reduction in Total Suspended Solids (TSS) concentration [1] [25].

$$SST_{outlet} = SST_{inlet} - SST_{eliminated} = SST_{inlet} - (0{,}1 \cdot SST_{inlet}) = 200 - 0{,}1 \cdot 20 = 180\ mg/L$$

The same procedure is applied during the peak season, resulting in a TSS concentration of approximately 225 mg/L.

→ Total Screen Area

To design the coarse screening grates, the total and effective flow-through areas are calculated. These areas can be determined based on the bar thickness and the flow coefficient. The most conservative value between both seasons options is considered [1].

Formula: TSA [m^2] = Flow Rate [m^3/h] / Velocity [m/s] x K [-] x 1/C [-] (10)

Where:

- F = flow coefficient
- C = clogging coefficient
- L = mesh opening
- G = bar thickness
- v = screen pass velocity (1 m/s) for both seasons

The flow coefficient (F) determines the efficiency of the screens for the passage of liquid and is used to calculate the total space required to ensure the proper functioning of the system [18].

$$F = \frac{L[mm]}{L\ [mm] + G[mm]} = \frac{30mm}{(30+10)mm} = 0{,}75$$

The clogging coefficient C represents the free grate area (as a fraction) for a predetermined level of debris. In urban treatment plants, a 30% clogged grate is typically considered for calculations, and consequently, the value of C in this case is 0,7 [18].

$$TSA = \frac{Q\ [m^3/h]}{V\ [m/s]} \cdot \frac{L[mm] \cdot e[mm]}{L\ [mm]} \cdot \frac{1}{C} = 0{,}024\ m^2$$

→ **Effective Screen Area**

The necessary screen area is calculated considering the bar spacing and flow conditions. It is calculated for both seasons, using the most conservative value [1].

Formula: ESA [m^2] = Total Screen Area [m^2] x (1 – e [mm]) x Coefficient (11)

Where:

- e [mm] = obstruction value (0,40) for both seasons

$$ESA\ = S\ [m^2] \cdot (1 - e\ [mm]) \cdot K[-] = 0{,}024\ m^2 \cdot (1 - 0{,}40\ mm) \cdot 0{,}75 = 0{,}011\ m^2$$

→ **Channel Dimensions**

The required screen height and width are calculated based on the flow rate, the mesh opening, and the desired velocity of water passing through the screen.

The width of the channel is calculated using the relation of H = 1,3 × B [18], where H is the screen height and B is the channel width.

$$Surface = H \cdot B = 1{,}3 \cdot H^2 \rightarrow H = \sqrt{S/1{,}3} = \sqrt{0{,}011^2/1{,}3} = 0{,}135\ m$$

So, the height adopted for both seasons is 0,5 m. Since the height and the width are fixed, it could be calculated the total unitary surface of the channel resulting with 0,052 m^2 in a rectangular geometry.

→ **Screen pass velocity and Head loss**

For each operating condition ($\overline{Q}$, Qmax), the flow velocities through the clean and obstructed grate are calculated, as well as the velocity through the channel and the head loss [18].

Formula:

- Velocity [m/s] = Flow rate [m³/h] / Flow-through area [m²] (12)

Obstructed screen velocity [m/s] $v_1 = \frac{Qmax\ [m^3/h]}{ESA\ [m^2]} = \frac{154{,}30\ m^3/h}{0{,}023 m^2} = 1{,}830\ m/s$

Clean screen velocity [m/s] $v_2 = v_1\ [m/s]\ (1 - e\ [mm]) = 1{,}830\ \cdot (1 - 0{,}40) = 1{,}098\ m/s$

Channel velocity [m/s] $v_3 = \frac{Qmax\ [m^3/h]}{TSA\ [m^2]} = \frac{150{,}30\ m^3/h}{0{,}052\ m^2} = 0{,}823\ m/s$

1.4. Fine screening

Similarly, the total and effective area of the fine screens is calculated. In this case, the thickness of the bars is 8 mm [18], resulting in a flow coefficient of 0,43.

This does not affect the adopted height of the screens, but it does alter the total surface area of the channel, which in this case is 0,09 m².

→ **Screen pass velocity and Head loss calculation**

In the same way, the flow velocities and the estimated head loss are calculated using the same procedure and equations. In this case, fine screens, the values will be higher than in the previous case, as the filtration is also greater [18].

Obstructed screen velocity [m/s] $v_1 = \frac{Qmax\ [m^3/h]}{ESA\ [m^2]} = \frac{150{,}30\ m^3/h}{0{,}023\ m^2} = 1{,}862\ m/s$

Clean screen velocity [m/s] $v_2 = v_1\ [m/s]\ (1 - e\ [mm]) = 1{,}862\ \cdot (1 - 0{,}40) = 1{,}117\ m/s$

Channel velocity [m/s] $v_3 = \frac{Qmax\ [m^3/h]}{TSA\ [m^2]} = \frac{150{,}30\ m^3/h}{0{,}09\ m^2} = 0{,}479\ m/s$

1.5. Equalization tank

The peak flow rate will be used in the design, ensuring that the tank can handle the full incoming flow during higher flow periods, while also accommodating lower flows in winter [19].

Since 24-hour flow variations weren't initially considered, the variability of residual water from an external project was analyzed, and data was extracted to determine the hourly flow evolution. The measured flows are shown in Appendix 2: Detailed Procedure Design, along with the relative percentage compared to the average flow, which will be applied to our case.

The hourly flow for the plant is derived from the average design flow. To do this, the average accumulated volume and the actual accumulated volume have been represented based on the inflow rate over 24 hours.

Table 48 Initial information of Tank

Properties	Units	Low season	Peak season
$\bar{Q}$	m^3/h	20,89	38,58
BOD_5	mg/L	480	600

Table 49 Evolution flow estimation

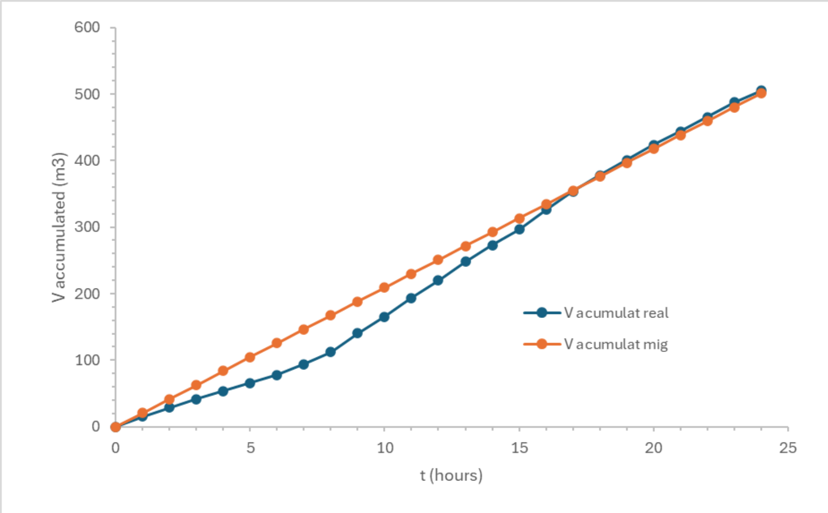
time (h)	Real Flow (m^3/h)	%	Project Flow (m^3/h)
0	3,71	83%	31,84
1	3,23	72%	27,72
2	2,94	65%	25,23
3	2,74	61%	23,52
4	2,62	58%	22,49
5	2,63	59%	22,57
6	2,54	57%	21,80
7	3,57	79%	30,64
8	3,92	87%	33,64
9	6,03	134%	51,75
10	5,34	119%	45,83
11	6,04	134%	51,84
12	5,73	127%	49,18
13	6,07	135%	52,09
14	5,32	118%	45,66
15	5,09	113%	43,68
16	6,41	143%	55,01
17	5,85	130%	50,21
18	5,20	116%	44,63
19	5,01	111%	43,00
20	4,87	108%	41,80
21	4,32	96%	37,07
22	4,70	105%	40,34
23	4,74	105%	40,68
24	3,75	83%	32,18
Medium flow ($\bar{Q}'$) =	4,49	Medium flow ($\bar{Q}$) =	38,58

Table 50 Volume accumulated calculation in low season

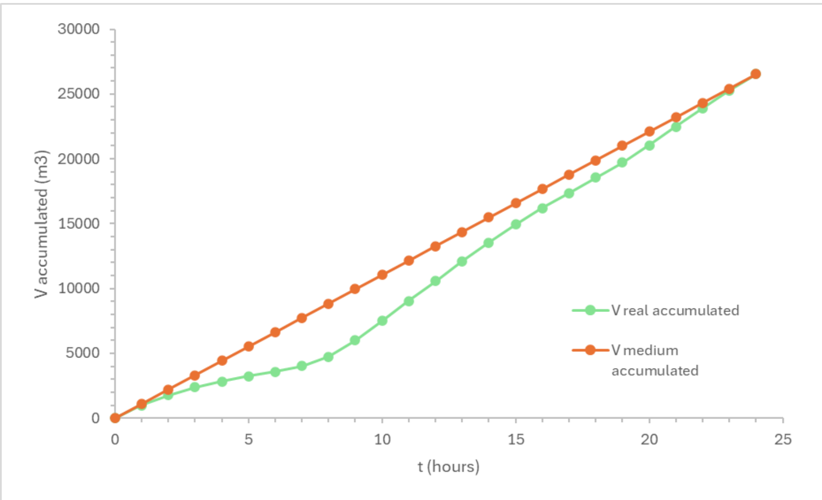
time (h)	Low flow (m^3/h)	Vaccumulated (m^3)	Vmedium (m^3)	$Q - \overline{Q}$	Trapezoids
0	17,24	0	0	3,65	4,7617
1	15,01	15,01	20,885	5,88	6,5506
2	13,66	28,67	41,77	7,22	7,6890
3	12,73	41,40	62,655	8,15	8,4324
4	12,17	53,57	83,54	8,71	8,6880
5	12,22	65,79	104,425	8,66	8,8738
6	11,80	77,60	125,31	9,08	6,6900
7	16,59	94,18	146,195	4,30	3,4839
8	18,21	112,40	167,08	2,67	4,9020
9	28,02	140,42	187,965	7,13	5,5302
10	24,81	165,23	208,85	3,93	5,5535
11	28,06	193,29	229,735	7,18	6,4595
12	26,62	219,92	250,62	5,74	6,5292
13	28,20	248,12	271,505	7,32	5,5767
14	24,72	272,84	292,39	3,83	3,2999
15	23,65	296,49	313,275	2,77	5,8323
16	29,78	326,28	334,16	8,90	7,5979
17	27,18	353,46	355,045	6,30	4,7868
18	24,16	377,62	375,93	3,28	2,8353
19	23,28	400,90	396,815	2,39	2,0686
20	22,63	423,53	417,7	1,74	1,2778
21	20,07	443,60	438,585	0,81	0,8828
22	21,84	465,44	459,47	0,95	1,0464
23	22,02	487,46	480,355	1,14	2,3000
24	17,42	504,89	501,24	3,46	-
Average =	**20,89**			**Total volume =**	**121,65**

Table 51 Volume accumulated calculation in peak season

time (h)	Peak flow (m^3/h)	$V_{accumulated}$ (m^3)	V_{medium} (m^3)	$Q-\bar{Q}$	Trapezoids
0	31,84	0	0	6,74	8,7949
1	27,72	990	1105	10,85	12,0991
2	25,23	1786	2210	13,34	14,2017
3	23,52	2376	3315	15,06	15,5748
4	22,49	2844	4420	16,09	16,0468
5	22,57	3222	5525	16,00	16,3901
6	21,80	3578	6630	16,78	12,3565
7	30,64	4007	7735	7,94	6,4348
8	33,64	4741	8840	4,93	9,0541
9	51,75	6016	9945	13,18	10,2144
10	45,83	7492	11051	7,25	10,2573
11	51,84	9022	12156	13,26	11,9308
12	49,18	10570	13261	10,60	12,0596
13	52,09	12100	14366	13,52	10,3002
14	45,66	13558	15471	7,08	6,0950
15	43,68	14944	16576	5,11	10,7723
16	55,01	16207	17681	16,44	14,0335
17	50,21	17377	18786	11,63	8,8413
18	44,63	18547	19891	6,05	5,2368
19	43,00	19728	20996	4,42	3,8207
20	41,80	21042	22101	3,22	2,3600
21	37,07	22478	23206	1,50	1,6306
22	40,34	23915	24311	1,76	1,9326
23	40,68	25279	25416	2,10	4,2481
24	32,18	26521	26521	6,39	--
Average =	**38,58**			**Total volume =**	**224,69**



Graphic 1 Real Volume and Medium Volume Accumulated Relation (low season)



Graphic 2 Real Volume and Medium Volume Accumulated Relation (peak season)

Table 52 Final results of Equalization Tank Design

Properties	Units	Low season	Peak season
Volume	m^3	200	300
Depth	m	3,00	3,00
Surface	m^2	66,67	100,00

Once represented, it can be observed how the function of the actual accumulated volume deviates from the average value, which forms a straight line; the concentric area between the two functions will give us the value of the required volume. In this way, the volume required for equalization tank is obtained.

Once the surface area and depth are determined, the width is set to a standardized value of 5 meters, and in this way, the length of the tank is calculated. With these dimensions, the geometry of the tank is defined.

Table 53 Tank dimensions

Propriety	Units	Adopted values	Typical tank dimensions [1]
Adopted volume	m^3	300,0	-
Depth	m	3,0	3,0 – 6,0
Length	m	12,5	5,0 – 10,0
Width	m	8,0	10,0 – 30,0

1.6. Membrane bioreactor

Regarding the biological reactor – membrane system, a distinction will indeed be made between flow rates to determine the most suitable configuration when changing seasons. The membrane is located inside the biological reactor, forming a compact submerged MBR system.

→ **Initial data and load calculations**

n this configuration, the total flow considered includes the internal recirculation within the bioreactor to ensure optimal biological performance and avoid concentration gradients. A conservative internal recirculation rate of 100% of the influent flow is assumed in this pre-design phase, not considering sludge wasting or external recycle lines (e.g., from a secondary settler, since the MBR integrates solid-liquid separation).

$$Total\ flow\ with\ recirculation = Q\ [m^3/h] \cdot (1 + \%\ recirculation) = 2Q$$

Table 54 Flows values with recirculation

Proprieties	Units	Low Season	Peak Season
Medium flow ($\bar{Q}$)	m^3/h	20,89	38,58
Medium flow with recirculation ($\overline{Qr}$)	m^3/h	41,77	77,15
Peak flow with recirculation (Qp,r)	m^3/h	83,54	154,30

At this stage of the process, the ratio between soluble BOD and total BOD must be 50%; from this, the soluble BOD at the inlet of the reactor can be calculated [1] [25].

$$Daily\ soluble\ BOD\ load\ [kg/d] = \overline{Qr}\ [m^3/h] \cdot BOD_{solbule}[mg/L] = \overline{Qr} \cdot BOD_{total} \cdot 0{,}5$$

Table 55 BOD values

Proprieties	Units	Low Season	Peak Season
Total BOD	mg/l	240	300
Soluble BOD	mg/l	120	150
Daily soluble BOD load	kg/d	5,01	11,57

→ **Removal efficiencies and effluent concentrations**

In the MBR system, there is a significant reduction of pollutants. The following section presents the reduction percentages for each parameter, along with the corresponding pollutant loads at the inlet and outlet of the MBR. Typical reductions in MBR systems are approximately [1]: 95% for BOD, 99% for COD, 90% for TSS, 65% for TKN, and 50% for phosphorus (P) [25].

Using these reduction rates, the outlet concentrations of contaminants are calculated accordingly. All the results are detailed in section 8 (Adopted Solution).

$$BOD_{outlet} = BOD_{inlet} \cdot (1 - \%\ reduction) = 240 \cdot (1 - 0{,}95) = 12\ mg/L$$

→ **Biological reactor design**

According to von Sperling (1996) [7], for UASB reactors treating domestic sewage, typical values for volumetric load range from 0,5 to 1,2 kg BOD/m³·day, depending on factors such as temperature, hydraulic retention time (HRT), and influent BOD concentration. The adoption of 0,6 kg BOD/m³·day, a conservative volumetric load, ensures greater operational stability, improved organic matter removal, and a reduced risk of organic overload, especially during seasonal variations in load or temperature.

Formula: Volume = BOD_5 [kg/d] / V_L [kg BOD/m³·d]

The adopted volume must ensure operational safety by including a 10% safety factor [1] (VT = V + 10% V). Next, the Hydraulic Retention Time (HRT) is calculated using the following equation:

$$Hydraulic\ Retention\ Time\ [h] = \frac{Total\ volume\ [m^3]}{Flow\ [m^3/h]} \quad (13)$$

This value is recommended to stay between six and twelve hours. A summary table with all the properties results is followed below:

Table 56 Biological reactor properties

Proprieties	Units	Values
Geometry	Rectangular tank	
Surface	m^2	84
Depth	m	6
Volume	m^3	510
Hydraulic Retention Time (HRT)	h	12,18

In MBR systems, the reactor volume can remain constant despite varying flow conditions because the system decouples HRT from Solids Retention Time (SRT). The membrane retains all biomass, allowing the SRT to remain stable while the HRT adjusts according to flow fluctuations. As long as the system operates within the designed parameter ranges, treatment performance remains efficient, making it fully justifiable to use a fixed reactor volume for varying influent flows [1].

Table 57 Typical operating parameters for a MBR [1]

Parameter	Typical Design Range	Remarks
HRT	4 – 12 hours	Depends on influent flow rate and organic load. Decreases with higher flows.
SRT	15 – 30 days	Remains constant regardless of flow, due to complete biomass retention
Membrane flux (J)	15 – 30 $L/m^2 \cdot h$	Varies with membrane type

→ **Required Area Membrane system**

In MBR systems, ultrafiltration (UF) membranes are commonly used due to their ability to retain solids and microorganisms while producing high-quality effluent. They eliminate the need for secondary clarifiers and are well suited for municipal applications where space, reliability, and effluent quality are critical.

The required membrane area is determined using the following formula:

Formula: A = $\overline{Qr}$ [m³/h] / J [L/m²·h] (14)

The design flux membrane (J) is a key parameter representing the filtration rate per unit membrane surface area and is essential for correctly sizing the membrane area in an MBR system. This value typically accounts for [1]:

- Real operating conditions, such as the concentration of solids in the bioreactor
- Fouling control and periodic membrane cleaning
- Long-term system stability

In this case, for a municipal MBR where stable, low-energy operation and fouling control are priorities, submersible membranes have been selected, with a design flux (J) of 20 L/m²·h (0.02 m³/m²·h) [1].

Table 58 Membrane configuration

Proprieties	Units	Low Season	Peak Season
Required membrane unitary area	m²	1050	1930
Nº of needed membrane trains (inside container)	ut.	2	2
Nº of modules needed per train	ut.	2	3
Total of needed modules	ut.	4	6
Total required membrane area	m²	4200	11580

→ **Membranes tank surface**

The design of the membrane tank is based on the peak flow, as this represents the most demanding operating condition for the system [1]. The characteristics of the membrane tanks are listed below; all tanks share the same dimensions:

Table 59 Membranes tanks characteristics

Proprieties	Units	Value
Heigh	m	3,5
Width	m	3,0
Length	m	6,0
Volume	m³	63,0

→ **Aeration system**

The air requirement per membrane area is approximately 0,2 – 0,4 Nm³/h·m² minimum [1], therefore:

Formula: Airflow [$Nm^3/h\cdot m^2$] = Membrane area [m^2] x air per m^2 (15)

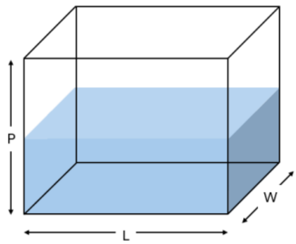
Table 60 Aeration characteristics

Proprieties	Units	Low Season	Peak Season	Range [1]
Air system		Blowing positive displacement type		
Cleaning Minimum Airflow	$Nm^3/h\cdot m^2$	315	579	386 - 772
Nº of blowers	ut.	3	3	(2+1)
Airflow per blower	Nm^3/h	894	894	

1.7. Effluent collection chamber

→ **Volume and useful Surface of the chamber**

To calculate the volume of the plant's final clarifier chamber, the maximum outlet flow rate must be considered, assuming a 10% reduction due to sludge removal and evaporation, and the hydraulic retention time (HRT), which ranges between 15 and 30 minutes to ensure proper homogenization [10].



$$Qoutlet \sim 154{,}30\ m^3/h \cdot (1-0{,}1) = 138{,}9\ m^3/h$$

In the low season case, also assuming a 10% reduction [10], the outlet flow rate is 75,19 m^3/h.

Formula:

- Volume [m^3] = Outlet flow rate [m^3/h] × HRT [h] (16)
- Surface [m^2] = Longitude [m] × Width [m] (17)

$$V = Qoutlet \cdot HRT = 138{,}6\ m^3/h \cdot 0{,}5 = 69{,}45\ m^3$$

By fixing the depth at approximately 3 m, a surface area of 25 m^2 is adopted. Since the tank is square-shaped, the dimensions are 5 × 5 × 3 m.

2. SLUDGE LINE

As previously described, a submerged MBR system with ultrafiltration membranes has been selected for this project, due to its compact configuration and high effluent quality.

Based on this design choice, the required membrane surface area is calculated below using the average flow and selected design flux.

2.1. Sludge production

To calculate sludge production, a ratio of the suspended solids removed is used; this value depends on the technology applied. In this case, sludge is generated at a rate of 0,8 kg TSS/kg BOD_5 removed [1]. The amount of BOD_5 removed is calculated as:

$$BOD_{5\ eliminated} = (BOD_{max-inlet} - BOD_{outlet})[kg/d] \cdot \bar{Q}[m^3/h] \quad (16)$$

Therefore, the total sludge production, which is equivalent to the production of secondary sludge since there is no primary treatment, is:

$$Sludge\ production = BOD_{eliminated}[kg/d] \cdot SG\ [kgTSS/kgBOD_5\ removed] \quad (17)$$

Considering that the concentration of sludge leaving the MBR is 0,01% by mass [18], the sludge volume can also be determined

$$Volume = Sludge\ production\ [kgTSS/d] \cdot C_{sludge}[\%] \quad (18)$$

The table below shows the results of all these preliminary calculations.

Table 61 Sludge production characteristics

Proprieties	Units	Low Season	Peak Season
BOD_5 eliminated	kg/d	114,28	263,85
Production	kg STT/d	91,43	211,08
Volume	m^3	9,14	21,11

2.2. Sludge recirculation

A recirculation ratio of 1,5% is used [18], so recirculation flow rates ($\overline{Qsr}$) are:

$$\overline{Qsr}[m^3/h] = \bar{Q}[m^3/h] \cdot R[\%] = 20{,}89 \cdot 1{,}5\% = 31{,}33\ m^3/h$$

The same procedure is followed for peak season values, which leads to 57,86 m^3/h.

2.3. Sludge purge

The daily sludge purge flow rate is calculated based on its production and the mass concentration it must have to be purged (8 kg/m³) as follows [18]:

$$Qp[m^3/d] = \frac{Sludge\ producction\ [kg\ SST/d]}{Concentration\ [kg/m^3]} \quad (19)$$

To calculate the hourly sludge flow to be purged, a working day is fixed on 8 hours per day [1]. Below is a table with all the obtained values.

Table 62 Sludge purge flow rates

Proprieties	Units	Low Season	Peak Season
Qpurge	m^3/d	11,43	26,39
	m^3/h	1,43	3,30

2.4. Thickener

For the design of the thickener, the diameter and cylindrical height are defined to calculate its total surface area and volume.

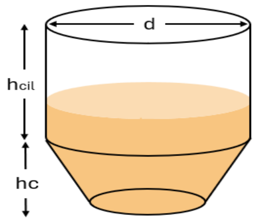


Figure 15 Thickener geometry

The influent flow to the thickener is calculated based on the sludge production and the concentration, which is 10 kg/m³ for thickened sludge [1]:

$$Thickener\ flow[m^3/h] = Sludge\ production\ [kgTSS/d] \cdot C_{sludge}[kg/m^3] \quad (20)$$

The calculated flow rates are 9,14 m³/h and 21,11 m³/h for the low and high seasons, respectively.

The geometry is similar to that used for the coarse solids pit; in this case, the thickener consists of a cylinder topped by a cone. The diameter and both heights are fixed as follows:

$$Conical\ Volume = \frac{1}{3} \cdot \pi \cdot R^2 \cdot H_c = \frac{1}{3} \cdot \pi \cdot (2)^2 \cdot 1 = 4\ m^3$$

$$Cilindrical\ Volume = \pi \cdot R^2 \cdot H_{cil} = \pi \cdot (2)^2 \cdot 1 = \ 38\ m^3$$

Given the seasonal variation in sludge production, the most conservative approach is adopted by using the highest value observed during the high season:

$$Surface\ charge = \frac{Qp\ [m^3/h]}{Surface\ [m^2]} = \frac{26{,}39 m^3/h}{13\ m^2} = 2{,}10\ m^3/m^2/h$$

$$Solids\ charge = \frac{Sludge\ production\ [kgTSS/d]}{Surface\ [m^2]} = \frac{211{,}08\ kgTSS/d}{13\ m^2} = 16{,}80\ kg/m^2/d$$

Only the cylindrical surface area is considered in these calculations to ensure a safer and more conservative design. The conical section serves primarily for sludge accumulation and concentration, not for the initial solids separation. Although the base is conical, the rest of the design procedures remain the same. The results are presented in the next section, 8. Adopted Solution.

2.5. Planted drying bed

Sludge production is calculated in terms of dry solids per calendar day, based on the biological treatment performance and pollutant loads. However, since sludge handling (e.g., extraction, transport, or treatment) is typically carried out only during working days, it is necessary to convert this production into a managed amount per working day.

$$Sludge\ production\ (natural\ day) = Sludge\ production\ \left[\frac{kgTSS}{d}\right] \cdot \frac{natural\ d}{worked\ d} = 91{,}4\frac{kg}{d}$$

A weekly working schedule of 5 days/week is assumed. Therefore, the sludge mass to be managed per working day is:

$$Managed\ sludge = Production\left[\frac{kgTSS}{d}\right] \cdot \frac{natural\ d}{worked\ d} = 91{,}4\frac{kg}{d} \cdot \frac{7\ days}{5\ days} = 128\ kg\ TSS/working\ day$$

Knowing the hours and days worked per week and the total solids content, the natural and working daily sludge volumes can be calculated as follows:

$$Sludge\ Volume = \frac{Sludge\ weight\ [kg/d]}{Solid\ content\ [kg/m^3]} = \frac{91{,}4\ kg/d}{30\ kg/m^3} = 3{,}05\ m^3/d$$

The same procedure applied to the peak season results in 295,5 kg/d and 7,04 m³/d.

In the dewatering process, the required surface area must be calculated, and for this, the surface loading rate used for design is needed; from the table below, we can obtain the number of beds PDB is required:

Table 63 Number of beds per P.E. (Planted Drying Bed) [18]

PE	CC o AG	CC o AG	AG
≤ 2.000	4 beds	6 beds	8 beds
2.000 - 10.000	X	6 beds	8 beds
10.000 - 20.000	X	X	8 beds
≥ 20.000	X	X	≥ 10 beds

CC = concentrate chamber, AG = above ground

A surface loading rate of 40 kg TSS/m²/year is used for 8 cells [36]. Using these values, the required surface area and necessary dimensions for the PDB system can be calculated. In this design, 4 cells are used during the low season and 8 cells during the peak season, maintaining the same total membrane surface area. The PDB system characteristics are listed below:

Table 64 Planted Drying System Characteristics

Proprieties	Units	Low Season	Peak Season
Surface loading for design	kg TSS/m²/year	40	40
Required surface area	m²	1285	2967
Nº of needed cells	ut.	4	8
Unitary surface needed	m²	322	370
Width	m	7,0	7,0
Length	m	46,0	53,0
Depth	m	2,2	2,2

2.6. Compost production

It is assumed that after composting, the total mass reduces by approximately 50–60% [1], and the final compost has a bulk density of around 0,7 to 0,9 tonnes per cubic metre [1]. In this case, assuming a 60% reduction in mass and a density of 0,8 t/m³, the final compost output for the larger scenario (peak season) would be 53,9 m³/year. The calculation is as follows:

$$Annual\ Volume = \frac{Thickened\ sludge\ reduced}{density} = \frac{0{,}6 \cdot 107{,}86\ kg/year}{800\ kg/m^3} = 53{,}9\ m^3/year$$

Although the annual production is 53.9 m^3, this volume does not accumulate all at once. The compost is generated gradually throughout the year, and extraction can often be carried out in a staggered or partial manner [1]. Therefore, a 25 m^3 roll-off container—approximately half of the total annual production—has been selected for storage, paired with a fixed concrete storage area of similar capacity and a roof cover. This sizing reflects the expected accumulation between periodic extractions, ensuring sufficient capacity while avoiding oversizing the storage.

APPENDIX 4: MATHEMATICAL PROCESS FOR PIPING

This appendix summarizes the hydraulic calculation procedures applied for pipeline sizing in the WWTP project, even though no specific simulations are performed at this stage. The methods are based on classical hydraulics and follow design guidelines from CEDEX [23] and standard academic references such as Tchobanoglous et al. [24], ensuring the technical consistency of the preliminary design. These include the Bernoulli equation for pressurized conduits, the Darcy-Weisbach formulation for head losses, and Manning's equation for gravity flow conduits.

Application of Classical Hydraulic Models

The basic equation used for all steady state pressurized hydraulic calculations is the energy conservation equation, or Bernoulli's equation (21), adapted to the basic assumptions of pressurized flow. It expresses that the total energy relative to a horizontal reference plane remains constant between sections of a conduit, although the individual components of energy may vary between sections.

$$z_i + \frac{P_i}{\gamma} + \frac{v_i^2}{2 \cdot g} = z_{i+1} + \frac{P_{i+1}}{\gamma} + \frac{v_{i+1}^2}{2 \cdot g} + \Delta h_{i \to i+1} \quad (21)$$

Where:

- z_i (m), geometric elevation of the invert at section i
- P_i (kg/m2), gauge pressure at section i
- v_i (m/s), average velocity at cross-section i
- γ (kg/m3), specific weight of the fluid
- g (m/s2), gravitational acceleration
- $\Delta h_{i \to i+1}$ (m), energy loss between sections i and i+1

Energy losses between sections i and i+1 are of two types:

- Continuous losses (h_C), caused by friction along the pipe

- Localized losses (h_L), caused by local phenomena such as changes in alignment or cross-section, inlet/outlet effects, or elements like valves or branches

$$\Delta h_{i\rightarrow i+1} = h_C + h_L \quad (22)$$

Continuous head losses

Continuous head losses are expressed as the product of the unit head loss (j) and the pipe length (L):

$$h_C = j \cdot L \quad (23)$$

The unit head loss by friction is given by the Darcy-Weisbach equation:

$$j = \frac{f}{D} \cdot \frac{v^2}{2 \cdot g} \quad (24)$$

Where:

- j (mWC/m), unit head loss
- D (m), internal pipe diameter
- v (m/s), flow velocity
- g (m/s2), gravitational acceleration
- f (-), friction factor

The friction factor f is calculated depending on the type of flow, i.e., on the Reynolds number. For fully developed turbulent flow (Re>4000), the friction factor is estimated using:

$$Re = \frac{v \cdot D}{\mu} = \frac{\left(4 \cdot \frac{Q}{\pi \cdot D^2}\right) \cdot D}{\mu} = \frac{4 \cdot Q}{\pi \cdot D \cdot \mu} \quad (25)$$

Where:

- Q (m^3/s), peak flow rate in the pipe
- μ (m2/s), kinematic viscosity

Kinematic viscosity is temperature-dependent, so the lowest (most conservative) temperature expected at the plant (15 °C) is used:

$$\mu = \frac{0{,}0178}{10.000 + 337 \cdot T + 2{,}21 \cdot T^2} = 1{,}14 \cdot 10^{-6}\ m^2/s$$

$$\frac{1}{\sqrt{f}} = -2 \cdot \log\left(\frac{\varepsilon/D}{3{,}7} + 2{,}57/\mu \cdot \sqrt{f}\right) \quad (26)$$

Where:

- ε (mm), absolute roughness

Given the safety margin in design, a roughness of 0.1 mm is considered for new pipes.

Localized Head Losses

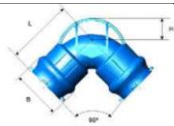
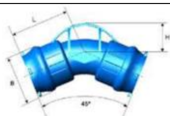
Localized head losses are calculated using:

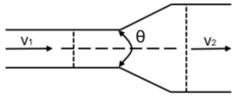
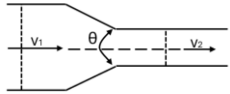
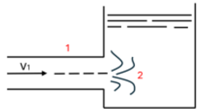
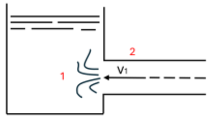
$$h_L = K \cdot \frac{v^2}{2 \cdot g} \quad (27)$$

Where:

- K (-), loss coefficient

Each type of localized element has its specific K value, following manufacturer specifications and CEDEX guidelines for pressurized water transport.

Equipment	Loss charge located (K)	Figure
Check valve (totally open)	2,00	
Gate valve (totally gate)	0,20	
T	1,80	
90º elbow, standard radius	0,75	
45º elbow, standard radius	0,40	

Gradual expansion, according to Gibson	$1-\frac{D_1^4}{D_2^4}$	
Gradual contraction	$1-\frac{D_2^4}{D_1^4}$	
Outlet	1	
Inlet	1	

Orifices

Hydraulic head across orifices (e.g., submerged passages or gates) is calculated as:

$$Q = C_w \cdot A_o \cdot \sqrt{2 \cdot g \cdot h} \quad (28)$$

Where:

- Cw (-), discharge coefficient (typically 0.62 for thin-walled orifices)
- Ao (m2), area of the orifice

Free-surface flow conduits

For gravity conduits with steady uniform flow, Manning's equation is used:

$$v = \frac{1}{n} \cdot Rh^{2/3} \cdot 1^{1/2} \quad (29)$$

For rectangular channels:

$$Rh = \frac{b \cdot y}{b + 2 \cdot y} \quad (30) \qquad v = \frac{Q}{b \cdot y} \quad (31)$$

Where:

- v (m/s), fluid velocity
- n (-), Manning's coefficient (0.015 for concrete)
- Rh (-), hydraulic radius

- I (m/m), channel slope
- b (m), channel width
- y (m), flow depth
- Q (m3/s), flow rate

Combining equations (20) (30) and (31), it obtains equation 31:

$$\frac{Q}{b \cdot y} = \frac{1}{n} \cdot \left(\frac{b \cdot y}{b + 2 \cdot y}\right)^{2/3} \cdot I^{1/2} \quad (32)$$

The uniform regime is verified, and the head loss is calculated as the slope times the length.

APPENDIX 5: LIST OF EQUIPMENT, INSTRUMENTATION AND VALVES

WWTP PROJECT - EQUIPMENT LIST

Nº PLAN	WWTP	ZONE	PROCESS	EQUIPMENT	Nº	CODE TAG	DESCRIPTION (EQUIPMENT + FUNCTION)
ARRIVAL AND RAW WATER PUMPING							
							COARSE SCREENING CHAMBER
							CLAMSHELL BUCKET
4.01	DBEG-A2	AE	01	CB00	001	DBEG-A2_AE01_CB00_001	Recollida de solids voluminosos
							HOIST
4.01	DBEG-A2	AE	01	PL00	001	DBEG-A2_AE01_PL00_001	Existing clamshell bucket
							COARSE WASTE CONTAINER
4.01	DBEG-A2	AE	01	CT00	001	DBEG-A2_AE01_CT00_001	Emmagatzematge dels sòlids
							COARSE SCREENING INLET TO PUMPING
							AUTOMATIC CHANNEL GATE
4.01	DBEG-A2	AE	02	CPCM	001	DBEG-A2_AE02_CPCM_001	Main channel
4.01	DBEG-A2	AE	02	CPCM	002	DBEG-A2_AE02_CPCM_002	Main channel
4.01	DBEG-A2	AE	02	CPCM	003	DBEG-A2_AE02_CPCM_003	Bypass channel
4.01	DBEG-A2	AE	02	CPCM	004	DBEG-A2_AE02_CPCM_004	Bypass channel
							SELF-CLEANING SCREEN
4.01	DBEG-A2	AE	02	RXA0	001	DBEG-A2_AE02_RXA0_001	Filtratge i desbast d'aigua
							WASTE SCREW CONVEYOR
4.01	DBEG-A2	AE	02	CGT0	001	DBEG-A2_AE02_CGT0_001	Waste transport
							COARSE WASTE CONTAINER
4.01	DBEG-A2	AE	02	CT00	001	DBEG-A2_AE02_CT00_001	Waste storage
							MANUAL SCREEN
4.01	DBEG-A2	AE	02	RX0M	001	DBEG-A2_AE02_RX0M_001	Filtratge manual
							GRAEASE COLLECTION BASKET
4.01	DBEG-A2	AE	02	CGE0	001	DBEG-A2_AE02_CGE0_001	Waste storage
							INLET PUMPING STATION
							SUBMERSIBLE PUMPS
4.01	DBEG-A2	AE	03	BS00	001	DBEG-A2_AE03_BS00_001	Wastewater pumping
4.01	DBEG-A2	AE	03	BS00	002	DBEG-A2_AE03_BS00_002	Wastewater pumping
4.01	DBEG-A2	AE	03	BS00	003	DBEG-A2_AE03_BS00_003	Wastewater pumping
							HOIST
4.01	DBEG-A2	AE	03	PL00	001	DBEG-A2_AE03_PL00_001	Transport and maintenance
							FLOWMETER DISMANTLING WHEEL
4.01	DBEG-A2	AE	03	RD00	001	DBEG-A2_AE03_RD00_001	Transport and maintenance
							OVERFLOW/BYPASS PEAK FLOW AT INLET
							AUTOMATIC BYPASS GATE
4.01	DBEG-A2	AE	04	CPCA	001	DBEG-A2_AE04_CPCA_001	Bypass channel
PRETREATMENT							
							SCREENING
							AUTOMATIC CHANNEL GATE
4.01	DBEG-A2	PR	01	CPCM	001	DBEG-A2_PR01_CPCM_001	Main channel
4.01	DBEG-A2	PR	01	CPCM	002	DBEG-A2_PR01_CPCM_002	Main channel
4.01	DBEG-A2	PR	01	CPCM	003	DBEG-A2_PR01_CPCM_003	Main channel
4.01	DBEG-A2	PR	01	CPCM	004	DBEG-A2_PR01_CPCM_004	Main channel

							AUTOMATIC COARSE WASTE SCREEN
4.01	DBEG-A2	PR	01	RXAM	001	DBEG-A2_PR01_RXAM_001	Coarse screening
4.01	DBEG-A2	PR	01	RXAM	002	DBEG-A2_PR01_RXAM_002	Coarse screening
							FINE BAR SCREEN
4.01	DBEG-A2	PR	01	TMDB	001	DBEG-A2_PR01_TMDB_001	Fine screening
4.01	DBEG-A2	PR	01	TMDB	002	DBEG-A2_PR01_TMDB_002	Fine screening
							WASTE SCREW CONVEYOR
4.01	DBEG-A2	PR	01	CTP0	001	DBEG-A2_PR01_CTP0_001	Waste transport
4.01	DBEG-A2	PR	01	CTP0	002	DBEG-A2_PR01_CTP0_002	Waste transport
4.01	DBEG-A2	PR	01	CTP0	003	DBEG-A2_PR01_CTP0_003	Waste transport
4.01	DBEG-A2	PR	01	CTP0	004	DBEG-A2_PR01_CTP0_004	Waste transport
4.01	DBEG-A2	PR	01	CTP0	005	DBEG-A2_PR01_CTP0_005	Waste transport
							COMPACTOR PRESS
4.01	DBEG-A2	PR	01	PSC0	001	DBEG-A2_PR01_PSC0_001	Waste reduced volume
							COARSE WASTE CONTAINER
4.01	DBEG-A2	PR	01	CT00	001	DBEG-A2_PR01_CT00_001	Waste storage
							OVERFLOW/BYPASS PEAK FLOW AT INLET
							AUTOMATIC BYPASS GATE
4.01	DBEG-A2	PR	02	CPCA	005	DBEG-A2_PR02_CPCA_005	Bypass channel
4.01	DBEG-A2	PR	02	CPCA	006	DBEG-A2_PR02_CPCA_006	Bypass channel
							MANUAL SCREEN
4.01	DBEG-A2	PR	02	RX0M	001	DBEG-A2_PR02_RX0M_001	Coarse screening
							GREASE COLLECTION BASKET
4.01	DBEG-A2	PR	02	CGE0	001	DBEG-A2_PR02_CGE0_001	Waste storage
PRIMARY TREATMENT							
							EQUALIZATIN TANK
							AUTOMATIC CHANNEL GATE
4.01	DBEG-A2	DP	01	CPCM	001	DBEG-A2_DP01_CPCM_001	Main channel
4.01	DBEG-A2	DP	01	CPCM	002	DBEG-A2_DP01_CPCM_002	Main channel
4.01	DBEG-A2	DP	01	CPCM	005	DBEG-A2_DP01_CPCM_005	Main channel
							VERTICAL HELICAL AGITATORS
4.01	DBEG-A2	DP	01	AG00	001	DBEG-A2_DP01_AG00_001	Homogeneització del tanc
4.01	DBEG-A2	DP	01	AG00	002	DBEG-A2_DP01_AG00_002	Homogeneització del tanc
							SUBMERSIBLE PUMPS
4.01	DBEG-A2	DP	01	BS00	001	DBEG-A2_DP01_BS00_001	Impulsió d'aigua
4.01	DBEG-A2	DP	01	BS00	002	DBEG-A2_DP01_BS00_002	Impulsió d'aigua
4.01	DBEG-A2	DP	01	BS00	003	DBEG-A2_DP01_BS00_003	Impulsió d'aigua
							OVERFLOW/BYPASS PEAK FLOW AT INLET
							AUTOMATIC BYPASS GATE
4.01	DBEG-A2	DP	02	CPCM	003	DBEG-A2_DP02_CPCM_003	Bypass channel
4.01	DBEG-A2	DP	02	CPCM	004	DBEG-A2_DP02_CPCM_004	Bypass channel
							FLOWMETER DISMANTLING WHEEL
4.01	DBEG-A2	DP	03	RD00	001	DBEG-A2_DP03_RD00_001	Transport and maintenance
BIOLOGICAL TREATMENT							
							BIOLOGICAL REACTOR
							DIFFUSER GRID
4.02	DBEG-A2	TS	01	DABF	001	DBEG-A2_TS01_DABF_001	Air distribution
							BLOWERS
4.02	DBEG-A2	TS	01	BUF0	001	DBEG-A2_TS01_BUF0_001	Air inlet
4.02	DBEG-A2	TS	01	BUF0	002	DBEG-A2_TS01_BUF0_002	Air inlet
							HANDWHEELS
4.02	DBEG-A2	TS	01	MNG0	001	DBEG-A2_TS01_MNG0_001	Blowers vibration reduction

4.02	DBEG-A2	TS	01	MNG0	002	DBEG-A2_TS01_MNG0_002	Blowers vibration reduction
4.02	DBEG-A2	TS	01	MNG0	003	DBEG-A2_TS01_MNG0_003	Blowers vibration reduction
							VERTICAL HELICAL AGITATORS
4.02	DBEG-A2	TS	01	AG00	001	DBEG-A2_TS01_AG00_001	Homogeneization
4.02	DBEG-A2	TS	01	AG00	002	DBEG-A2_TS01_AG00_002	Homogeneization
							SUBMERSIBLE PUMPS
4.02	DBEG-A2	TS	01	BS00	001	DBEG-A2_TS01_BS00_001	Impulsió d'aigua
4.02	DBEG-A2	TS	01	BS00	002	DBEG-A2_TS01_BS00_002	Impulsió d'aigua
							MEMBRANE SYSTEM
							MEMBRANE TANK
4.02	DBEG-A2	TS	02	DPMB	001	DBEG-A2_TS02_DPMB_001	Tank 1
4.02	DBEG-A2	TS	02	DPMB	002	DBEG-A2_TS02_DPMB_002	Tank 2
4.02	DBEG-A2	TS	02	DPMB	003	DBEG-A2_TS02_DPMB_003	Tank 3
							MEMBRANE MODULE
4.02	DBEG-A2	TS	02	MMB0	001	DBEG-A2_TS02_MMB0_001	Tank 1
4.02	DBEG-A2	TS	02	MMB0	002	DBEG-A2_TS02_MMB0_002	Tank 1
4.02	DBEG-A2	TS	02	MMB0	003	DBEG-A2_TS02_MMB0_003	Tank 2
4.02	DBEG-A2	TS	02	MMB0	004	DBEG-A2_TS02_MMB0_004	Tank 2
4.02	DBEG-A2	TS	02	MMB0	005	DBEG-A2_TS02_MMB0_005	Tank 3
4.02	DBEG-A2	TS	02	MMB0	006	DBEG-A2_TS02_MMB0_006	Tank 3
							DIFFUSER GRID
4.02	DBEG-A2	TS	02	DABF	001	DBEG-A2_TS02_DABF_001	Air distribution
4.02	DBEG-A2	TS	02	DABF	002	DBEG-A2_TS02_DABF_002	Air distribution
4.02	DBEG-A2	TS	02	DABF	003	DBEG-A2_TS02_DABF_003	Air distribution
4.02	DBEG-A2	TS	02	DABF	004	DBEG-A2_TS02_DABF_004	Air distribution
4.02	DBEG-A2	TS	02	DABF	005	DBEG-A2_TS02_DABF_005	Air distribution
4.02	DBEG-A2	TS	02	DABF	006	DBEG-A2_TS02_DABF_006	Air distribution
							BLOWERS
4.02	DBEG-A2	TS	02	BUF0	001	DBEG-A2_TS02_BUF0_001	Air inlet
4.02	DBEG-A2	TS	02	BUF0	002	DBEG-A2_TS02_BUF0_002	Air inlet
							HANDWHEELS
4.02	DBEG-A2	TS	02	MNG0	001	DBEG-A2_TS02_MNG0_001	Blowers vibration reduction
4.02	DBEG-A2	TS	02	MNG0	002	DBEG-A2_TS02_MNG0_002	Blowers vibration reduction
4.02	DBEG-A2	TS	02	MNG0	003	DBEG-A2_TS02_MNG0_003	Blowers vibration reduction
4.02	DBEG-A2	TS	02	MNG0	004	DBEG-A2_TS02_MNG0_004	Blowers vibration reduction
4.02	DBEG-A2	TS	02	MNG0	005	DBEG-A2_TS02_MNG0_005	Blowers vibration reduction
4.02	DBEG-A2	TS	02	MNG0	006	DBEG-A2_TS02_MNG0_006	Blowers vibration reduction
4.02	DBEG-A2	TS	02	MNG0	007	DBEG-A2_TS02_MNG0_007	Blowers vibration reduction
4.02	DBEG-A2	TS	02	MNG0	008	DBEG-A2_TS02_MNG0_008	Blowers vibration reduction
							SLUDGE RECIRCULATION
							SUBMERSIBLE PUMPS
4.02	DBEG-A2	TS	03	BS00	001	DBEG-A2_TS03_BS00_001	Wastewater pumping
4.02	DBEG-A2	TS	03	BS00	002	DBEG-A2_TS03_BS00_002	Wastewater pumping
							SLUDGE PURGA
							SUBMERSIBLE PUMPS
4.02	DBEG-A2	TS	04	BS00	001	DBEG-A2_TS04_BS00_001	Reactor extraction
4.02	DBEG-A2	TS	04	BS00	002	DBEG-A2_TS04_BS00_002	Reactor extraction
4.02	DBEG-A2	TS	04	BS00	003	DBEG-A2_TS04_BS00_003	Membrane system extraction
4.02	DBEG-A2	TS	04	BS00	004	DBEG-A2_TS04_BS00_004	Membrane system extraction
							FLOWMETER DISMANTLING WHEL
4.02	DBEG-A2	TS	04	RD00	001	DBEG-A2_TS04_RD00_001	Transport and maintenance
							CHEMICAL CLEANING SYSTEM
							CHEMICAL PRODUCT TANK

4.02	DBEG-A2	TS	05	DP00	001	DBEG-A2_TS05_DP00_001	Sodium hypochlorite
4.02	DBEG-A2	TS	05	DP00	002	DBEG-A2_TS05_DP00_002	Cítric acid
							CENTRIFUGAL PUMPS FOR CHEMICAL PRODUCT
4.02	DBEG-A2	TS	05	BC00	001	DBEG-A2_TS05_BC00_001	Chemical inlet flow
4.02	DBEG-A2	TS	05	BC00	002	DBEG-A2_TS05_BC00_002	Chemical inlet flow
							BIDIRECTIONAL SUBMERSIBLE PUMP
4.02	DBEG-A2	TS	05	BSDB	001	DBEG-A2_TS05_BSDB_001	Chemical cleaning control system
							OVERFLOW/BYPASS PEAK SECONDARY FLOW
							AUTOMATIC CHANNEL GATE
4.02	DBEG-A2	TS	06	CPCM	001	DBEG-A2_TS06_CPCM_001	Bypass channel
TREATED WATER							
							TREATED WATER PRESENTATION
							FLOWMETERDISMANTLING WHEEL
4.02	DBEG-A2	AT	01	RD00	001	DBEG-A2_AT01_RD00_001	Transport and maintenance
SLUDGE TREATMENT							
							GRAVITY THICKENING
							ROTATING SCRAPER ARM
4.03	DBEG-A2	EF	01	BRR0	001	DBEG-A2_EF01_BRR0_001	Thickener homogenization
							HELICOIDAL SCREW PUMP
4.03	DBEG-A2	EF	02	BCGH	001	DBEG-A2_EF02_BCGH_001	Sludge pumping
4.03	DBEG-A2	EF	02	BCGH	002	DBEG-A2_EF02_BCGH_002	Sludge pumping
							SUBMERSIBLE PUMPS
4.03	DBEG-A2	EF	03	BS00	001	DBEG-A2_EF03_BS00_001	Leachate extraction
4.03	DBEG-A2	EF	03	BS00	002	DBEG-A2_EF03_BS00_002	Leachate extraction
							PLANTED DYING BED SYSTEM
							PLANTED DYING BED TANKS
4.03	DBEG-A2	DE	01	TRZ0	001	DBEG-A2_DE01_TRZ0_001	Composting process space
4.03	DBEG-A2	DE	01	TRZ0	002	DBEG-A2_DE01_TRZ0_002	Composting process space
4.03	DBEG-A2	DE	01	TRZ0	003	DBEG-A2_DE01_TRZ0_003	Composting process space
4.03	DBEG-A2	DE	01	TRZ0	004	DBEG-A2_DE01_TRZ0_004	Composting process space
4.03	DBEG-A2	DE	01	TRZ0	005	DBEG-A2_DE01_TRZ0_005	Composting process space
4.03	DBEG-A2	DE	01	TRZ0	006	DBEG-A2_DE01_TRZ0_006	Composting process space
4.03	DBEG-A2	DE	01	TRZ0	007	DBEG-A2_DE01_TRZ0_007	Composting process space
4.03	DBEG-A2	DE	01	TRZ0	008	DBEG-A2_DE01_TRZ0_008	Composting process space
							COMPOST STORAGE
							BACKHOE
4.03	DBEG-A2	DE	01	RECP	001	DBEG-A2_DE01_RECP_001	Compost extraction
							CONTAINER
4.03	DBEG-A2	DE	02	CT00	001	DBEG-A2_DE02_CT00_001	Compost storage

WWTP PROJECT - INSTRUMENTATION LIST

Nº PLAN	WWTP	ZONE	PROCESS	EQUIPMENT	Nº	CODE TAG	LOCATION	INSTRUMENTATION
ARRIVAL AND RAW WATER PUMPING								
							COARSE SCREENING CHAMBER	
4.01	DBEG-A2	AE	01	LIT0	001	DBEG-A2_AE01_LIT0_001	Coarse screening overflow	Level Indicator Transmitter
							OVERFLOW/BYPASS PEAK FLOW	
4.01	DBEG-A2	AE	02	LSH0	001	DBEG-A2_AE02_LSH0_001	Bypass channel	Level Switch High
							INLET PUMPING STATION	
4.01	DBEG-A2	AE	03	LSHH	001	DBEG-A2_AE03_LSHH_001	Security sensor	Level Switch High High
4.01	DBEG-A2	AE	03	LSH0	001	DBEG-A2_AE03_LSH0_001	Màximum sensor	Level Switch High
4.01	DBEG-A2	AE	03	LS00	001	DBEG-A2_AE03_LS00_001	Start up sensor	Level Switch
4.01	DBEG-A2	AE	03	LS00	002	DBEG-A2_AE03_LS00_002	Start upt sensor	Level Switch
4.01	DBEG-A2	AE	03	LSL0	001	DBEG-A2_AE03_LSL0_001	Minimum sensor	Level Switch Low
4.01	DBEG-A2	AE	03	PLC0	001	DBEG-A2_AE03_PLC0_001	Submersibles pumps controler	Programmable Logic Controller
4.01	DBEG-A2	AE	03	LIT0	001	DBEG-A2_AE03_LIT0_001	Inlet pumping station	Level Indicator Transmitter
4.01	DBEG-A2	AE	03	FIT0	001	DBEG-A2_AE03_FIT0_001	Inlet pumping station	Flow Indicator Transmitter
							OVERFLOW/BYPASS PEAK FLOW	
4.01	DBEG-A2	AE	03	LSH0	002	DBEG-A2_AE03_LSH0_002	Bypass channel	Level Switch Low
PRETREATMENT								
							SCREENING	
4.01	DBEG-A2	PR	01	LIT0	001	DBEG-A2_PR01_LIT0_001	Coarse screening	Level Indicator Transmitter
4.01	DBEG-A2	PR	01	LIT0	002	DBEG-A2_PR01_LIT0_002	Coarse screening	Level Indicator Transmitter
							OVERFLOW/BYPASS PEAK FLOW AT INLET	
4.01	DBEG-A2	PR	01	LSH0	001	DBEG-A2_PR01_LSH0_001	Bypass channel	Level Switch High
PRIMARY TREATMENT								
							EQUALIZATIN TANK	
4.01	DBEG-A2	DP	01	LSHH	001	DBEG-A2_DP01_LSHH_001	Security sensor	Level Switch High High
4.01	DBEG-A2	DP	01	LSH0	001	DBEG-A2_DP01_LSH0_001	Màximum sensor	Level Switch High
4.01	DBEG-A2	DP	01	LS00	001	DBEG-A2_DP01_LS00_001	Start up sensor	Level Switch
4.01	DBEG-A2	DP	01	LSL0	001	DBEG-A2_DP01_LSL0_001	Minimum sensor	Level Switch Low
4.01	DBEG-A2	DP	01	PLC0	001	DBEG-A2_DP01_PLC0_001	Submersibles pumps controler	Programmable Logic Controller
4.01	DBEG-A2	DP	01	LIT0	001	DBEG-A2_DP01_LIT0_001	Equalization tank	Level Indicator Transmitter

								OVERFLOW/BYPASS PEAK FLOW
4.01	DBEG-A2	DP	02	LSH0	001	DBEG-A2_DP02_LSH0_001	Bypass channel	Level Switch high
4.01	DBEG-A2	DP	03	FIT0	001	DBEG-A2_DP03_FIT0_001	Primary treatment outlet	Flow Indicator Transmitter
						BIOLOGICAL TREATMENT		
								BIOLOGICAL REACTOR
4.02	DBEG-A2	TS	01	AIT0	001	DBEG-A2_TS01_AIT0_001	Biological reactor	Oxygen sensor
4.02	DBEG-A2	TS	01	TIT0	001	DBEG-A2_TS01_TIT0_001	Biological reactor	Temperature sensor
4.02	DBEG-A2	TS	01	ORP0	001	DBEG-A2_TS01_ORP0_001	Biological reactor	pH sensor
4.02	DBEG-A2	TS	01	PLC0	001	DBEG-A2_TS01_PLC0_001	Biological reactor sensors	Programmable Logic Controller
4.02	DBEG-A2	TS	01	LIT0	001	DBEG-A2_TS01_LIT0_001	Biological reactor	Level Indicator Transmitter
4.02	DBEG-A2	TS	01	LSHH	001	DBEG-A2_TS01_LSHH_001	Security sensor	Level Switch High High
4.02	DBEG-A2	TS	01	LSH0	001	DBEG-A2_TS01_LSH0_001	Màximum sensor	Level Switch High
4.02	DBEG-A2	TS	01	LS00	001	DBEG-A2_TS01_LS00_001	Start up sensor	Level Switch
4.02	DBEG-A2	TS	01	LSL0	001	DBEG-A2_TS01_LSL0_001	Minimum sensor	Level Switch Low
4.02	DBEG-A2	TS	01	PLC0	001	DBEG-A2_TS01_PLC0_001	Submersibles pumps controler	Programmable Logic Controller
4.02	DBEG-A2	TS	01	MN00	001	DBEG-A2_TS01_MN00_001	Diffuser grid	Pressure gauge
4.02	DBEG-A2	TS	01	TIT0	001	DBEG-A2_TS01_TIT0_001	Diffuser grid	Temperature sensor
								MEMBRANE SYSTEM
4.02	DBEG-A2	TS	02	PT00	001	DBEG-A2_TS02_PT00_001	Membrane module	Mesura de pressió
4.02	DBEG-A2	TS	02	PT00	002	DBEG-A2_TS02_PT00_002	Membrane module	Mesura de pressió
4.02	DBEG-A2	TS	02	PT00	003	DBEG-A2_TS02_PT00_003	Membrane module	Mesura de pressió
4.02	DBEG-A2	TS	02	PT00	004	DBEG-A2_TS02_PT00_004	Membrane module	Mesura de pressió
4.02	DBEG-A2	TS	02	PT00	005	DBEG-A2_TS02_PT00_005	Membrane module	Mesura de pressió
4.02	DBEG-A2	TS	02	PT00	006	DBEG-A2_TS02_PT00_006	Membrane module	Mesura de pressió
4.02	DBEG-A2	TS	02	PLC0	001	DBEG-A2_TS02_PLC0_001	PT controler	Programmable Logic Controller
4.02	DBEG-A2	TS	04	FIT0	001	DBEG-A2_TS04_FIT0_001	Secondary tratment outlet	Flow Indicator Transmitter
4.02	DBEG-A2	TS	01	MN00	001	DBEG-A2_TS01_MN00_001	Diffuser grid	Pessure gauge
4.02	DBEG-A2	TS	01	TIT0	001	DBEG-A2_TS01_TIT0_001	Diffuser grid	Temperature sensor
								SLUDGE RECIRCULATION
4.02	DBEG-A2	TS	03	LSHH	001	DBEG-A2_TS03_LSHH_001	Security sensor	Level Switch High High
4.02	DBEG-A2	TS	03	LSH0	001	DBEG-A2_TS03_LSH0_001	Màximum sensor	Level Switch High
4.02	DBEG-A2	TS	03	LS00	001	DBEG-A2_TS03_LS00_001	Start up sensor	Level Switch
4.02	DBEG-A2	TS	03	LSL0	001	DBEG-A2_TS03_LSL0_001	Minimum sensor	Level Switch Low
4.02	DBEG-A2	TS	03	PLC0	001	DBEG-A2_TS03_PLC0_001	Submersibles pumps controler	Programmable Logic Controller
								SLUDGE PURGA
4.02	DBEG-A2	TS	04	LSHH	001	DBEG-A2_TS04_LSHH_001	Security sensor	Level Switch High High
4.02	DBEG-A2	TS	04	LSH0	001	DBEG-A2_TS04_LSH0_001	Màximum sensor	Level Switch High
4.02	DBEG-A2	TS	04	LS00	001	DBEG-A2_TS04_LS00_001	Start up sensor	Level Switch
4.02	DBEG-A2	TS	04	LSL0	001	DBEG-A2_TS04_LSL0_001	Minimum sensor	Level Switch Low
4.02	DBEG-A2	TS	03	PLC0	001	DBEG-A2_TS03_PLC0_001	Submersibles pumps controler	Programmable Logic Controller

CHEMICAL CLEANING SYSTEM								
4.02	DBEG-A2	TS	05	LSH0	001	DBEG-A2_TS05_LSH0_001	Maximum sensor	Level Switch High
4.02	DBEG-A2	TS	05	LSL0	001	DBEG-A2_TS05_LSL0_001	Minimum sensor	Level Switch Low
4.02	DBEG-A2	TS	05	PLC0	001	DBEG-A2_TS05_PLC0_001	Submersibles pumps controler	Programmable Logic Controller
4.02	DBEG-A2	TS	05	LSH0	002	DBEG-A2_TS05_LSH0_002	Maximum sensor	Level Switch High
4.02	DBEG-A2	TS	05	LSL0	002	DBEG-A2_TS05_LSL0_002	Minimum sensor	Level Switch Low
4.02	DBEG-A2	TS	05	LSH0	003	DBEG-A2_TS05_LSH0_003	Maximum sensor	Level Switch High
4.02	DBEG-A2	TS	05	LSL0	003	DBEG-A2_TS05_LSL0_003	Minimum sensor	Level Switch Low
OVERFLOW/BYPASS PEAK SECONDARY FLOW								
4.02	DBEG-A2	TS	06	LSH0	001	DBEG-A2_TS06_LSH0_001	Bypass channel	Level Switch High
TREATED WATER								
TREATED WATER PRESENTATION								
4.02	DBEG-A2	AT	01	FIT0	001	DBEG-A2_AT01_FIT0_001	Inspection chamber	Flow Indicator Transmitter
4.02	DBEG-A2	AT	01	LIT0	001	DBEG-A2_AT01_LIT0_001	Inspection chamber	Level Indicator Transmitter
4.02	DBEG-A2	AT	01	ORP0	001	DBEG-A2_AT01_ORP0_001	Inspection chamber	pH sensor
SLUDGE TREATMENT								
GRAVITY THICKENING								
4.03	DBEG-A2	EF	01	LIT0	001	DBEG-A2_EF01_LIT0_001	Espessidor	Level Indicator Transmitter
4.03	DBEG-A2	EF	01	LSH0	001	DBEG-A2_EF01_LSH0_001	Màximum sensor	Level Switch High
4.03	DBEG-A2	EF	01	LSL0	002	DBEG-A2_EF01_LSL0_002	Start up sensor	Level Switch Low
4.03	DBEG-A2	EF	01	LSL0	003	DBEG-A2_EF01_LSL0_003	Minimum sensor	Level Switch Low
4.03	DBEG-A2	EF	01	PLC0	001	DBEG-A2_EF01_PLC0_001	Submersibles pumps controler	Programmable Logic Controller
LEACHATES PUMPING								
4.03	DBEG-A2	EF	03	LSHH	001	DBEG-A2_EF03_LSHH_001	Security sensor	Level Switch High High
4.03	DBEG-A2	EF	03	LSH0	001	DBEG-A2_EF03_LSH0_001	Màximum sensor	Level Switch High
4.03	DBEG-A2	EF	03	LS00	001	DBEG-A2_EF03_LS00_001	Start up sensor	Level Switch
4.03	DBEG-A2	EF	03	LSL0	001	DBEG-A2_EF03_LSL0_001	Minimum sensor	Level Switch Low
4.03	DBEG-A2	EF	03	PLC0	001	DBEG-A2_EF03_PLC0_001	Submersibles pumps controler	Programmable Logic Controller
PLANTED DYING BED SYSTEM								
4.03	DBEG-A2	DE	01	TIT0	001	DBEG-A2_DE01_TIT0_001	Bed 1-2	Temperature sensor
4.03	DBEG-A2	DE	01	TIT0	002	DBEG-A2_DE01_TIT0_002	Bed 3-4	Temperature sensor
4.03	DBEG-A2	DE	01	TIT0	003	DBEG-A2_DE01_TIT0_003	Bed 5-6	Temperature sensor
4.03	DBEG-A2	DE	01	TIT0	004	DBEG-A2_DE01_TIT0_004	Bed 7-8	Temperature sensor
4.03	DBEG-A2	DE	01	AIT0	001	DBEG-A2_DE01_AIT0_001	Bed 1-2	Oxygen sensor
4.03	DBEG-A2	DE	01	AIT0	002	DBEG-A2_DE01_AIT0_002	Bed 3-4	Oxygen sensor
4.03	DBEG-A2	DE	01	AIT0	003	DBEG-A2_DE01_AIT0_003	Bed 5-6	Oxygen sensor
4.03	DBEG-A2	DE	01	AIT0	004	DBEG-A2_DE01_AIT0_004	Bed 7-8	Oxygen sensor
4.03	DBEG-A2	DE	01	RH00	001	DBEG-A2_DE01_RH00_001	Bed 1-2	Humity sensor

4.03	DBEG-A2	DE	01	RH00	002	DBEG-A2_DE01_RH00_002	Bed 3-4	Humity sensor
4.03	DBEG-A2	DE	01	RH00	003	DBEG-A2_DE01_RH00_003	Bed 5-6	Humity sensor
4.03	DBEG-A2	DE	01	RH00	004	DBEG-A2_DE01_RH00_004	Bed 7-8	Humity sensor
4.03	DBEG-A2	DE	01	PLC0	001	DBEG-A2_DE01_PLC0_001	Planted dying bed system control	Programmable Logic Controller

WWTP PROJECT - VALVES LIST

Nº PLAN	WWTP	ZONE	PROCESS	EQUIPMENT	Nº	CODE TAG	LOCATION	VALVES
ARRIVAL AND RAW WATER PUMPING								
INLET PUMING STATION								
4.01	DBEG-A2	AE	03	VRB0	001	DBEG-A2_AE03_VRB0_001	Bomba 1	Check valve
4.01	DBEG-A2	AE	03	VCM0	001	DBEG-A2_AE03_VCM0_001	Bomba 1	Gate valve
4.01	DBEG-A2	AE	03	VRB0	002	DBEG-A2_AE03_VRB0_002	Bomba 2	Check valve
4.01	DBEG-A2	AE	03	VCM0	002	DBEG-A2_AE03_VCM0_002	Bomba 2	Gate valve
4.01	DBEG-A2	AE	03	VRB0	003	DBEG-A2_AE03_VRB0_003	Bomba 3	Check valve
4.01	DBEG-A2	AE	03	VCM0	003	DBEG-A2_AE03_VCM0_003	Bomba 3	Gate valve
PRETREATMENT								
SCREENING								
4.01	DBEG-A2	PR	01	VSN0	001	DBEG-A2_PR01_VSN0_001	Reixa de fins	Solenoide valve
PRIMARY TREATMENT								
EQUALIZATIN TANK								
4.01	DBEG-A2	DP	01	VRB0	001	DBEG-A2_DP01_VRB0_001	Bomba 1	Check valve
4.01	DBEG-A2	DP	01	VCM0	001	DBEG-A2_DP01_VCM0_001	Bomba 1	Gate valve
4.01	DBEG-A2	DP	01	VRB0	002	DBEG-A2_DP01_VRB0_002	Bomba 2	Check valve
4.01	DBEG-A2	DP	01	VCM0	002	DBEG-A2_DP01_VCM0_002	Bomba 2	Gate valve
4.01	DBEG-A2	DP	01	VRB0	003	DBEG-A2_DP01_VRB0_003	Bomba 3	Check valve
4.01	DBEG-A2	DP	01	VCM0	003	DBEG-A2_DP01_VCM0_003	Bomba 3	Gate valve
4.01	DBEG-A2	DP	03	VCM0	001	DBEG-A2_DP03_VCM0_001	Equalization tank outlet (FIT)	Gate valve
4.01	DBEG-A2	DP	03	VCM0	002	DBEG-A2_DP03_VCM0_002	Equalization tank outlet (FIT)	Gate valve
4.01	DBEG-A2	DP	03	VCM0	003	DBEG-A2_DP03_VCM0_003	Equalization tank outlet (FIT)	Gate valve
BIOLOGICAL TREATMENT								
BIOLOGICAL REACTOR								
4.02	DBEG-A2	TS	01	VRB0	001	DBEG-A2_TS01_VRB0_001	Bomba 1	Ball valve
4.02	DBEG-A2	TS	01	VCM0	001	DBEG-A2_TS01_VCM0_001	Bomba 1	Check valve
4.02	DBEG-A2	TS	01	VRB0	002	DBEG-A2_TS01_VRB0_002	Bomba 2	Ball valve
4.02	DBEG-A2	TS	01	VCM0	002	DBEG-A2_TS01_VCM0_002	Bomba 2	Check valve
4.02	DBEG-A2	TS	01	VPP0	001	DBEG-A2_TS01_VPP0_001	Bufants	Butterfly valve
4.02	DBEG-A2	TS	01	VPP0	002	DBEG-A2_TS01_VPP0_002	Bufants	Butterfly valve
SLUDGE PURGA								

4.02	DBEG-A2	TS	04	VRB0	001	DBEG-A2_TS04_VRB0_001	Bomba 1	Ball valve
4.02	DBEG-A2	TS	04	VCM0	001	DBEG-A2_TS04_VCM0_001	Bomba 1	Check valve
4.02	DBEG-A2	TS	04	VRB0	002	DBEG-A2_TS04_VRB0_002	Bomba 2	Ball valve
4.02	DBEG-A2	TS	04	VCM0	002	DBEG-A2_TS04_VCM0_002	Bomba 2	Check valve
4.02	DBEG-A2	TS	04	VRB0	003	DBEG-A2_TS04_VRB0_003	Bomba 3	Ball valve
4.02	DBEG-A2	TS	04	VCM0	003	DBEG-A2_TS04_VCM0_003	Bomba 3	Check valve
4.02	DBEG-A2	TS	04	VRB0	004	DBEG-A2_TS04_VRB0_004	Bomba 4	Ball valve
4.02	DBEG-A2	TS	04	VCM0	004	DBEG-A2_TS04_VCM0_004	Bomba 4	Check valve
							SLUDGE RECIRCULATION	
4.02	DBEG-A2	TS	03	VRB0	001	DBEG-A2_TS03_VRB0_001	Bomba 1	Ball valve
4.02	DBEG-A2	TS	03	VCM0	001	DBEG-A2_TS03_VCM0_001	Bomba 1	Check valve
4.02	DBEG-A2	TS	03	VRB0	002	DBEG-A2_TS03_VRB0_002	Bomba 2	Ball valve
4.02	DBEG-A2	TS	03	VCM0	002	DBEG-A2_TS03_VCM0_002	Bomba 2	Check valve
							MEMBRANE SYSTEM	
4.02	DBEG-A2	TS	02	VCM0	001	DBEG-A2_TS02_VCM0_001	distribució membranes	Gate valve
4.02	DBEG-A2	TS	02	VCM0	002	DBEG-A2_TS02_VCM0_002	distribució membranes	Gate valve
4.02	DBEG-A2	TS	02	VCM0	003	DBEG-A2_TS02_VCM0_003	distribució membranes	Gate valve
4.02	DBEG-A2	TS	02	VCM0	004	DBEG-A2_TS02_VCM0_004	distribució membranes	Gate valve
4.02	DBEG-A2	TS	02	VCM0	005	DBEG-A2_TS02_VCM0_005	distribució membranes	Gate valve
4.02	DBEG-A2	TS	02	VCM0	006	DBEG-A2_TS02_VCM0_006	distribució membranes	Gate valve
4.02	DBEG-A2	TS	02	VPP0	001	DBEG-A2_TS02_VPP0_001	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	002	DBEG-A2_TS02_VPP0_002	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	003	DBEG-A2_TS02_VPP0_003	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	004	DBEG-A2_TS02_VPP0_004	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	005	DBEG-A2_TS02_VPP0_005	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	006	DBEG-A2_TS02_VPP0_006	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	007	DBEG-A2_TS02_VPP0_007	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	008	DBEG-A2_TS02_VPP0_008	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	009	DBEG-A2_TS02_VPP0_009	Bufants	Butterfly valve
4.02	DBEG-A2	TS	02	VPP0	010	DBEG-A2_TS02_VPP0_010	Bufants	Butterfly valve
4.02	DBEG-A2	TS	04	VCM0	001	DBEG-A2_TS04_VCM0_001	Secondary treatment outlet (FIT)	Gate valve
4.02	DBEG-A2	TS	04	VCM0	002	DBEG-A2_TS04_VCM0_002	Secondary treatment outlet (FIT)	Gate valve
4.02	DBEG-A2	TS	04	VCM0	003	DBEG-A2_TS04_VCM0_003	Secondary treatment outlet (FIT)	Gate valve
							CHEMICAL CLEANING SYSTEM	
4.02	DBEG-A2	TS	05	VBM0	001	DBEG-A2_TS05_VBM0_001		Ball valve
4.02	DBEG-A2	TS	05	VBM0	002	DBEG-A2_TS05_VBM0_002		Ball valve
						TREATED WATER		
							TREATED WATER PRESENTATION	
4.02	DBEG-A2	AT	01	VCM0	001	DBEG-A2_AT01_VCM0_001	FIT	Gate valve

4.02	DBEG-A2	AT	01	VCM0	002	DBEG-A2_AT01_VCM0_002	FIT	Gate valve
4.02	DBEG-A2	AT	01	VCM0	003	DBEG-A2_AT01_VCM0_003	FIT	Gate valve
SLUDGE TREATMENT								
LEACHATES PUMPING								
4.03	DBEG-A2	EF	03	VRB0	001	DBEG-A2_EF03_VRB0_001	Bomba 1	Ball valve
4.03	DBEG-A2	EF	03	VCM0	001	DBEG-A2_EF03_VCM0_001	Bomba 1	Check valve
4.03	DBEG-A2	EF	03	VRB0	002	DBEG-A2_EF03_VRB0_002	Bomba 2	Ball valve
4.03	DBEG-A2	EF	03	VCM0	002	DBEG-A2_EF03_VCM0_002	Bomba 2	Check valve
4.03	DBEG-A2	EF	02	VRB0	001	DBEG-A2_EF02_VRB0_001	Bomba 1	Ball valve
4.03	DBEG-A2	EF	02	VCM0	001	DBEG-A2_EF02_VCM0_001	Bomba 1	Check valve
4.03	DBEG-A2	EF	02	VRB0	002	DBEG-A2_EF02_VRB0_002	Bomba 2	Ball valve
4.03	DBEG-A2	EF	02	VCM0	002	DBEG-A2_EF02_VCM0_002	Bomba 2	Check valve

APPENDIX 6: TECHNICAL SPECIFICATION SHEETS

All technical data regarding the electromechanical equipment used in this project has been obtained from internal documentation provided by Enghydra S.L. during the professional internship period (2024) [18]. These specification sheets, supplied by manufacturers and compiled during the design phase, contain essential information such as dimensions, flow rates, power requirements, materials, and functional parameters.

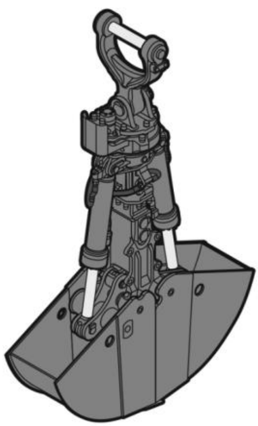
This information is crucial for the proper selection, dimensioning, and integration of equipment within the overall WWTP design. Accurate technical data ensures that each component meets the operational needs of the plant, complies with design constraints, and contributes to the system's overall performance and reliability.

Below is a list of the main electromechanical equipment considered in this project. Their corresponding technical specification sheets are included in the annexes:

- Bivalve clamshell
- Submersible pump
- Self-cleaning screen
- Coarse screen
- Fine screen
- Vertical agitator
- Biological reactor
- Membrane modules
- Thickener

TECHNICAL SPECIFICATION SHEETS		
EQUIPMENT		
DESIGN AND DRAFTING FOR THE NEW WWTP IN BEGUR	EQUIPMENT	CULLERA BIVALVA
	FUNCTION	SOLID EXTRACTION
	REFERENCE	DBEG-A2_AE01_CB00_001
General characteristics		
Type	Electro bivalve clamshell	
Action mode	Mechanical mode	
Construction	Square	
Charge capacity	100 l	
Maximum valve opening	465 mm	
Valve width	465 mm	
Maximum width	519 mm	
Open clamshell heigh	1.043 mm	
Close clamshell heigh	1.039 mm	
Opening time	2-4 s	
Closing time	3-5 s	
Weight	319 kg	

Graphic



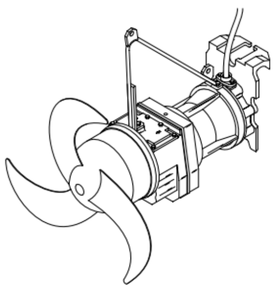
TECHNICAL SPECIFICATION SHEETS		
EQUIPMENT		
DESIGN AND DRAFTING FOR THE NEW WWTP IN BEGUR	**EQUIPMENT**	HEAD PUMP
	FUNCTION	HEAD PUMPING
	REFERENCE	DBEG-A2_AE03_BS00_001
General characteristics		
Type	Submersible Fixed	
Fluid to pump	Wastewater	
Maximum flow	160 m^3/h	
Performance	62,9 %	
Heigh	10,05 m	
Solids passage	75 mm	
Impeller mouth	DN 100	
Weight	109 kg	
Motor		
Nominal voltage	400 V	
Power absorbed on shaft P2	2,95 kW	
Power factor	0,76	
Frequency	50 Hz	
Nominal current	6,4 A	
Graphic		

TECHNICAL SPECIFICATION SHEETS		
EQUIPMENT		
DESIGN AND DRAFTING FOR THE NEW WWTP IN BEGUR	**EQUIPMENT**	SELF-CLEANING SCREEN
	FUNCTION	COARSE CHAMBER SCREEN
	REFERENCE	DBEG-A2_AE02_RXA0_001
General characteristics		
Fluid to pump	Wastewater	
Screen aperture	30 mm	
Channel width	1200 mm	
Screen width	1180 mm	
Total unitary channel surface	0,04 m^2	
Total heigh	4400 mm	
Inclination:	75º	
Nº cleaning brushes	6	
Bar length	1000 mm	
Bar section	40*10 mm	
Output velocity	5 – 10 rpm	
Graphic		

TECHNICAL SPECIFICATION SHEETS		
EQUIPMENT		
DESIGN AND DRAFTING FOR THE NEW WWTP IN BEGUR	EQUIPMENT	COARSE SCREEN
	FUNCTION	COARSE SCREENING
	REFERENCE	DBEG-A2_PR01_RXAM_001
General characteristics		
Fluid to pump	Wastewater	
Screen aperture	10 mm	
Channel width	1200 mm	
Screen width	1180 mm	
Channel heigh	2600 mm	
Total heigh	4400 mm	
Inclination:	75º	
Nº cleaning brushes	6	
Bar length	1000 mm	
Bar section	40*10 mm	
Output velocity	5 – 10 rpm	
Graphic		

TECHNICAL SPECIFICATION SHEETS		
EQUIPMENT		
DESIGN AND DRAFTING FOR THE NEW WWTP IN BEGUR	**EQUIPMENT**	FINE SCREEN
	FUNCTION	FINES SCREENING
	REFERENCE	DBEG-A2_PR01_TMDB_001
General characteristics		
Fluid to pump	Wastewater	
Screen aperture	6 mm	
Channel width	1200 mm	
Screen width	1180 mm	
Channel heigh	2600 mm	
Total heigh	4400 mm	
Inclination:	75º	
Nº cleaning brushes	6	
Bar length	1000 mm	
Bar section	40*10 mm	
Output velocity	5 – 10 rpm	
Graphic		

TECHNICAL SPECIFICATION SHEETS		
EQUIPMENT		
DESIGN AND DRAFTING FOR THE NEW WWTP IN BEGUR	**EQUIPMENT**	AGITATOR
	FUNCTION	HOMOGENIZATION TANK
	REFERENCE	DBEG-A2_DP01_AG00_001
General characteristics		
Type	Submersible	
Fluid to pump	Wastewater	
Agitation flow	1,4 m^3/s	
Streng	1,032 N	
Weight	150 kg	
Helix Diameter	1.600 mm	
Helix Velocity	42 rpm	
Motor		
Type	Three-phase with squirrel-cage rotor	
Nominal power to the axis	1,4 kW	
Nominal absorbed power	1,79 kW	
Voltage	400 V	
Frequency	50 Hz	
Current	2,97 A	
Factor de power	0,88	
Maximum submergibility	20 m	
Graphic		



TECHNICAL SPECIFICATION SHEETS		
EQUIPMENT		
DESIGN AND DRAFTING FOR THE NEW WWTP IN BEGUR	**EQUIPMENT**	MEMBRANE MODULE
	FUNCTION	MEMBRANE TANK
	REFERENCE	DBEG-A2_TS02_DPMB_001
General characteristics		
Type	Ultrafiltration membranes	
Flow rate	20,89 – 38,58 m^3/h	
Number of modules	8	
Unitary surface per module	2000 m^2	
Dimensions	Length: 2258 mm	
	Width: 1780 mm	
	Heigh: 2652 mm	
Membranes per module	44/44	
Type	Empty fibre	
Nominal pore size	0,03 um	
Fiber external diameter	2,6 mm	
Maximum operating pressure	0,6 bar	
Graphic