HYDROUSA

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Water in the context of circular economy

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Constructed wetland installed and operating

Annex 2

Operational and Maintenance plan of full-scale CW system

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ABBREVIATIONS

ATS	**Anaerobic Treatment system**
BOD	**Biochemical Oxygen Demand**
CW	**Constructed wetland**
HDPE	**High-Density Polyethylene**
LS	**level sensors**
LSH	**level switch high**
LSHH	**level switch highest**
LSL	**level switch low**
LSLL	**level switch lowest**
ND	**Nominal Diameter**
O&M	**Operation and maintenance**
PVC	**Polyvinyl Chloride**
SAT	**Saturated**
SMC	**Sheet moulding compound**
SSF	**Subsurface flow (wetlands)**
TN	**Total Nitrogen**
TSS	**Total Suspended Solids**
UASB	**Upflow anaerobic sludge blanket**
UF	**Ultrafiltration (Membrane)**
UNSAT	**Unsaturated**
UV	**Ultraviolet**
VF	**Vertical flow (subsurface flow constructed wetland)**
WWTP	**Wastewater treatment plant**

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1. INTRODUCTION

The Operation & Management Plan is an essential practice to assure:

- the right functioning of the wastewater treatment plant (WWTP) with a stable fulfilment of the chosen treatment goals;
- an enlargement of the WWTP operating period;
- a complete comprehension of the operating procedures;
- timely diagnosis of serious problems, e.g. continuous overloading.

Constructed wetlands are designed for an easy management with a discontinuous effort, but they require a certain care and observation due to their nature of complex dynamic ecosystems which involves a lot of different variables.

This manual has been edited with the following aims:

- to make all the O&M practices immediately identifiable and comprehensible;
- to provide to the operator an adequate understanding of depuration system in all its parts;
- to provide the sufficient tools for optimising the O&M practices on the basis of the directly acquired experiences;
- to find advise as when to call an expert because of problems rising above normal O&M tasks.

1.1 How to use the O&M manual

The Annex 1 of this manual is an overview of the WWTP where all the components are showed.

The Manual consists of a User Manual with operation guide and maintenance guide for each component of the plant, and the Maintenance Plan.

The **User Manual** consists of a brief description of each component and its proper functioning. Each component is provided with specific drawings and graphic representations for allowing an easy and immediate understanding and a quick identification of the described items.

The operation guide, and the following maintenance guide, contains precise descriptions and detailed checks to be carried out and any action required. In particular these descriptions contain:

- resources and tools needed for intervention;
- the minimum performance level that has to be verified, and, if not reached, which kind of action must be done;
- anomalies found during inspection that may suggest a more accurate maintenance or checks;
- a description of the regular maintenance, specifying if it can be executed by the operator or if it requires the intervention of specialized personnel.

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At a glance:

<u>Description</u>

<u>How to properly use</u>

<u>Check 2.1</u> — *Check identification number*

What’s the inspection and on which component has to be done

<u>anomalies found</u>

What may be the problem/fault

<u>minimum performance level</u>

What are the minimum component’s requirements that guarantee the correct plant operation

<u>Actions</u>

What should be done if the control has been successful

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Maintenance Program summarizes all the controls and operations to be performed on various components of the WWTP. In the initial box are indicated interventions and management to run periodically irrespective of the inspections results.

The following table contains:

- subprogram controls, containing a calendar that shows ordinary checks and controls, with specific references to their description module.
- subprogram performance, which contains the minimum requirements that guarantee the correct plant operation;
- subprogram maintenance interventions that contains the maintenance to be carried out in case of noticed deficiency in the performances of sub-specific identified component.

At a glance:

Management actions to be carried out, regardless of the sub controls and performance

SCHEDULE	ACTION
How often you have to make the operation	What you have to do

Checks, performances and management actions Subprogram

Schedule	***Component***	***Checks Subprogram***	***Performance Subprogram***	***Management actions Subprogram***
How often you have to make the control	Which plant component has to be checked and where in the manual you can find a detailed description	What you have to check	What are the minimum performance requirements necessary for a proper component functioning	What should be done if the inspection has reacted negatively, i.e. if the components performance is found to be different from those minimum correct operation

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2. USER MANUAL

2.1 Short description

The aim of the Lesvos pilot site (HYDRO1) is to demonstrate the possibility to treat wastewater produced by a touristic site (high fluctuation in sewage production due to seasonality of touristic activities) and produce an effluent suitable for reuse in irrigation under strict Greek water quality standards. The treatment chain of the Lesvos pilot include: UASB + constructed wetland + ultrafiltration + UV lamp. The current document summarizes the operational and maintenance activities only for the constructed wetlands (CWs) for the treatment of the UASB effluent from the Lesvos demo sites. O&M for primary (UASB) and tertiary (UF + UV) are reported in an another separated document.

The full scale system is composed by a hybrid combination of vertical subsurface flow (VF) CWs and treats from 10 to 100 mc/d. The full scale system is designed with two stages: 1st stage, saturated downflow VF (VF1 SAT); 2nd stage unsaturated intermitted load VF CW (VF2 UNSAT). Different recirculation options allow to test up to 4 different configurations, investigating the best scheme for Greek and also other Mediterranean conditions (e.g. different water quality standards for TN).

The CW full scale line receives the effluent of UASB digester and is composed of (see **Figure 2.1**):

- General by-pass, C1;
- Bypass manhole towards VF1 SAT, B1;
- 1st stage saturated vertical subsurface down flow CW, VF1 SAT, with a bed of 17.5x14 m (245 m2);
- Pumping station for VF2 UNSAT, P1;
- 2nd stage unsaturated intermittent load VF CW, VF2 UNSAT, which is divided in 3 beds to fit the local orography; the 3 beds host the 4 VF2 UNSAT lines for batch feeding (lines A, B, C, and D); each line sizes 18x8.5 m, i.e. about 150 m^2; the total net surface of VF2 UNSAT is equal to about 600 m2.
- Recirculation manhole R2 towards effluent of UASB digester (influent to VF1 SAT).

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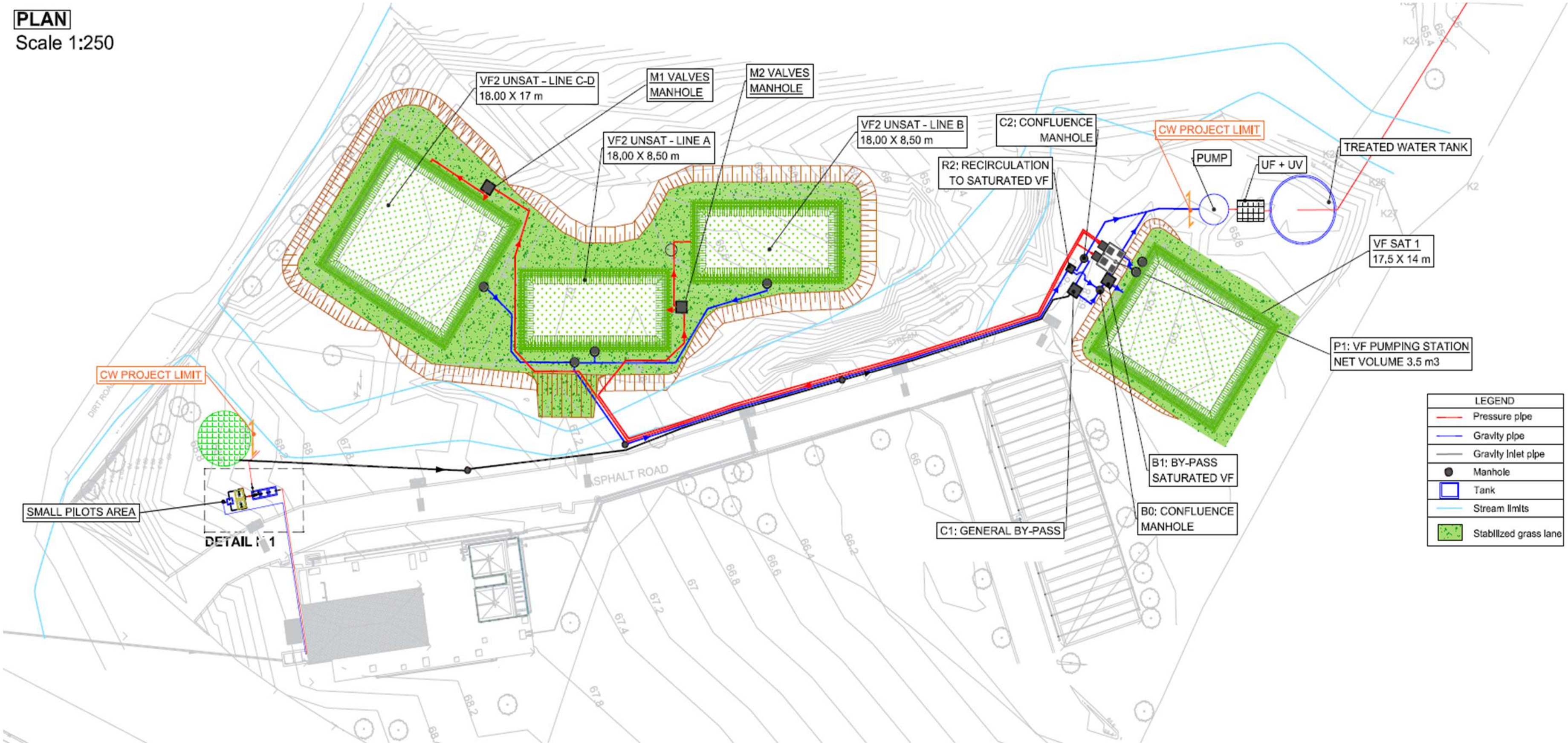

Figure 2.1: Plan layout of Lesvos full-scale system – final detailed design

2.2 General Information

The system operates independently without the need for any intervention during operation: any chemical-physical parameters have to be kept under constant control and any operational modification has to be performed, on the contrary as it is common for traditional biological systems.

The primary sludge from the UASB tank must be periodically removed and then disposed in accordance with the current legislation; for this activity, we remand to the dedicated O&M of the UASB reactor.

The routine operation and maintenance (O&M) requirements for submerged wetlands include hydraulic and water depth control, inlet/outlet structure cleaning, grass mowing on berms, inspection of berm integrity, wetland vegetation management, and routine monitoring.

The **water depth** in the VF2 UNSAT beds doesn’t need periodic adjustment because the water is drained on the bottom of the bed, completely dewatering it after each loading; in VF1 SAT wetland, instead, the level is fixed by the regulation device in the outlet manhole, permitting to keeping the water level under the gravel surface.

Mosquito control should not be required for a subsurface flow (SSF) wetland system as long as the water level is maintained below the top of the media surface during each loading and the beds are maintained empty.

Vegetation management in these SSF wetlands does not include a routine harvest and removal of the harvested material. Plant uptake of pollutants represents a relatively minor pathway so harvest and removal on a routine basis does not provide a significant treatment benefit. Therefore <u>one cut per year</u> is enough. Removal of accumulated litter is also necessary. By the way, our suggestion is to cut and remove all the died plants every year, starting from the second year from plantation, cutting them over the bed surface and taking care in not damaging their roots.

Routine **water quality** monitoring will be required for all SSF systems with an official discharge permit, and the permit will specify the pollutants and frequency. Sampling for discharge permit monitoring is usually limited to the untreated wastewater and the final system effluent. Since the wetland component is usually preceded by some form of preliminary and primary treatment, the monitoring program does not document wetland influent characteristics. It is recommended, in all but the smallest systems that periodic samples of the wetland influent could be collected and tested for operational purposes in addition to the discharge permit requirements. This will allow the operator a better understanding of wetland performance and provide a basis for adjustments if necessary.

Operation

Natural treatment systems are relatively simple to operate; in case of VF2 UNSAT, the most important activity is the control of the pumping system, the checking of the observance of rest/loading period and the uniformity of the wastewater distribution; in case of VF1 SAT the flow passes through the bed by gravity without any necessary regulation, checking only periodically if clogging issues are appearing in the inlet section. The simplest gravity flow control system in the wetland cell is either a simple weir or elbow pipe structure.

Constructed Wetlands must be managed if they are to perform well. Wetland management should focus on the most important factors in treatment performance:

- assuring the correct loading and resting periods for VF2 UNSAT beds

- respecting the maximum capacity in terms of organic and hydraulic loads
- assuring that flows reach all parts of the wetland
- maintaining a healthy environment for microbes
- maintaining a vigorous growth of vegetation.
- In VF1 SAT bed a precise water level control in the wetland cell is important to ensure the best results in term of removal: water level has to be kept 10 cm below the gravel surface, keeping open the 2nd plug from the top and the rest closed. In VF2 UNSAT beds the normal operating water depth for a VF wetland cell is about 5 cm and it is obtained maintaining the lower plug in the regulation manhole open. To enhance denitrification, it is possible opening the second plug from the bottom and closing the rest.
- Shallow flooding (2-5 cm) is a very occasional condition adopted for extraordinary maintenance closing all the plugs except the upper one, and it can limit invasion of weedy or terrestrial species once the wetlands plants have stems higher than 8-12 cm (it is absolutely essential that stems and leaves of desirable species rise up well above the water's surface to avoid drowning of new or even older established plants). In this case the extension of the beds is limited and we suggest to control the weeds manually, using flooding conditions only in extraordinary cases and in absence of people.
- Small submersible pumps provide a precise method of flow control. The control can consist simply of a submersible pump per 2 VF2 UNSAT sectors, allocated in the same tank, attached to four floating device. A control panel manages the alternate activation of each pump. The pump would direct flow to the VF feeding system, and then gravity flow would take over.

After the first year of operation, the operation and maintenance typically consists of walking around the boundary of the beds at least once a week to check for any damage on the structure or animal damage in the bed, to check to correct operation of the pump system weekly and to collect water quality samples as needed

- Routine weekly inspections are necessary to ensure appropriate flows through the inlet distributor and outlet collector piping as well as leaks in the piping itself.
- Flow distribution within cells should be occasionally inspected to detect if there are obstructions in the feeding pipes; pipes are covered so it is not possible any visual inspection without removing gravel and coverage pipes: in any case obstructions are very infrequent if the pumping system operates daily, and to check if there are some obstructed holes it is enough to check the uniform growth of the plant.
- wetlands vegetation should be checked at least once a week to identify any visible signs of stress or disease such as grass yellowing, chlorosis, leaf damage, etc. Should stress or disease be noticed, a specialist should be consulted.
- Pumps, valves should be checked at least once each week to ensure that pumps and all piping are operating properly.
- The wetland should be operated with clean water or very low-strength wastewater for the first month after planting. During the fifth week, initiate operation with one-half the design flows and continue for one month. After the end of the second month, begin operation with full-strength wastewater or with full design flows. Check proper operation of all piping, pumps and water control structures and monitor vegetation.

Operation and maintenance (O&M) are described in this O&M plan. The plan has to be updated to reflect specific system characteristics learned during actual operation.

HYDROLOGY

Constructed wetlands should be checked to see that surface flow is not developing. If water is noticed on the top of the surface except during each feeding phases, it means that clogging is happened and the instructions included in the clogging section of this manual have to be followed in order to recover the perfect functionality of the system.
Stagnant water on the surface decreases removal and increases the likelihood of mosquitoes and unsightly conditions. Flows and water levels should be checked regularly!

STRUCTURES
Dikes, spillways, and water control structures should be inspected on a regular basis and immediately after any unusual flow event. Constructed Wetlands should be checked after high flows and after heavy rainfall. Any damage, erosion, or blockage should be corrected as soon as possible to prevent catastrophic failure and expensive repairs.

VEGETATION
Weed control is the key to determining the success of vegetation; vegetation should be inspected regularly and invasive species should be removed. Herbicides should not be used except in extreme circumstances, and then only with extreme care, since they can severely damage emergent vegetation. The roots of shrubs and trees can create damages to the waterproofing liner and subsequent leakage throughout the berms.
Considering the limited extension of the beds, this activity can be done manually and only in rare case in absence of people by temporary flooding conditions.

2.3 Capacity of the treatment system

The capacity of the treatment system is summarised below:

	m^3/day	BOD (mg/l)	BOD (kg/d)
Winter not touristic season	**10**	**330**	**3.3**
Summer touristic season	**100**	**330**	**33.0**

The UASB+CW+UF+UV pilot plant is designed to respect the Greek effluent water quality regulation for unrestricted agricultural reuse, which is reported as follows:

BOD_5 < 10 mg/L for 80% of the samples
Suspended solids < 10 mg/L for 80% of the samples
Turbidity ≤ 2 NTU (median value)
***E.coli* ≤ 5 for 80% of the samples & ≤ 50 for 95% of the samples**

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2.4 Sheet Nº1: General by-pass manhole, C1

Description

The general by-pass manhole C1 (**Figure 2.2**) consists in a manhole with two gate valves, used to manually set the operation Mode 4 (UASB+UF+UV) or other operation modes including the wetland beds (Mode 1, 2, 3). Regarding how to set the valves function of different operation modes, see Sheet n° 7: Setting for different operation modes. The manhole is made of reinforced concrete with 1.30 x 1.30 m (internal dimensions); and internal height of 0.9 m. The two gate valves are ND200 and installed on a PVC Tee90° ND200 (**Figure 2.2**).

The pipes **inlet** to the manhole are:

- N° 1 PVC Sn4 ND200 from the UASB

The pipes **outlet** to the manhole are:

- N°1 PVC Sn4 ND200 towards manhole C2
- N°1 PVC Sn4 ND200 towards manhole B0

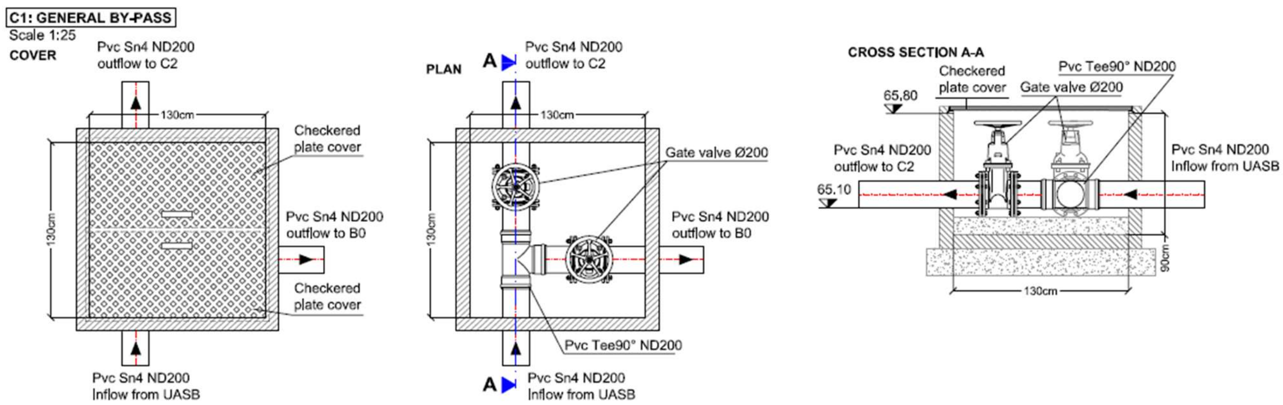

Figure 2.2: Planimetry and section of by-pass manhole C1

How to properly use it

The by-pass manhole does not require any continuous operational and monitoring activities. The opening and closing setting of the gate valves must be changed only in case of a change of operation mode, following the indication given in Sheet n° 7: Setting for different operation modes.

Check 1.1

Every 6 months or every change of operation mode setting is needed to be checked:

- Check the functioning of the valves i.e Gate valve and Check valve every 6 months
- Gate valves are opened and closed in order to proper set the desired operation mode

Anomalies found

- Gate valve is hard to move;
- Wrong operation mode;

Performance Minimum level

- Gate valve is easy to open and close;
- Proper operation mode set function of opening and closing of the valves

Actions

- Grease the hand wheel and repeat closing and opening several times; then leave the gate valve open or closed according with the operation mode selected
- Set the open and close of valve according to the indications reported in Sheet n° 7: Setting for different operation modes.

2.5 Sheet N°2: By-pass manhole VF1 SAT, B1

Description

The by-pass manhole B1 (**Figure 2.3**) consists in a manhole with two gate valves, used to manually set use or not the VF1 SAT bed within different operation modes. Regarding how to set the valves function of different operation modes, see Sheet n° 7: Setting for different operation modes. The manhole is made of reinforced concrete with 1.30 x 1.30 m (internal dimensions); and internal height of 0.9 m. The two gate valves are ND200 and installed on a PVC Tee90° ND200 (**Figure 2.3**).

The pipes **inlet** to the manhole are:

- N° 1 PVC Sn4 ND200 from the confluence manhole B0

The pipes **outlet** to the manhole are:

- N°1 PVC Sn4 ND200 towards manhole pumping station P1
- N°1 PVC Sn4 ND200 towards VF SAT1

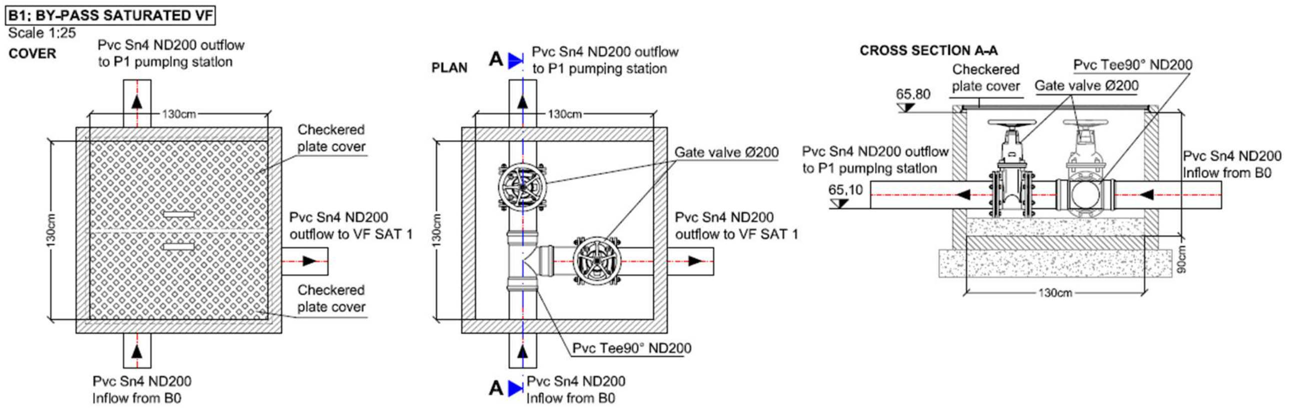

Figure 2.3: Planimetry and section of by-pass manhole B1

How to properly use it

The by-pass manhole does not require any continuous operational and monitoring activities. The opening and closing setting of the gate valves must be changed only in case of a change of operation mode, following the indication given in Sheet n° 7: Setting for different operation modes.

Check 2.1

Every 6 months or every change of operation mode setting is needed to be checked:
- Check the functioning of the valves i.e Gate valve and Check valve every 6 months
- Gate valves are opened and closed in order to proper set the desired operation mode

Anomalies found
- Gate valve is hard to move;
- Wrong operation mode;

Performance Minimum level
- Gate valve is easy to open and close;
- Proper operation mode set function of opening and closing of the valves

Actions
- Grease the hand wheel and repeat closing and opening several times; then leave the gate valve open or closed according with the operation mode selected
- Set the open and close of valve according to the indications reported in Sheet n° 7: Setting for different operation modes.

2.6 Sheet N°3: Saturated vertical subsurface downflow wetland, VF1 SAT

Description

The VF1 SAT unit (**Figure 2.4**- section; **Figure 2.7**- planimetry) consists of the following characteristics (**Table 2.1**).

Table 2.1: VF1 SAT unit construction characteristics

Flow	m^3/d	10-100
Bottom surface area	m^2	250
Size and depth of filter media (starting from bottom) **30 – 50 mm round washed gravel** **10-20 mm round, washed gravel** **5-10 mm round, washed gravel**	m	0.80 0.10 0.10
Total Depth of filter media	m	1.00
Free board	m	0.30
Total Depth	m	1.30
Type of plants	-	*Phragmites australis*
Material of construction	-	Excavated in the soil, soil embankments, waterproofed with HDPE liner 1.5 mm

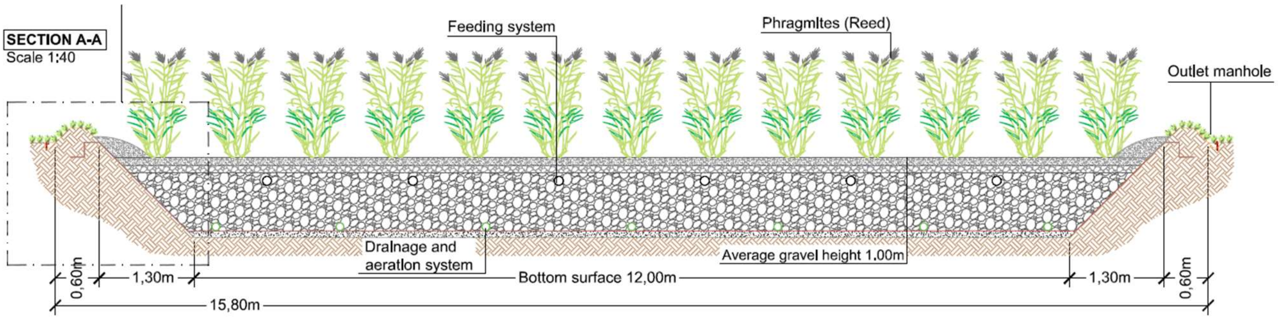

Figure 2.4: Section of VF1 SAT

The **feeding system** of the VF1 SAT bed is constituted by several PVC pipes ND125 connected to a main distribution PVC pipe ND200 by PVC reducer Tee 90° ND200-125. The branches are closed at the end through caps for allowing regular washings.

The **drainage water pipe** of the VF1 SAT bed is constituted by several slotted drainage PVC pipes DN110 connected to a main collecting slotted PVC pipe ND160 by PVC reducer Tee 90° ND160-110. The drainage collecting pipe is connected on two PVC pipes ND160 that pass through the liner and are connected to two manholes.

- Outlet manhole: a circular manhole with internal diameter of 1.0 m, total height 1 m; the manhole receives a PVC ND160 pipe from the VF SAT1 drainage system; before entering into the manhole, the pipe has two elbows 90° ND160, which permit to regulate the water level within the bed; the entering pipe is installed in a water level control device. The water level device is composed of two PVC Tee 90° with plug, allowing 3 settings (see **Figure 2.5**)
    - *Operational and maintenance mode*: about + 55 cm from the bottom of the VF1 SAT bed, permitting to decrease the water level in the bed to provide maintenance of the feeding system, which result uncovered by the water level in this functioning mode (**(1) Figure 2.5**)
    - *Standard mode*: about +100 cm from the bottom of the VF1 SAT bed, maintain saturated condition within the bed in standard conditions and covering the buried feeding system with the water level (**(2) Figure 2.5**)
    - *Start-up and flooding maintenance mode*: about +110 cm from the bottom of the VF1 SAT bed, flooding the bed with +10 cm above the gravel bed surface to control the weed during the planting phase of the start-up or for weed maintenance in general (**(3) Figure 2.5**)
- Emergency emptying manhole: a circular manhole with internal diameter of 1.0 m, total height 1.5 m; the manhole receives a Pead ND125 pipe from the VF SAT1 drainage system; inside the manhole is installed a gate valve ND125, which permit to empty the VF1 SAT bed in case of emergency maintenance activity (see **Figure 2.6**).

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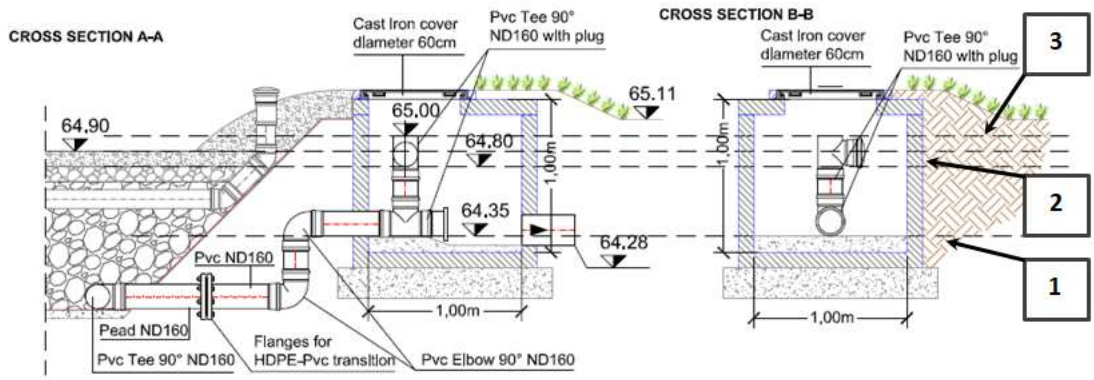

1. **Operational and maintenance mode**
2. **Standard mode**
3. **Start-up and flooding maintenance mode**

Figure 2.5: Outlet manhole of VF1 SAT bed

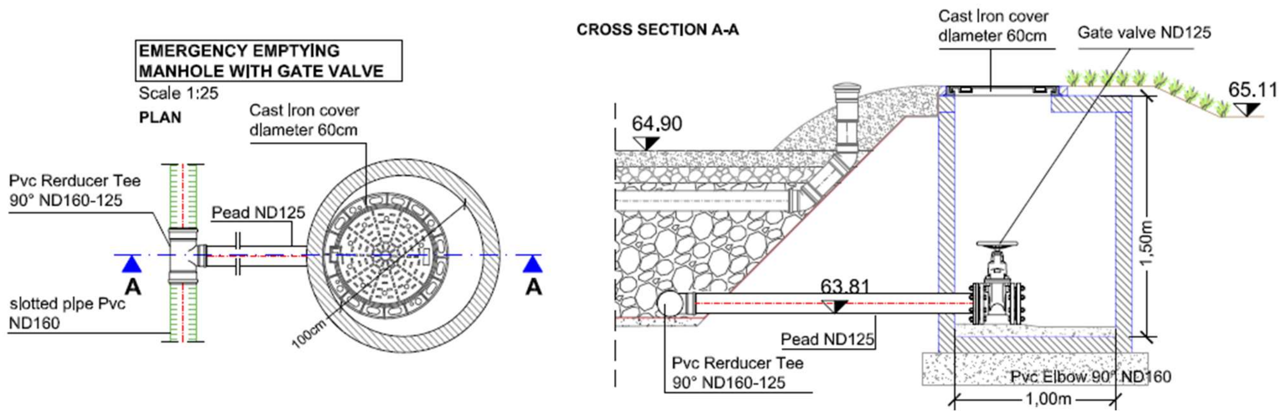

Figure 2.6: Emergency emptying manhole of VF1 SAT bed

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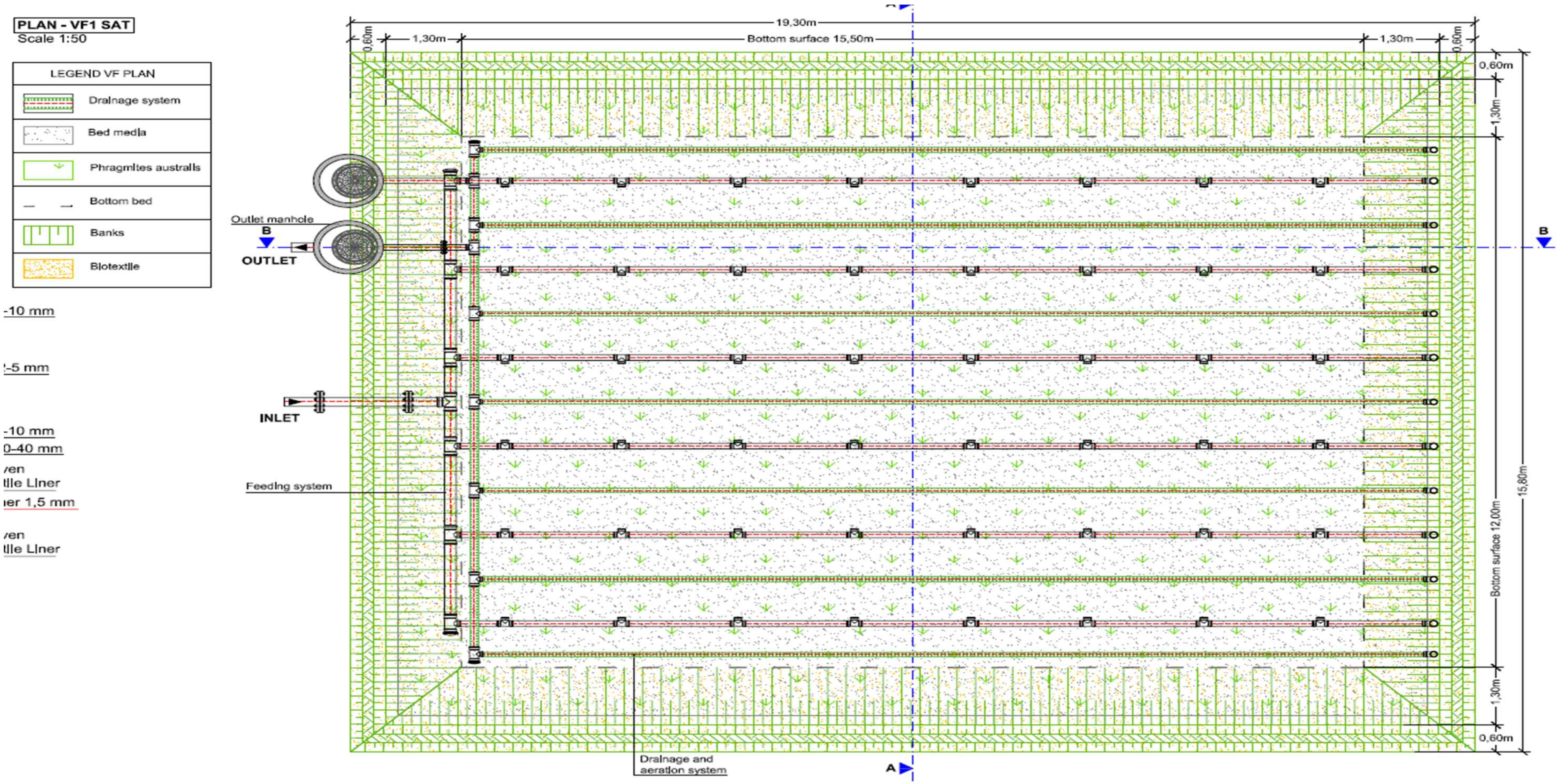

Figure 2.7: Planimetry of VF1 SAT

<u>How to properly use</u>

The water level device needs to be set to work in standard mode, i.e. permitting to have a water level of +100 cm from the bottom of the VF1 SAT bed (**(2) Figure 2.5**). To this aim, plugs of the outlet manhole and gate valve of the emergency emptying manhole must be set as follow:

- <u>Outlet manhole</u>
    - Plug on the PVC Tee 90° at the bottom of the manhole: **closed**
    - Plug on the vertical PVC Tee 90°: **open**
- <u>Emergency emptying manhole</u>:
    - Gate valve: **closed**

All controls and the maintenance may be done without the help of skilled labour, by personnel with specific knowledge on the functioning of the procedures contained in this manual.

The reeds cutting inside the bed must be made with the aid of mechanical or manual device; the first time after 2 years of operation, then each year. The plants should be cut at the base of the emerged part, without damaging the root zone.

VF1 SAT Bed

Check 3.1
Every 3 months and after intense storm events the integrity of the bed should be checked

<u>Anomalies found</u>
- Boundary trench damages;
- No-uniform distribution of reeds;
- Presence of disease on plants or damages caused by insects or animals;
- Presence of weeds.

<u>Performance Minimum level</u>
- The boundary trenches have not to be damaged
- The density of plant must be on average plus than 10 plants per square meter after the first year of operation.

<u>Actions</u>
- Damages have to be promptly repaired
- if the distribution of plants is not uniform you have to plant the lacking areas with new reeds; an unequal distribution could be generated by a not perfect distribution of the wastewater by the feeding pipes; in case of large areas on a feeding line is noticed for a long time after the second year of operation, it is suggested to uncover the pipe and control if no obstruction or other obstacle are present in proximity of the feeding system;
- in the case of plant diseases or damages caused by insects or animals the appropriate intervention will be given by qualified personnel;
- in the case of presence of weeds, their removal will be by hand or in extraordinary case with controlled flooding technique. It's particularly important to check for the presence of weeds during the reed's

growing season, in order to avoid, with an urgent removal and control of invading weeds, their shadowing on growing stems of reeds.

Check 3.2

Every month check the surface of the beds

Anomalies found

- on the surface of the beds there are puddles or stagnant water during dry periods;

Performance Minimum level

- The top surface has to be dry;

Actions

- see the proper strategy in the trouble shooting section for subsurface flow systems;

Water level control device

Check 3.3

Every 6 months check of bed outlet pipeline, manhole outlet pipeline and bottom of manhole;

Anomalies found

- The presence of obstructions in the outlet pipe from the bed and in the pipeline from the manhole;
- Presence of settled material on the manhole bottom;

Performance Minimum level

- No settled material on the manhole bottom

Actions

- Washing with pressure water the blocked pipes
- Settled material removal and its appropriate disposal

2.7 Sheet N°4: Pumping station

Description

To load VF2 UNSAT beds in each line of the treatment system, n°2 submersible pumps controlled by a control unit are installed in a reinforced concrete tank. The reinforced concrete tank is 2.5x3.25 m (external dimensions); the internal height has to be min. 2.5 m; the maximum water level of 1.85 m is controlled by an overflow pipe, which is connected to the finale effluent pipe towards tertiary treatment (**Figure 2.8**).

The selected pumps have the characteristics indicated in the specific user's instructions of the component:
- **Flow: 20 L/s**
- **Head: 12 m**

The pump is controlled by a control panel comprehensive of:
- Electrical protection and automatic or manual command of no. 2 pump 4.7 kWw each, 400 V, 50 Hz
- Type of custody: Cabinet in SMC (fibreglass-reinforced plastic) in protected execution IP65 with hinge door. Type of custody: For external installation.
- The Local switchboards shall meet the requirements of degree of protection index IP55.

The panel will contain mounted and connected the following materials:
- n°1 Rotary knife, lockable door blocking maneuver
- n°1 Fuse 3 pole with fuse to feature delayed
- n°1 Complete thermal relay contactors
- n°1 Selectors man-o-aut (manual position not stable) for each pump
- n° 2 Beamers with lamps for each pump
- 1 lights (pump marching) for each pump
- 1 lights (pump stopped) for each pump
- n° 1 single-phase transformer for auxiliary circuits adequate power - q.s. relay shutter operation (alternation)
- Control unit for pump switching and connection with start and stop switch levels

The control unit receive inputs from **n° 4 floating valves**, which regulate the water level within the tank as follow:
- <u>Float 1 – LSLL</u>: level switch lowest, emergency stop of pumps for lowest allowed level within the tank;
- <u>Float 2 – LSL</u>: level switch low, stop of the pumps for ending of the design flush volume to be feed;
- <u>Float 3 – LSH</u>: level switch high, start of the pumps for reaching of the design flush volume to be feed;
- <u>Float 4 – LSHH</u>: level switch highest, start of the pumps for highest allowed level within the tank.

The pump is easily removable for inspection or service, requiring no bolts, nuts, or other fastenings to be disconnected.

Each pump is equipped with:
- Check valve ND100
- Gate valve ND100

The pumping station **receives**:

- Treated wastewater from the VF1 SAT stage with a PVC ND200 pipe
- By-passed wastewater from the B1 by-pass manhole with a PVC ND200 pipe

The following pipes **come out** from the pumping station:
- Pead Pn10 ND160 to feed VF2 UNSAT lines A and B;
- Pead Pn10 ND160 to feed VF2 UNSAT lines C and D;
- Overflow pipe PVC ND200

How to properly use

The pumping station functions as follow:

- Every day the loading on the bed is in a batch mode, controlled by the control panel to program pump start and duration of pumping;
- the pump starts, on average and during touristic season, every 2.7 hour, for about 4.8 minutes, transferring a volume of 6.1 m^3 (2 cm/m^2 of bed); in this way we obtain a resting period of 2.7 hours; check the minutes of pumping with the real productivity of the pump: the level decrease to obtain the flush volume is 1.0 m, therefore measure the needed time to decrease the level in the tank of 1 m in absence of incoming water.
- Floating valve: the batch volume is regulated by the two intermediate valves, i.e. the LSL and the LSH valves at 60 cm and 160 cm from the bottom of the tank, respectively;
- Further two floating valves permits the emergency stop and start of the pumps, i.e. the LSLL and the LSHH valves at 40 cm and 175 cm from the bottom of the tank, respectively.
- If the max level regulated by the LSHH valve is reached, the two pumps starts for a maximum time of 4.8 minutes; above the 4.8 minutes, the exceeding influent wastewater is discharged from the pumping station by the overflow pipe by gravity

All controls and the maintenance on the pumps and control panel has to be done by skilled labour, following the user instructions of the component.

Before to proceed with any operational and maintenance activity on the pumps, it must be checked that the electricity is closed and that the pump cannot start.

The following general consideration general considerations must be respected during operational and maintenance activities with submersible pumps:
- If the pump is removed from water at a temperature < 0°C, the pump impeller could freeze
- Once the pump is removed from the water, let works the pump for a while, in order to completely empty it
- If the pump was not used for a long period it must be protected from heat and humidity; every 2 months of inactivity, the pump impeller should be rotated by hand

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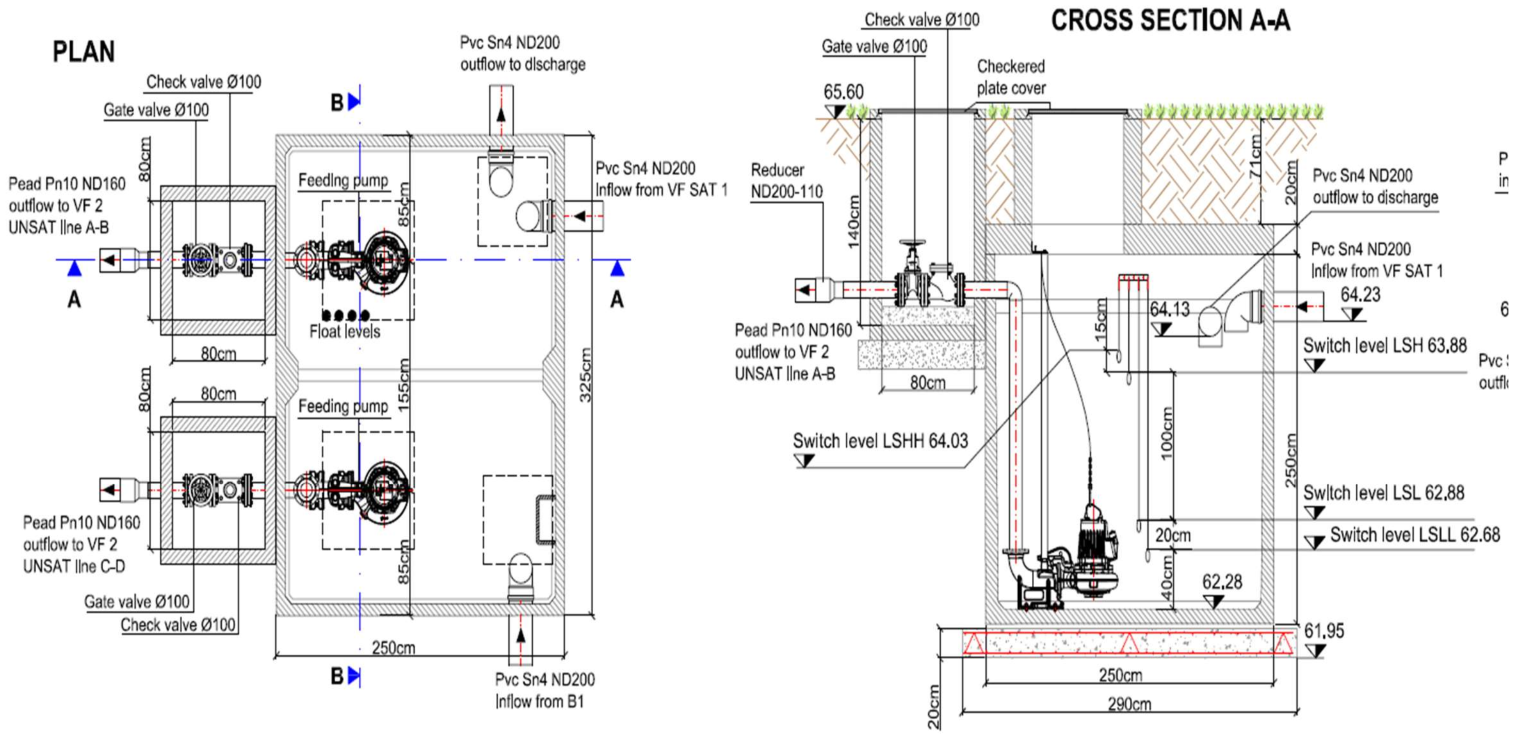

Figure 2.8: Planimetry and section of pumping system

Check 4.1
- Every month control the perfect functioning of the pumping system

Anomalies found
- Pumping time is often less than the selected time, due to emergency start stop level
- pump doesn't work
- Both LSH and LSHH floating valves doesn't work and wastewater go out through the overflow
- Both LSL and LSLL floating valves doesn't work and pump continue to work even if the minimal level is reached

Performance Minimum level
- The flush volume should be at least 6100 liters in the most part of the pumping cycles during the day
- Pump must work with the productivity measured during testing at the end of the works
- Pump starts when it reaches the level where the LSH floating valve is
- Pump stops when it reaches the level where the LSL floating valve is

Actions
- Incoming flow is much less than expected; increase the rest period between every pumping cycle
- Extract and check the pump (activity to be done by skilled labour)
- Try to move the floating valve LSH and LSHH; in case of unsuccessful, temporarily stop the VF2 UNSAT feeding and ask for the intervention of skilled labour to check the connections in the control panel or substitute the valve
- Try to move the floating valve LSL and LSLL; in case of unsuccessful, temporarily stop the VF2 UNSAT feeding and ask for the intervention of skilled labor to check the connections in the control panel or substitute the valve

Check 4.2
- Check the level of the oil one week after the change of the seal and then periodically (every 2/3000 hours of functioning). Insert a small pipe in the inspection hole, close the top opening of the pipe and extract the small pipe, recovering the oil remained in the bottom part of the pipe;
- Regular checking of the electrical system: measure the voltage and the current intensities; check the fuses and the mag thermic switches, as well as the setting of relay;
- Check every 2000 hours of functioning that the isolation resistance between the power cord and the ground is above the 20 Mohm

Anomalies found
- There is clear evidences of water emulsified with oil
- Grey or yellow water colour

Performance Minimum level
- The oil must neither has presence of water or emulsions nor colour different than usual standard one

Actions
- Change the oil and make a new check after one week. To change the oil the instruction of the pump service manual must be followed. If the one week later check has a negative result, the mechanical seal of the pump and/or the sealing rings must be checked.

Check 4.3
The pump should be checked at least once per year:
- Impeller and bearings
- External appearance

Anomalies found
- Presence of obstructions;
- Vibration or irregular noises during the functioning;
- Presence of broken or corroded parts

Actions
- Remove the obstructions;
- Check the impeller, the bearings and the suction cover and, if needed, substitute them by skilled labour.

Check 4.4

Check the overuse of the motor bearing every 2000 hours of functioning

Anomalies found
- Presence of more noises during the normal functioning

Actions
- Contact the supplier to substitute the bearings

Check 4.5
- Check the functioning of the valves i.e Gate valve and Check valve every 6 months;

Anomalies found
- Gate valve is hard to move;
- Also in case of closed gate, pump continue to transfer water to the bed;

Performance Minimum level
- Gate valve is easy to open and close
- With the valve closed, pump can't transfer water to the bed;

Actions
- Grease the hand wheel and repeat closing and opening several times; then leave the gate valve open
- Disable the corresponding pump; dismantle the valve and clean each component; in case of unsuccessful, individuate the failure and repair or substitute the valve.

Check 4.6
- Every 6 months check the inlet & outlet pipelines and bottom of pumping station;

Anomalies found
- The presence of obstructions in the inlet & outlet pipelines
- Presence of settled material on the bottom of pumping station;

Performance Minimum level
- No settled material on the bottom of pumping station

Actions
- Washing with pressure water the blocked pipes
- Settled material removal and its appropriate disposal

Check 4.7

- Check the integrity of the concrete structure every 3 years;

Anomalies found

- Concrete damages;
- rapid emptying of the tank due to leakages;

Performance Minimum level

- Concrete walls and coverage should be integer and without any damage
- No leakage;

Actions

- Repair the damages
- If there is a doubt on the perfect water tightness of the structure, fill the pumping station, set the general bypass C1 to avoid new influent wastewater towards the wetlands (Operation Mode 4, see Sheet n° 7: Setting for different operation modes) close for 3 hours every plugs in the 3 regulation manholes of the VF2 UNSAT beds and verify if there is a decrease of the water level in the tank. The presence of a leakage normally is evidenced by the presence of bubbles. In case of leakage, empty the tank and repair the damage with a proper product for cement waterproofing (i.e. osmotic mortar or similar)

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2.8 Sheet N°5: Unsaturated vertical subsurface flow wetland, VF2 UNSAT

Description

The VF2 UNSAT is divided in 3 beds to fit the local orography; the 3 beds host the 4 VF2 UNSAT lines for batch feeding (lines A, B, C, and D); each line sizes 18x8.5 m, i.e. about 150 m2; the total net surface of VF2 UNSAT is equal to about 600 m^2. (**Figure 2.10** - section; **Figure 2.12** - planimetry)

In order to allow ordinary (feeding system washing) and extra-ordinary management, the 4 different lines of the VF2 UNSAT stage 2 are served by two valve manholes (M1 and M2). The manholes are made of reinforced concrete with 1.30 x 1.30 m (internal dimensions); and internal height of 0.9 m. The entering pipe from the pumping station have installed n°2 PVC Tee90° with a reduction from ND160 to ND125, on which are installed n°2 gate valves ND125, respectively. The entering pipe end with a blind flange (**Figure 2.9**).

The pipes **inlet** to the manhole are:

- N° 1 Pead Pn10 ND160 from the pumping station

The pipes **outlet** to the manhole are:

- N°2 Pead Pn10 ND125 towards manhole the two hydraulically separated lines of the VF2 SAT stage

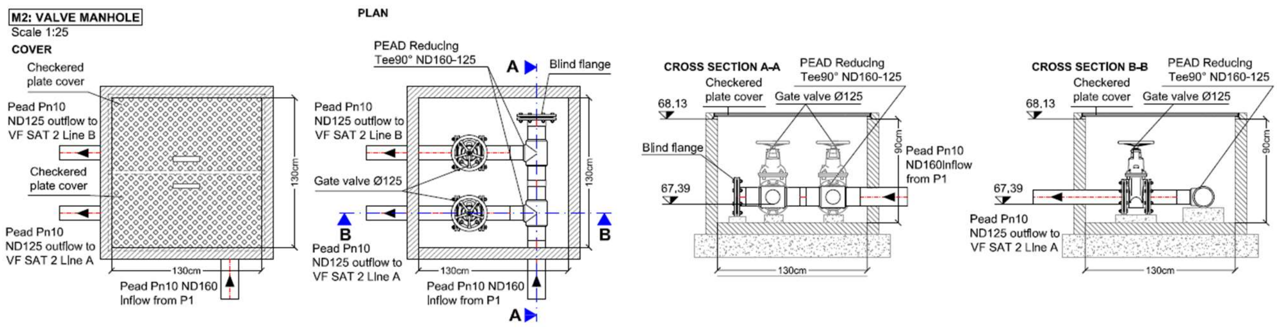

Figure 2.9: Planimetry and section of valve manhole M2

To test the potential also in terms of biodiversity increase, the 3 beds are filled with different aquatic species:

- Line A: *Iris Pseudacorus*
- Line B: *Scirpus Lacustris*
- Line C-D: *Juncus Effusus*, *Carex Acuta*

The VF2 UNSAT beds have the following characteristics (**Table 2.2**).

Table 2.2: VF2 UNSAT unit construction characteristics

Flow	m^3/d	10-100
Bottom surface area	m^2	600
Size and depth of filter media (starting from bottom)	m	0.20

20 – 40 mm round washed gravel **5-10 mm round, washed gravel** **sand 0,2-5 mm** **5-10 mm round, washed gravel**		0.20 0.40 0.20
Total Depth of filter media	m	1.00
Free board	m	0.30
Total Depth	m	1.30
Type of plants	-	*Typha latifolia, Iris pseudacorus, Carex spp, Scirpus lacustris*
Material of construction	-	Excavated in the soil, soil embankments, waterproofed with HDPE liner 1.5 mm

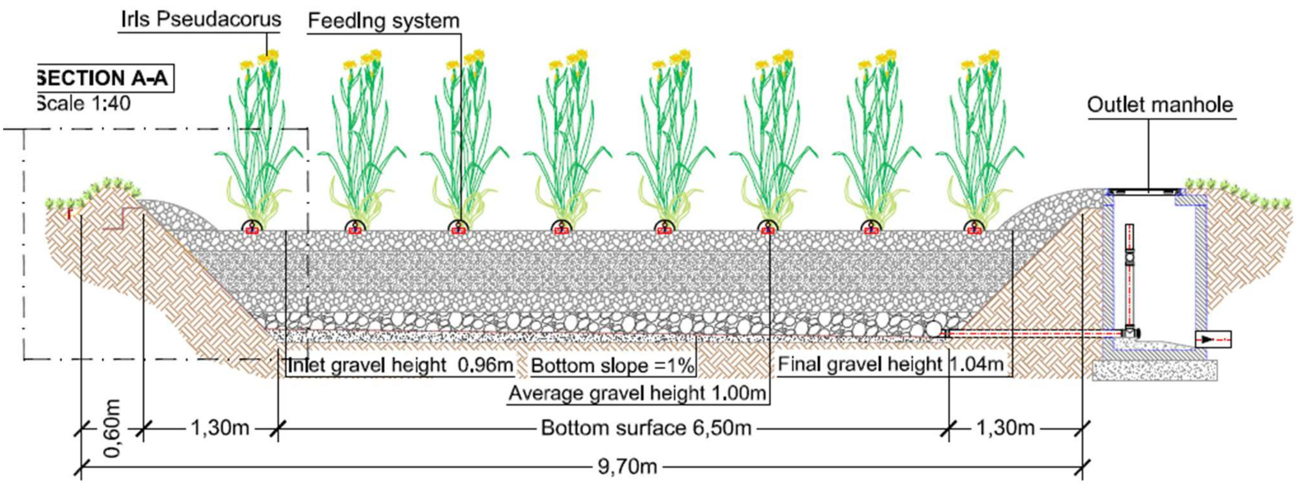

Figure 2.10: Section of VF2 UNSAT – Line A

The **feeding system** of the VF bed is constituted by several small pipelines with hole every 1 m connected to a main distribution pipe. The branches are closed at the end through plags for allowing regular washings. A line can be stopped by simply closing the corresponding gate valve in the valve manhole

- Valve manhole M1 for line A and B
- Valve manhole M2 for line C and D

The **drainage water pipe** of the VF bed is made by several slotted HDPE pipes connected on one side to a main pipe, linked to the outlet manhole; on the other side the slotted pipes reach the bed surface providing aeration on the lower part of the filter bed through a chimney. Downstream of the bed a water level control and sampling manhole is placed: inside the manhole a level control device achieved by segments of PVC pipe is located (**Figure 2.10**). The outlet pipe has three lateral openings, which can be individually blocked, for flooding, denitrification mode and emptying standard condition (from top to bottom). The water level device allows thus 3 settings:

- *Emptying bed. Standard condition*: set to maintain unsaturated the whole VF2 UNSAT bed and to empty the bed in case of denitrifcation mode or after the start-up starting flooded phase (**(1) Figure 2.11**);

- *Denitrification mode:* about + 30 cm from the bottom of of the VF2 UNSAT bed, it permits to develop partially saturated condition in the VF2 UNSAT and to sustain denitrification also at this stage (**(2) Figure 2.11**);
- *Start-up and flooding maintenance mode*: about +110 cm from the bottom of the VF2 UNSAT bed, flooding the bed with +10 cm above the gravel bed surface to control the weed during the planting phase of the start-up or for weed maintenance in general (**(3) Figure 2.11**)

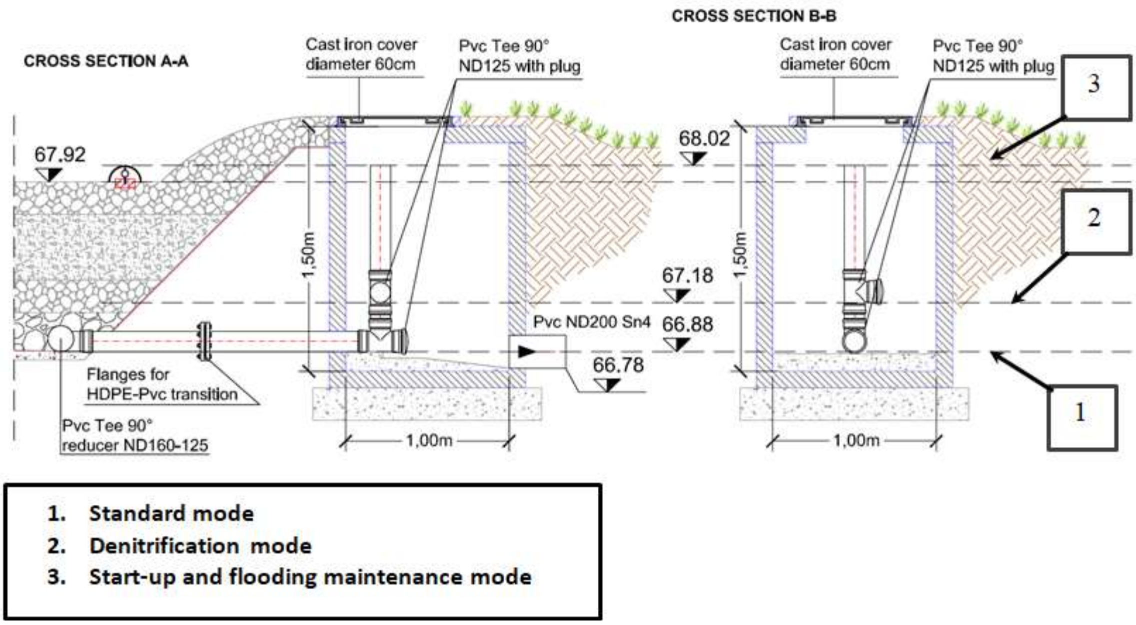

Figure 2.11: Outlet manhole of VF2 UNSAT bed – Line A

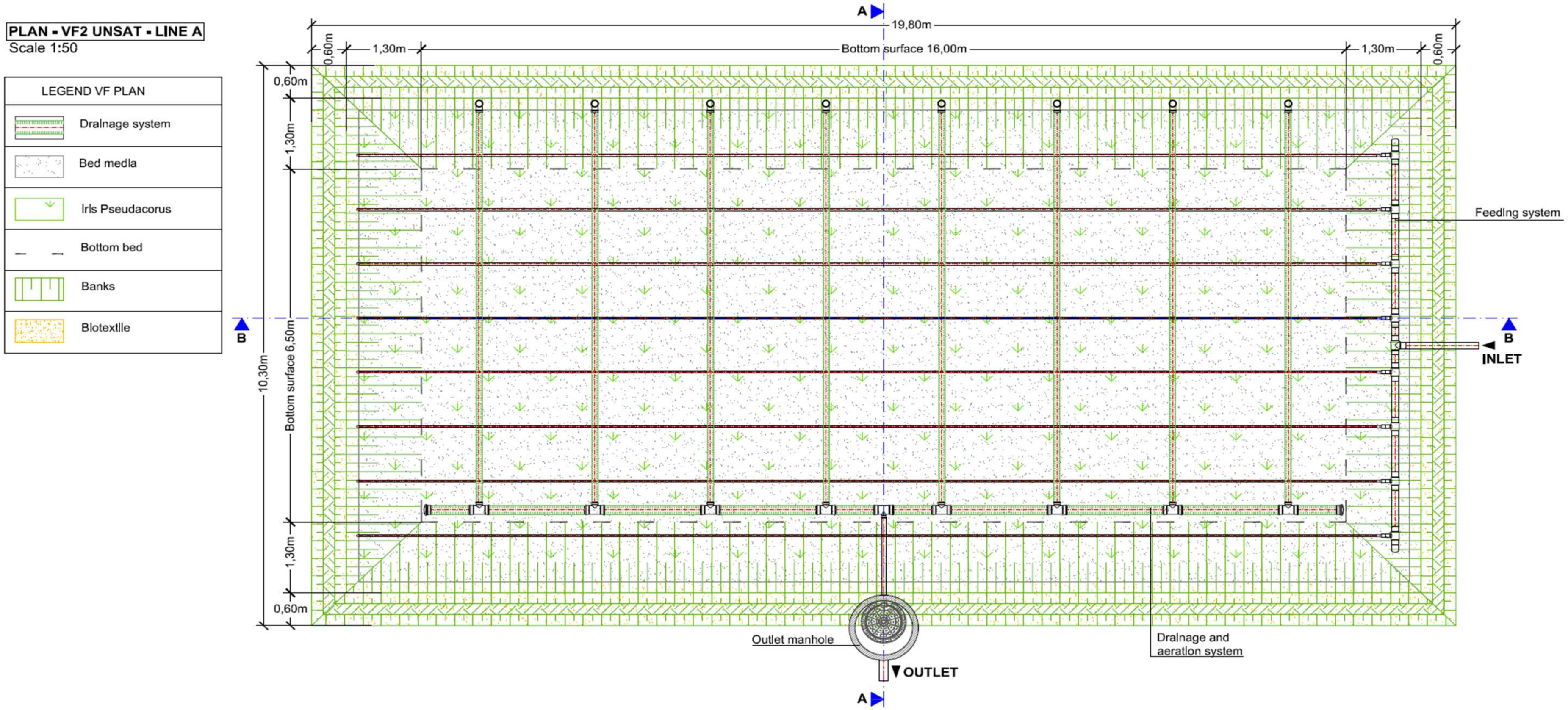

Figure 2.12: Planimetry of VF2 UNSAT – Line A

How to properly use

The **valve manholes** does not require any continuous operational and monitoring activities. In standard operational functioning, all the gate valves must stay open. Valves are closed only in case of extraordinary maintenance activities which require to by-bass and/or avoid to feed one or different sectors of the VF2 SAT stage.

The water level regulator should be set with the corresponding standard water level valve opened (**(1) Figure 2.11**) and all others closed.

To enhance denitrification it can be opened the second plug from the bottom (**(2) Figure 2.11**) and all others closed.

All controls and the maintenance may be done without the help of skilled labour, by personnel with specific knowledge on the functioning of the procedures contained in this manual.

The reeds cutting inside the bed must be made with the aid of mechanical or manual device; the first time after 2 years of operation, then each year. The plants should be cut at the base of the emerged part, without damaging the root zone.

Check 5.1

- Every 3 months and after intense storm events the integrity of the bed should be checked

Anomalies found

- Boundary trench damages;
- No-uniform distribution of reeds;
- Presence of disease on plants or damages caused by insects or animals;
- Presence of weeds.

Performance Minimum level

- The boundary trenches have not to be damaged
- The density of plant must be on average plus than 10 plants per square meter after the first year of operation.

Actions

- Damages have to be promptly repaired
- if the distribution of plants is not uniform you have to plant the lacking areas with new reeds; an unequal distribution could be generated by a not perfect distribution of the wastewater by the feeding pipes; in case of large areas on a feeding line is noticed for a long time after the second year of operation, it is suggested to uncover the pipe and control if no obstruction or other obstacle are present in proximity of the feeding system;
- in the case of plant diseases or damages caused by insects or animals the appropriate intervention will be given by qualified personnel;
- in the case of presence of weeds, their removal will be by hand or in extraordinary case with controlled flooding technique. It's particularly important to check for the presence of weeds during the reed's growing season, in order to avoid, with an urgent removal and control of invading weeds, their shadowing on growing stems of reeds.

<u>Check 5.2</u>

Every month check the surface of the beds

<u>Anomalies found</u>

- on the surface of the beds there are puddles or stagnant water during dry periods;
- a water level of more than 2 cm is present after more than 1 h from the end of the last loading on the top of the sand layer (20 cm below the surface);

<u>Performance Minimum level</u>

- The top surface has to be dry;
- The surface of the sand has to be wet, but not covered continuously by water, except during the loading and max 1 hour after the last load

<u>Actions</u>

- The system is strongly clogged: see the proper strategy in the trouble shooting section;
- The system is slightly clogged: see the proper strategy in the trouble shooting section;

<u>Check 5.3</u>

Every 6 months check of bed outlet pipeline, manhole outlet pipeline and bottom of manhole;

<u>Anomalies found</u>

- The presence of obstructions in the outlet pipe from the bed and in the pipeline from the manhole;
- Presence of settled material on the manhole bottom;

<u>Performance Minimum level</u>

- No settled material on the manhole bottom

<u>Actions</u>

- Washing with pressure water the blocked pipes
- Settled material removal and its appropriate disposal

<u>Check 5.4</u>

Every 6 months the valves of the valve manholes need to be checked:

- Check the functioning of the valves i.e Gate valve and Check valve every 6 months
- Gate valves are all open during standard functioning

<u>Anomalies found</u>

- Gate valve is hard to move;
- Gate valve are erroneously closed during standard functioning;

<u>Performance Minimum level</u>

- Gate valve is easy to open and close;
- Gate valves must be open during standard functioning

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2.9 Sheet N°6: Recirculation manhole towards VF1 SAT, R2

Description

The recirculation manhole R2 consists in a manhole with a 3 chambers

- N°1 inlet chamber, aimed to accumulate and calm the influent flow, in order to allow a uniform subdivision of the flow towards either or not recirculation stage
- N°2 outlet chambers, from which pipes feeding the next stages start

The inlet chamber is divided from the two outlet chambers by a 30 cm wall, shaped to permit to place up to n°5 solid blocks in lead per outlet chamber. The lead blocks permit to obtain different recirculation rates, according with the different operation modes (see Sheet n° 7: Setting for different operation modes). The manhole is made of reinforced concrete with 1.20 x 1.20 m (internal dimensions); and internal height of 0.8 m. The surface of the wall is coated with ceramic tile (**Figure 2.13**).

The pipes **inlet** to the manhole are:

- N° 1 PVC Sn4 ND200 from the manhole M4, which receives the treated wastewater from all the VF2 UNSAT lines

The pipes **outlet** to the manhole are:

- N°1 PVC Sn4 ND200 towards confluence manhole B0 (inlet to VF1 SAT stage)
- N°1 PVC Sn4 ND200 towards confluence manhole C2 (effluent the CW plant, towards the UF+UV unit)

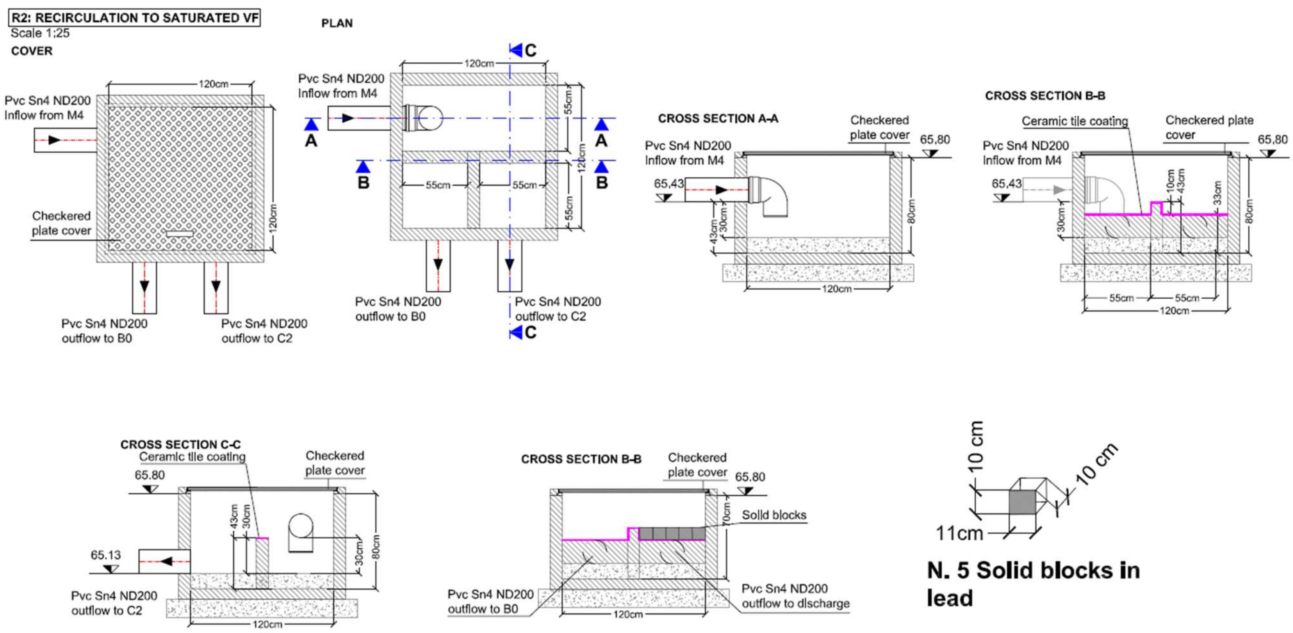


Figure 2.13: Planimetry and section of recirculation manhole R2

How to properly use it

The recirculation manhole does not require any continuous operational and monitoring activities. The position of the solid lead blocks must be changed only in case of a change of operation mode, following the indication given in Sheet n° 7: Setting for different operation modes.

Check 7.1

Every 6 months or every change of operation mode setting is needed to be checked:

- Solid blocks are placed in order to proper set the desired operation mode

Anomalies found

- Wrong operation mode;

Performance Minimum level

- Proper operation mode set function of solid blocks positioning

Actions

- Set the solid block positioning to the indications reported in Sheet n° 7: Setting for different operation modes.

2.8 Sheet N°7: Setting for different operation modes

The CW stage consists of a full scale system and two pilot systems, which are designed aiming to guarantee the Greek limits for wastewater reuse in irrigation in terms of TSS, BOD_5, TN as well as contributing in disinfection.

The full scale system is designed with two stages: 1st stage, saturated downflow VF (VF1 SAT); 2nd stage unsaturated intermitted load VF CW (VF2 UNSAT). Recirculation and by-pass chambers allow to test up to 4 different configurations, investigating the best scheme for Greek and also other Mediterranean conditions (e.g. different water quality standards for TN or different N:P ratio for fertigation).

Comparing to the design of the deliverable D3.2, the final design decided to limit the number of possibilities in terms of operational modes. This because the significant monitoring periods would be short, that is only the summer touristic peak seasons. Since we expect two summers as peak monitoring phases, the possibilities to test different configurations are limited. <u>To this aim, the final design removed the option to recirculate towards the UASB, maintaining only the recirculation towards the VF1 SAT as denitrification stage.</u>

The possible operational modes of the final design are:

- MODE 1: UASB + VF2 UNSAT + UV (no recirculation, nitrification, no denitrification):
- MODE 2: UASB + VF1 SAT + VF2 UNSAT +UV (no recirculation, nitrification, no denitrification, enhanced BOD_5 and TSS removal)
- MODE 3: UASB + VF1 SAT + VF2 UNSAT +UV plus recirculation to VF1 SAT (recirculation, nitrification, partial denitrification)
- MODE 4: UASB + UF + UV (no recirculation, nitrification, no nitrogen removal)

2.9 Operation MODE 1: UASB + VF2 UNSAT + UV

Operation MODE 1 (**Figure 2.14**) can be selected in case only the nitrification would be required. To this aim, no recirculation is provided, not using the VF1 SAT denitrification stage. The anaerobically treated wastewater flows by gravity towards by-pass manholes C1 and B1. The wastewater by-passes the VF1 SAT stage and is diverted from B1 towards the pumping system serving VF2 UNSAT stage, where the wastewater is uniformly distributed on the whole surface by a feeding system constituted by pressure pipes developed along the entire VF2 UNSAT surface. The feeding of VF2 UNSAT is in batch, feeding alternatively the four lines (either A, B, C, or D) according with the set batches and resting. Wastewater drains under the unsaturated bed and is collected at the bottom of the bed by the VF2 UNSAT drainage system, which delivers the wastewater towards the next stages. The wastewater by-passes the recirculation towards VF1 SAT R2 and is conveyed by gravity to a treated wastewater pumping system (not included in this detailed design). Finally, the wastewater is sent by pressure to the final UV stage (not included in this detailed design) for disinfection before to be used in agroforesty (WP4) system.

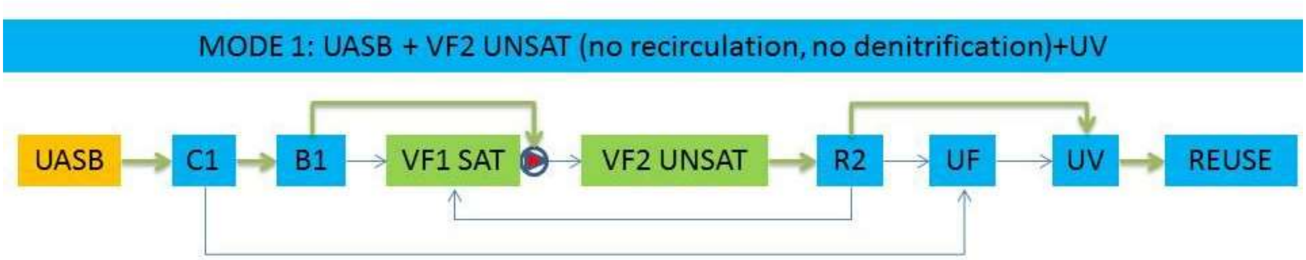
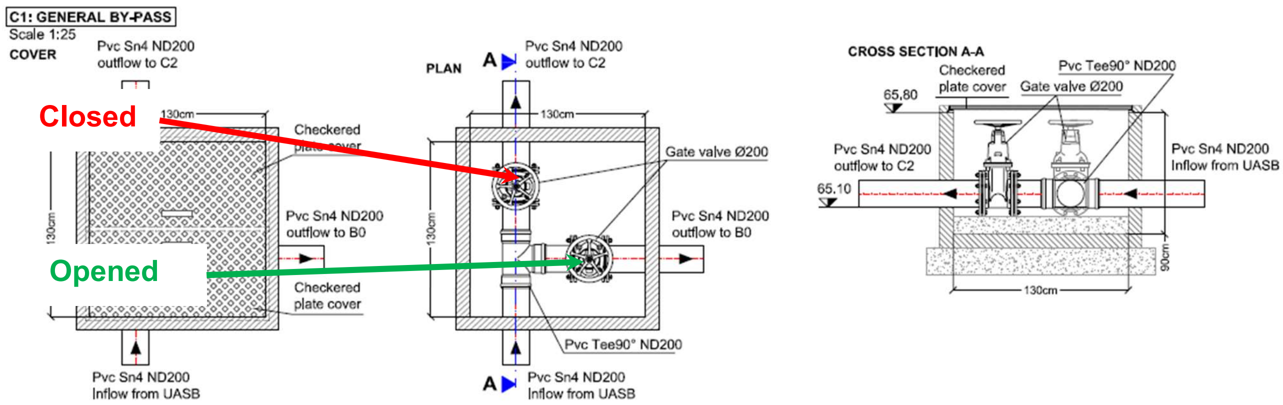
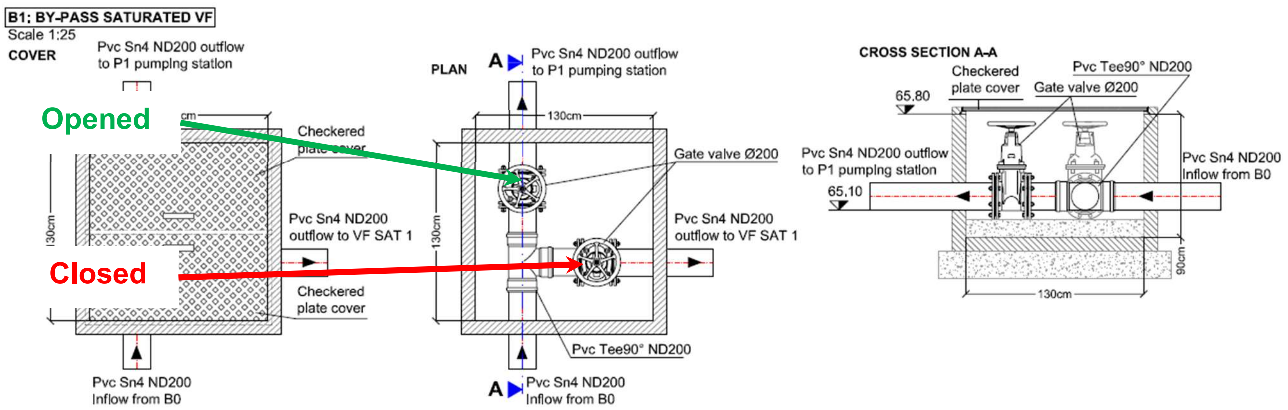


Figure 2.14: Schematization of MODE 1 operation modes of full scale Lesvos system: green arrows represent the functioning treatment chain, while the blue arrows the turned off options within the operational mode.

Table 2.3: C1, B1, and R2 manhole setting for operational MODE 1

<table>
<tr><td>MODE 1: UASB + VF2 UNSAT + UV
No recirculation, no denitrification</td><td>1/2</td></tr>
<tr><td colspan="2">General by-pass manhole, C1
● Gate valve DN200 towards manhole C2: closed
● Gate valve DN200 towards manhole B0: opened

</td></tr>
<tr><td colspan="2">By-pass manhole VF1 SAT, B1
● Gate valve DN200 towards pumping station P1: opened
● Gate valve DN200 towards VF SAT1: closed

</td></tr>
</table>

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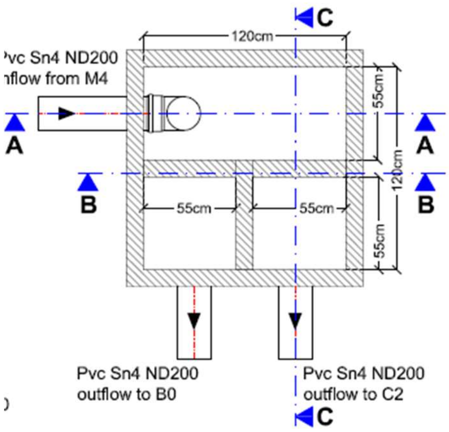
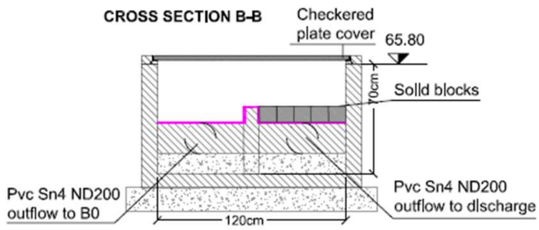
MODE 1: UASB + VF2 UNSAT + UV **No recirculation, no denitrification**	**2/2**

Recirculation manhole, R2

- n° of block towards B0 (VF1 SAT) **5 (no flow – no recirculation)**
- n° of block towards B0 (VF1 SAT) **0 (all the flow – no recirculation)**





	Towards manhole B0 (VF1 SAT)					**Towards manhole C2 (effluent UF + UV)**				
R=0						Q				

Scheme of blocks for operational MODE 1 (no recirculation). Each dark grey cell indicate the positioning of one block

2.10 Operation MODE 2: UASB + VF1 SAT + VF2 UNSAT +UV

Operation MODE 2 (**Figure 2.15**) can be selected in case the TSS and BOD5 removal would be enhanced exploiting also the VF1 SAT first stage, but without recirculation (i.e. without denitrification). In other words, VF1 SAT functions also as “safety” stage before the VF2 UNSAT stage, which is filled by sand and is more sensitive to potential sludge escaping from UASB reactor. The anaerobically treated wastewater flows by gravity towards by-pass manholes C1 and B1. The wastewater is conveyed by gravity from B1 to the VF1 SAT stage, where the wastewater is uniformly distributed on the whole surface by a feeding system constituted by gravity pipes developed along the entire VF1 surface. The feeding of VF1 SAT is continuous. Wastewater drains with a downward plug functioning under saturated conditions and is collected at the bottom of the bed by the VF2 UNSAT drainage system, which delivers the wastewater towards the pumping system serving VF2 UNSAT stage. The wastewater is taken from the VF2 UNSAT pumping station and is uniformly distributed on the whole surface by a feeding system constituted by pressure pipes developed along all the VF2 UNSAT surface. The feeding of VF2 UNSAT is in batch, feeding alternatively the four lines (either A, B, C, or D) according with the set batches and resting periods defined SHEET N°4: Pumping station. The wastewater drains under the unsaturated bed and is collected at the bottom of the bed by the VF2 UNSAT drainage system, which delivers the wastewater towards the next stages. The wastewater by passes the recirculation to VF1 SAT stage (R2) and is conveyed by gravity to a treated wastewater pumping system (not included in this detailed design). Finally, the wastewater is sent by pressure to the final UV stage (not included in this detailed design) for disinfection before to be used in agroforesty (WP4) system.

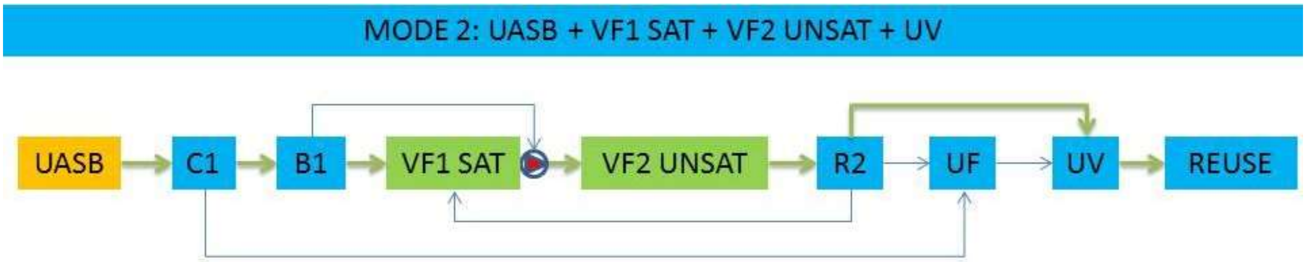


Figure 2.15: Schematization of MODE 2 operation modes of full scale Lesvos system: green arrows represent the functioning treatment chain, while the blue arrows the turned off options within the operational mode.

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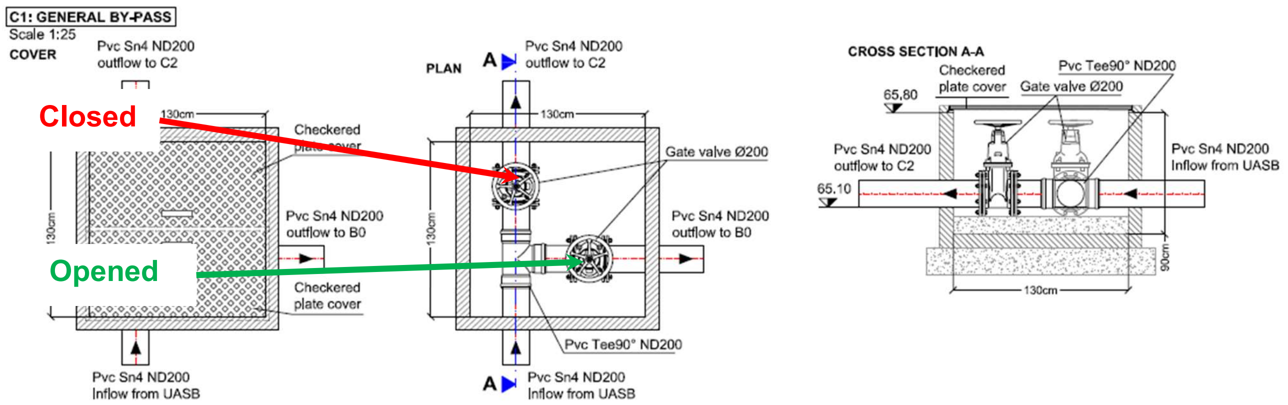
Table 2.4: C1, B1, and R2 manhole setting for operational MODE 2

MODE 2: UASB + VF1 SAT + VF2 UNSAT + UV **No recirculation, nitrification, no denitrification, enhanced BOD5 and TSS removal**	**1/2**

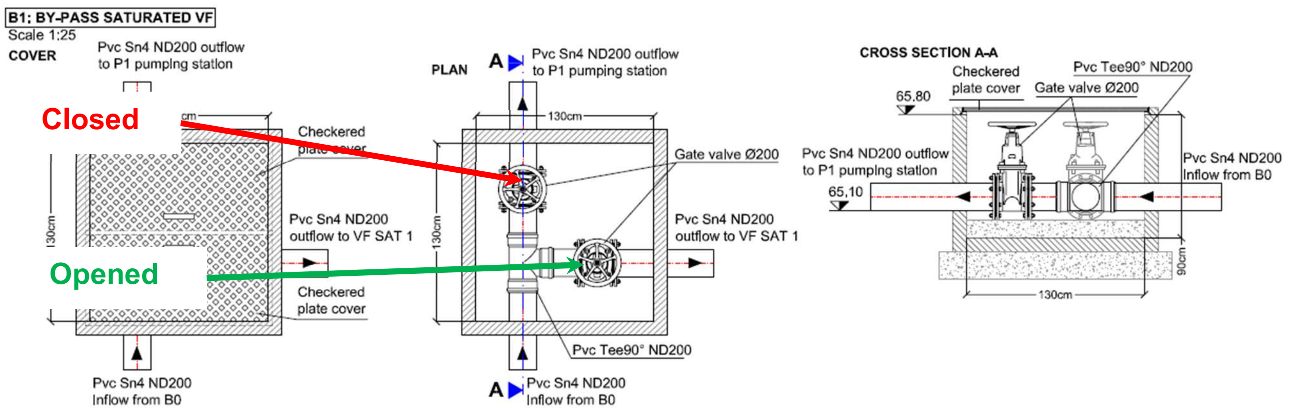
General by-pass manhole, C1

- Gate valve DN200 towards manhole C2: **closed**
- Gate valve DN200 towards manhole B0: **opened**



By-pass manhole VF1 SAT, B1

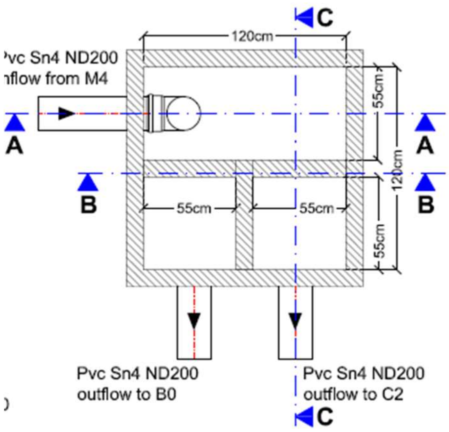
- Gate valve DN200 towards pumping station P1: **closed**
- Gate valve DN200 towards VF SAT1: **opened**

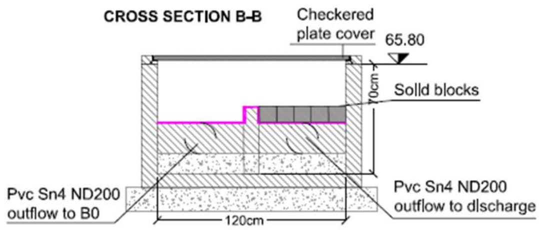


MODE 2: UASB + VF1 SAT + VF2 UNSAT + UV No recirculation, nitrification, no denitrification, enhanced BOD_5 and TSS removal	2/2

Recirculation manhole, R2

- n° of block towards B0 (VF1 SAT) **5 (no flow – no recirculation)**
- n° of block towards B0 (VF1 SAT) **0 (all the flow – no recirculation)**





	Towards manhole B0 (VF1 SAT)					Towards manhole C2 (effluent UF + UV)				
R=0						Q				

Scheme of blocks for operational MODE 2 (no recirculation). Each dark grey cell indicate the positioning of one block

2.11 Operation MODE 3: UASB + VF1 SAT + VF2 UNSAT +UV plus recirculation to VF1 SAT

Operation MODE 3 (**Figure 2.16**) can be selected in case both nitrification and denitrification would be required. To this aim, recirculation towards the VF1 SAT is activated. Therefore, this option exploits the VF1 SAT both as denitrification stage and as an additionally saturated bed for TSS and COD removal (as detailed in MODE 2 description). The anaerobically treated wastewater flows by gravity towards by-pass manholes C1 and B1. The wastewater is conveyed by gravity from B1 to the VF1 SAT stage, where the wastewater is uniformly distributed on the whole surface by a feeding system constituted by gravity pipes developed along the entire VF1 surface. The feeding of VF1 SAT is continuous. Wastewater drains with a downward plug functioning under saturated conditions and is collected at the bottom of the bed by the VF2 UNSAT drainage system, which delivers the wastewater towards the pumping system serving VF2 UNSAT stage. The wastewater is taken from the VF2 UNSAT pumping station and is uniformly distributed on the whole surface by a feeding system constituted by pressure pipes developed along all the VF2 UNSAT surface. The feeding of VF2 UNSAT is in batch, feeding alternatively the four lines (either A, B, C, or D) according with the set batches and resting periods defined in SHEET N°4: Pumping station. The wastewater drains under the unsaturated bed and is collected at the bottom of the bed by the VF2 UNSAT drainage system, which delivers the wastewater towards the next stages. The wastewater is sent to the recirculation to VF1 SAT stage (R2). Therefore, part of the VF2 UNSAT effluent is recirculated by gravity to VF1 SAT and another portion is conveyed by gravity to a treated wastewater pumping system (not included in this detailed design). Finally, the wastewater is sent by pressure to the final UV stage (not included in this detailed design) for disinfection before to be used in agroforesty (WP4) system.

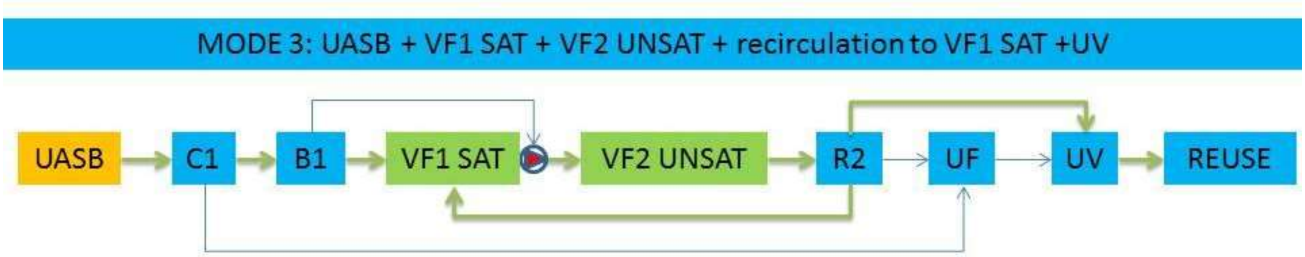
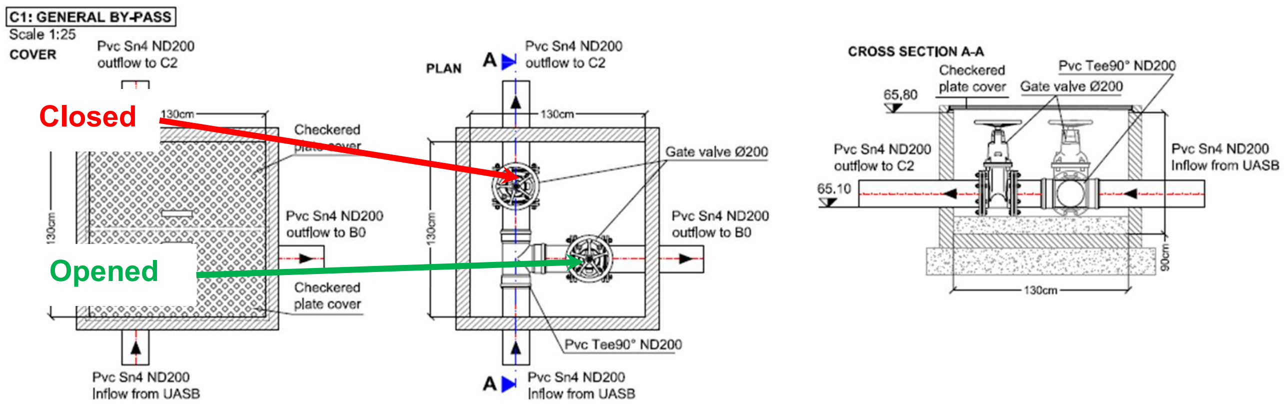
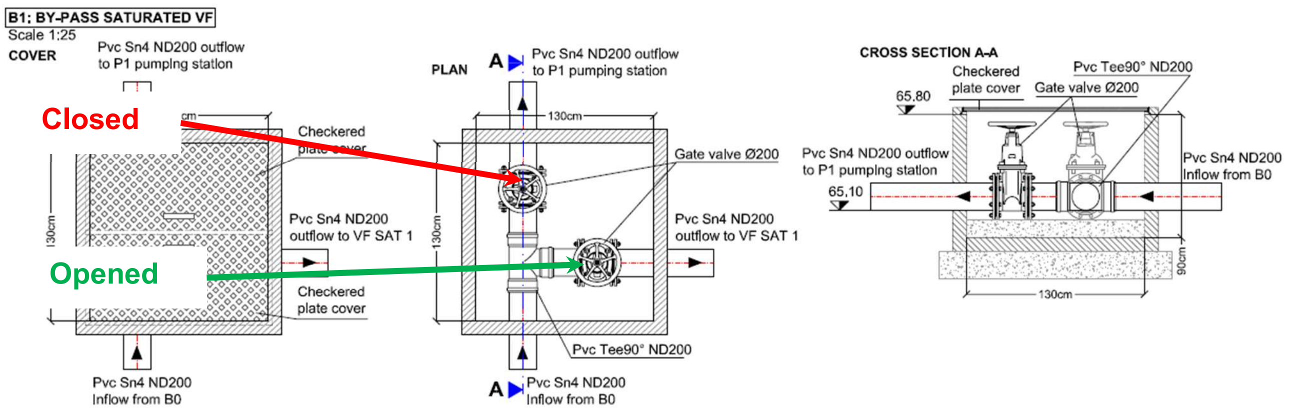


Figure 2.16: Schematization of MODE 3 operation modes of full scale Lesvos system: green arrows represent the functioning treatment chain, while the blue arrows the turned off options within the operational mode.

Table 2.5: C1, B1, and R2 manhole setting for operational MODE 3

MODE 3: UASB + VF1 SAT + VF2 UNSAT + UV plus recirculation to VF1 SAT Recirculation, nitrification, partial denitrification	1/2
General by-pass manhole, C1 ● Gate valve DN200 towards manhole C2: closed ● Gate valve DN200 towards manhole B0: opened 	
By-pass manhole VF1 SAT, B1 ● Gate valve DN200 towards pumping station P1: closed ● Gate valve DN200 towards VF SAT1: opened 	

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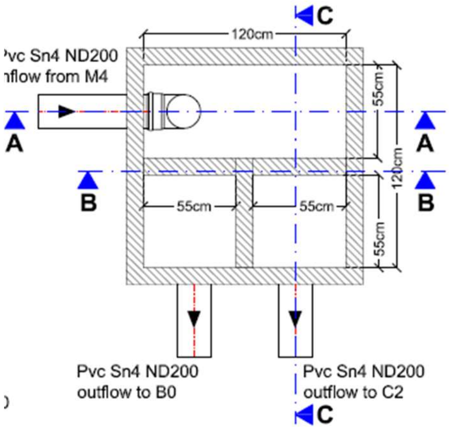
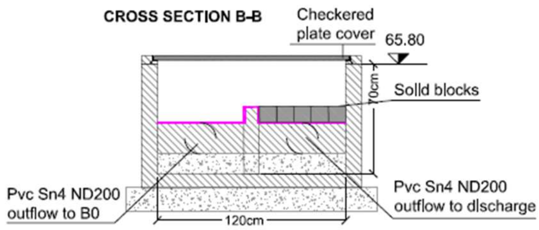
MODE 3: UASB + VF1 SAT + VF2 UNSAT + UV plus recirculation to VF1 SAT Recirculation, nitrification, partial denitrification	2/2

Recirculation manhole, R2

- n° of block towards B0 (VF1 SAT) **from 0 to 4 (from 1:1 to 1:5 recirculation rates)**
- n° of block towards B0 (VF1 SAT) **from 0 to 4 (from 1:1 to 1:5 recirculation rates)**





	Towards manhole B0 (VF1 SAT)					Towards manhole C2 (effluent UF + UV)				
R=1:5					Q	5Q				
R=1:4					Q	4Q				
R=1:3					Q	3Q				
R=1:2					Q	2Q				
R=1:1					Q	Q				

Examples of different recirculation ratio that can be set with different schemes of blocks for operational MODE 3 (recirculation). Each dark grey cell indicate the positioning of one block

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2.12 Operation MODE 4: UASB + UF + UV

Operation MODE 4 (**Figure 2.17**) can be selected to test the possibility to have neither nitrification nor denitrification, and to reuse anaerobically treated wastewater after only an ultrafiltration (UF) and a disinfection (UV) stages. To this aim, no recirculation is provided, not using the denitrification stage into VF1 SAT. Moreover, all the CW stages are by-passed. The anaerobically treated wastewater flows by gravity towards the general by-pass manhole C1. The wastewater by-passes both the VF1 SAT and VF2 UNSAT stages and is diverted from C1 by gravity to a treated wastewater pumping system (not included in this detailed design). Finally, the wastewater is sent by pressure to the UF and final UV stage for disinfection before to be used in agroforesty (WP4) system.

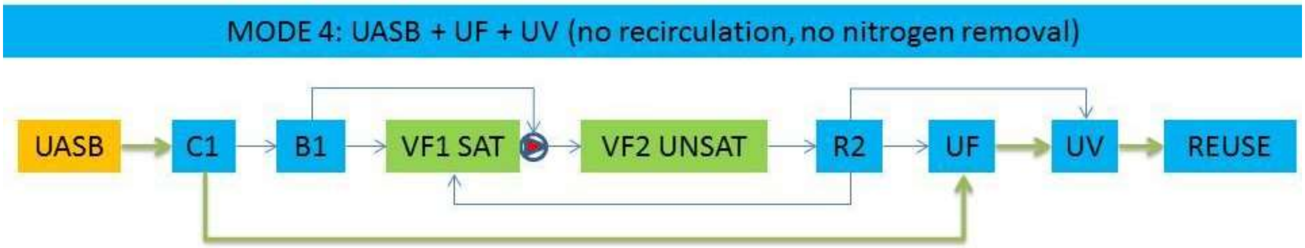
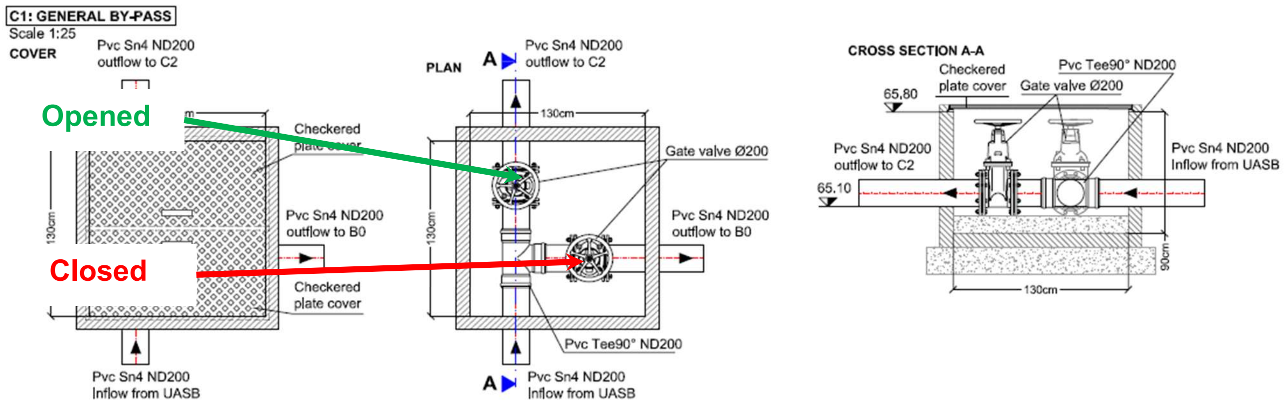


Figure 2.17: Schematization of MODE 4 operation modes of full scale Lesvos system: green arrows represent the functioning treatment chain, while the blue arrows the turned off options within the operational mode.

Table 2.6: C1 manhole setting for operational MODE 4; setting of B1, and R2 manhole are not relevant for operational MODE 4

MODE 4: UASB + UF + UV **No recirculation, nitrification, no nitrogen removal**	**1/1**
General by-pass manhole, C1 ● Gate valve DN200 towards manhole C2: **opened** ● Gate valve DN200 towards manhole B0: **closed**	



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3. MAINTENANCE MANUAL

3.1 Routine Operation

All the operations and actions mentioned in the maintenance plan, if not expressly written, are carried out by unskilled labour.

Management actions to be carried out, regardless of the sub controls and performance

SCHEDULE	ACTIONS
EVERY YEAR	1. Removal of settled sludge in the Anaerobic Treatment system (ATS) (with disaggregation of the scum every 3 months) and Main Pumping Station 2. Removal of weeds culms on the surface of the VF CWs with manual or mechanical equipment (bush cutter) 3. Check for the electrical insulation and protection 4. Visual inspection of boundary walls; painting and greasing steel structures
EVERY 2 YEARS	Pumps and electric control panel revision
EVERY 3 YEARS	Concrete structures and coverage revision

It should also be provided for the maintenance of the nearby area and surroundings of the treatment plant 3-4 times a year:

- Cutting of lawn (shrubs etc.);
- Maintenance of side paths and site access;

3.2 Checks, performances and management actions subprogram

Schedule	Component	Checks Subprogram	Performances Subprogram	Management actions Subprogram
Every week	Pumping station	Pumps and pumping cycles	See check 4.1	See check 4.1
Every 3 months	VF1 SAT and VF2 UNSAT	Check the bed: plants	Plants density > $10/m^2$	New plantation in lacking area
	VF1 SAT and VF2 UNSAT	Check the bed: sickness plants	Absence of sick plants and damages caused by insects or animals	Appropriate intervention by trained personnel
	VF1 SAT and VF2 UNSAT	Check the bed: weeds plants	Absence of weeds	Manual removal
	VF1 SAT and VF2 UNSAT	Check the bed: boundary trenches	Trenches must be undamaged	Restoration of the trenches designed
Every 6 months	VF2 UNSAT	Check the surface of the beds	Dry or slight wet, no puddles or stagnant water during dry periods	Strong clogging: see the proper strategy in the trouble shooting section
	VF2 UNSAT	Check the surface of the beds	No water, or <2 cm on the top of the sand layer (20 cm below the surface) after loading	Slight clogging: see the proper strategy in the trouble shooting section
	VF1 SAT	Check the surface of the beds at the inlet	Dry, no puddles or stagnant water during dry periods	Check the outlet regulation manhole if the standard level is correctly set. Check if the gravel level is uniform. It could be a clogging alarm: see the proper strategy in the trouble shooting section
	VF1 SAT and VF2 UNSAT: water level control and sampling wells	Check of outlet pipelines of the bed and of the well	No fouling: flow, even if minimal, continuous	Washing with under pressure water

	VF1 SAT and VF2 UNSAT: water level control and sampling wells	Check of the well bottom	Absence of settled material on the bottom	Appropriate removal and disposal of settled material
Every 3 years	Pumping Station	Check of the perfect watertight of the bed	Free surface = level of outlet pipeline bottom	Empty the bed and find the leak

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3.3 Summary of operation actions to be carried out

FREQUENCY	OPERATION
EVERY 15 DAYS	1. Check of Inlet and Outlet devices 2. Check of water level In CW systems 3. Check of bad odour 4. Check of functioning of electro-mechanical tools
EVERY MONTH	Check of sludge level in the Main Pumping Station
EVERY 3 MONTHS	Check of CW beds for sickness plants, weed plants and boundary brick walls
EVERY 6 MONTHS	Check the surface of CW beds, outlet pipelines of the bed and manhole, manhole bottom

3.4 Troubleshooting

3.4.1 Clogging problems in VF2 UNSAT

Immediate action has to be taken in the case of clogging. A VF can recover well after a resting period of two-three weeks in sunny and dry season, where the filter bed can dry out.

Once clogged, a VF system does not recover without resting periods.

If clogging occurs, the procedure is to disconnect the clogged sector for a period of 3 weeks, closing the corresponding valve.

3.4.2 Clogging problems in VF1 SAT

Based on the performance of existing saturated subsurface flow wetlands (usually horizontal flow), if VF1 SAT is at the first stage, inlet zone maintenance will be needed approximately every 10-15 years to avoid a large degree of overland flow; if VF1 SAT is placed at the final stage and the most part of solids are removed before it (by UASB), inlet zone maintenance could occur after 20 years or more. From an operational point of view, bed clogging can be diagnosed as overland flow in the inlet region, and adjustments to the effluent water level control structure will not correct the problem.

If the bed presents a constant superficial runoff of wastewater, probably some clogging problem is occurring in the feeding section of the system. Different levels of interventions could be programmed to solve the problem; start from the first and pass to the subsequent if the obtained results are not satisfying (i.e. the superficial runoff is disappear):

1. Control the correct functioning of the regulation manhole and if the bottom of the standard open screw plug corresponds to a quota at least -10 cm below the gravel surface;
2. wash the feeding section with pressure water; the water have to be pumped firstly in the feeding pipe from the inspection manhole, then from each vertical ND125 pipe serving the different feeding pipe along the whole width of the bed (n°6 ND125 pipes);
3. flood the bed closing the standard screw plug in the regulation manhole and opening the flooding plug; after 1 day opening again the standard plug, observe if sludge are remained on the surface and remove them after 2-3 days when they will be dried;
4. remove the gravel in the first cm on the top of the bed along the feeding pipes, check the integrity of the distribution system and if damaged repair it;
5. stop the plant loading; remove the feeding system and extract the gravel in the feeding section until the surface water is observed, being careful to not damage the liner; clean the gravel (or alternatively replace it with new ones) and after reset the gravel and the distribution system as per the initial design.
6. If no significant effects are observed and the superficial runoff occurs again after few weeks, the basic options (to be evaluated analysing the type of clogging and comparing the costs of the various alternatives) are:
    - Remove the clogged-bed media and replace with new material. It could be an expensive option because not only must the replacement media be purchased, but there will be evaluated also the disposal costs of the clogged media, depending by media chemical analysis, final destination and local rules;
    - Removing the clogged-bed media, washing it, and returning it to the wetland bed. This method in some cases may be preferable to purchasing new bed media, but it will be necessary adequate washing equipment and also there will likely be disposal costs associated with the extracted biosolids.

ANNEX 1: OPERATIONS PROCEDURES – GENERAL GUIDELINES

Steel Pipes

Installation procedures

The pipe should be identified by

1. nominal diameter in inches or mm
2. nominal pressure rate in psi or bar
3. material
4. manufacturer
5. production year
6. specification used for production/testing or recommendations.

Welding or bolting normally does the connections.

The installation by welding of new pipe includes following steps:

1. check if materials and tools are correctly available at site
2. check nominal diameter, nominal pressure and material of the pipe
3. check if the excavation is deeper as scheduled one
4. check if the bottom of excavation if reasonably smooth, if stones or hard components are presents; if ground is not acceptable, put sand or similar, proceeding for levelling
5. put the extremity of pipe to be installed face-to-face to the extremity of the existing one supporting the pipe using wooden frame if necessary
6. connect the earthing of welding machine to the pipe, firmly
7. weld at 90° in four points (tack-welding) using adequate diameter and material for welding rods and adequate untensity for welding machine
8. check the concentricity
9. weld completely, referring to the welding procedures
10. go forth, repeating items 5 to 9 at the second extremity with a new pipe
11. finally close the line and pressurise it looking for leakage
12. if leakage, repair it
13. if no leakage, protect the welded joints with the appropriate item (tar or similar)
14. place the pipe in adequate location, backfilling with sand or soft material
15. report number of pipes used, who, where, when the installation has been done
16. report at storage the used material
17. disinfect the pipe with chlorine (25 mg/l for 24 hrs or 500 mg/l for 30 minutes)
18. flush with fresh water before putting in operation.

The installation by bolting of new pipe include following steps:

1. check if materials and tools are correctly available at site
2. check nominal diameter, nominal pressure and material of the pipe
3. check if the excavation is deeper as scheduled one
4. check if the bottom of excavation if reasonably smooth, if stones or hard components are presents; if not put sand or similar, proceeding for levelling
5. clean the machined parts of the flanges of both the pipes
6. put the extremity of the installing pipe face-to-face to the extremity of the existing one supporting the pipe with wooden supports
7. insert the seal

8. fix the bolts, tighting manually (check the correct use for nuts)
9. check the concentricity
10. tight at nominal torque, acting in clockwise direction in two complete cycles
11. go forth repeating items 5 to 10 at the extremity of the second pipe
12. finally close the line and pressurise it looking, for leakage
13. if leakage are presents, tight additionally the related bolts
14. place the pipe in adequate location, backfilling with sand or soft material
15. report number of pipes used, who, where, when the installation have been done
16. report at storage the used material
17. disinfect the pipe with chlorine (25 mg/l for 24 hrs or 500 mg/l for 30 minutes)
18. flush with fresh water before putting in operation.

Maintenance and storage

The main problem with the storage of steel pipe is the oxidation; different solution are available for the pipe, but the two most used are the protective action of tar and the hot dip galvanisation; both in any case are in the outside wall of the pipe.

For correct maintenance pls.

1. at arrival, check if the delivered material is in accordance with the requested one for nominal diameter, pressure, material and quantity
2. fill the form for storage
3. for the accepted pipes, clean internally the pipes, using compressed air
4. grease outside both the extremities of the pipe
5. fix plastic cover, or PE film, fixing it using tape or soft wire
6. store using wooden large supports, avoiding deformation in the pipe
7. in case of storage in open environment, cover with corrugated sheet
8. remember that shocked or similar damaged areas are the preferred locations for oxidation.

Repairing procedures

A damaged pipe shall be repaired according to the size and the shape of the damage itself; in general we'll have hole (i.e. close to circular damage) or strip (two orthogonal dimensions are different) in longitudinal or orthogonal position to the flow.

The repairing small holes procedure includes following steps:

1. locate the broken area
2. excavate to reach the broken pipe
3. support the pipe using wooden supports for freely working in the broken section
4. clean the outside of the pipe as much as possible, using abrasive system
5. check for depressurising of the line
6. place the correct clamp around the pipe (bolts in opposite direction to the hole)
7. check for correct positioning of the seal
8. tight the bolts to reach the nominal torque
9. pressurise it the pipe line, looking for leakage
10. if not, re-install the protective coat
11. backfill with the excavated soil
12. disinfect using concentrate chlorine 25 mg/l for 24 hours or 500 mg/l for 30 minutes
13. flush with clear water before putting in operation.
14. report who, where, when and why to the management

15. fill the form for used materials to storage.

The replacement by welding of damaged pipe includes following steps:
1. check if materials and tools are correctly available at site
2. check nominal diameter, nominal pressure and material of the pipe
3. check if the excavation id deeper as scheduled one
4. check if the bottom of excavation if reasonably smooth, if stones or hard components are presents; if not backfill using sand or similar soft materials
5. check if the line is depressurised (no water inside); dry
6. mark on the section to be cutted using a flat flexible steel plate or similar
7. cut the pipe by grinding (better) or blowpipe looking for the smoothest as possible
8. smooth the extremity and clean inside from dust
9. put the extremity of the pipe to be installed face-to-face to the extremity of the existing one, supporting if necessary using wooden frame
10. weld at 90° in four points (tack-welding), using a appropriate welding rods and amps
11. check the concentricity
12. weld completely, referring to the welding procedures
13. go forth to the second extremity
14. finally close the line and pressurise it looking for leakage
15. if not, protect the welded sections with the appropriate item (tar or similar)
16. place the pipe in adequate location, backfilling with sand or soft material
17. disinfect using concentrate chlorine 25 mg/l for 24 hours or 500 mg/l for 30 minutes
18. flush with clear water before putting in operation.
19. report who, where, when and why to the management
20. fill the form for used materials to storage.

The replacement by bolting of damaged pipe includes following steps:
1. check if materials and tools are correctly available at site
2. check nominal diameter, nominal pressure and material of the pipe
3. check if the excavation is deeper as scheduled one
4. check if the bottom of excavation if reasonably smooth, if stones or hard components are presents; if not backfill using sand or similar soft materials, levelling it
5. unscrew the connecting flanges
6. in case of heavy oxidation use light petrol or similar
7. remove the damaged section of pipe
8. clean the machined parts of the flanges of both the pipes
9. put the extremity of the pipe to be installed face-to-face to the extremity of the existing one, supporting if necessary by wooden frame
10. insert the seal
11. fix the bolts, tighting manually
12. check the concentricity
13. tight at nominal torque, acting in clockwise direction in two complete cycles
14. go forth, repeating items 7 to 12 at second extremity of the pipe
15. finally close the line and pressurise it looking for leakage
16. place the pipe in adequate location, filling with sand or soft material
17. report number of pipes used, who, where, when the installation has been done
18. report at storage the used material.
19. disinfect using concentrate chlorine 25 mg/l for 24 hours or 500 mg/l for 30 minutes

20. flush with clear water before putting in operation.

HDPE and PVC Pipes

<u>Installation procedures</u>

The pipe should be identified by

1. nominal diameter in inches or mm
2. nominal pressure rate in psi or bar
3. material
4. manufacturer
5. production year
6. specification according which the pipe is made

The installation of new HDPE pipes includes the following steps:

1. check if materials and tools are correctly available at site
2. check nominal diameter, nominal pressure and material of the pipe
3. check if the excavation is deeper as scheduled one
4. check if the bottom of excavation if reasonably smooth, if stones or hard components are presents; if not put sand or similar, proceeding for levelling
5. prepare the extremity of pipe to be installed referring to the attached sketch
6. insert in the extremity of the pipe the threaded collar of the connection
7. push the prepared extremity to the existing one with seal, looking for not damaging the seal; better result if the pipe to be inserted is greased
8. put the new pipe face-to-face to the extremity of the existing one supporting it using wooden frame if necessary
9. insert in the extremity of the pipe the threaded collar of the connection
10. push the prepared extremity to the existing one with seal, looking for not damaging the seal; better result if the pipe to be inserted is greased
11. check the concentricity
12. check the inserted length of the pipe
13. torque the threaded collars
14. go forth with the line
15. finally close the line and pressurise it looking for leakage
16. place the pipe in adequate location, filling with sand or soft material
17. report number of pipes used, who, where, when the installation has been done
18. report at storage the used material
19. disinfect the pipe with chlorine (25 mg/l for 24 hrs or 500 mg/l for 30 minutes)
20. flush with fresh water before putting in operation.

<u>Maintenance and storage</u>

The main problem with the storage of hdpe pipe is:

1. to prevent from dirty inside
2. to prevent from sunlight deterioration
3. to prevent from plastic deformation.

For correct maintenance in storage:

1. at arrival, check if the delivered material is in accordance with the requested one for nominal diameter, pressure, material and quantity
2. fill the form for storage
3. clean internally the pipe, using compressed air
4. grease the extremities of the pipe
5. fix plastic cover, or PE film, fixing it using tape or soft wires
6. store using wooden large supports, avoiding deformation in the pipe
7. in case of storage in open environment, cover with corrugated sheet.

Repairing procedures

A damaged pipe shall be repaired according to the size and the shape of the damage itself; in general we'll have hole (i.e. close to circular damage) or strip (two orthogonal dimensions are different) in longitudinal or orthogonal position to the flow.

A quick and small failure repairing procedure include the following steps

1. locate the broken area
2. excavate to reach the broken pipe
3. support using wooden support for freely working in the broken section
4. clean the outside of the pipe as much as possible
5. check for depressurising of the line
6. place the correct clamp around the pipe (bolts in opposite direction to the hole)
7. tight the bolts to reach the nominal torque
8. pressurise the pipe line, looking for leakage
9. re-install the protective coat
10. backfill with the excavated soil
11. report who, where, when and why to the management.

The Replacement of a section of a damaged pipe procedure foreseen:

1. check if materials and tools are correctly available at site
2. check nominal diameter, nominal pressure and material of the pipe
3. check if the excavation id deeper as scheduled one
4. check if the bottom of excavation if reasonably smooth, if stones or hard components are presents; if not, backfill using sand or similar soft material, levelling it
5. check if the line is depressurised
6. mark clearly the diameter for cutting, using a soft steel or similar strip
7. cut away the defective length of the pipe using grinder
8. remove the damaged section of pipe
9. clean the cutted part of the pipe
10. prepare the extremity as per indicated sketch
11. cut a new section of pipe having the same length of the original removed one
12. prepare the extremity of pipe to be installed referring to the attached sketch
13. insert in the extremity of the pipe the threaded collar of the connection
14. push the prepared extremity to the existing one with seal, looking for not damaging the seal; better result if the pipe to be inserted is greased
15. put the new pipe face-to-face to the extremity of the existing one supporting it using wooden frame if necessary
16. insert in the extremity of the pipe the threaded collar of the connection

17. push the prepared extremity to the existing one with seal, looking for not damaging the seal ; better result if the pipe to be inserted is greased
18. check the concentricity
19. check the inserted length of the pipe
20. torque the threaded collars
21. repeat item 9 to 20 on the other extremity of the new pipe section
22. finally close the line and pressurise it looking for leakage
23. place the pipe in adequate location, filling with sand or soft material
24. report number of pipes used, who, where, when the installation have been done
25. report at storage the used material.
26. disinfect using concentrate chlorine 25 mg/l for 24 hours or 500 mg/l for 30 minutes
27. flush with clear water before putting in operation.

Gate Valves

General Description

The valve is the mechanical components used or installed for

- controlling the flow
- shut-off or open part of the network
- avoid the back-flow of the water.

Normally the valve is composed by a

1. body, normally inserted on-line in the pipe
2. bonnet, for closing the body, permitting the mechanical disassembly of the valve
3. disk, i.e. the mechanical part of the valve that physically closes/opens or controls the throughput of the flow
4. seats in different number, are the wear parts of the valve
5. stem, handwheel or lever, for manual control
6. gland, for ensuring the sealing in the stem/lever/hinge chamber
7. nuts/bolts for mechanical fixing of each components
8. seals, for removing any leakage possibilities.

Normally the mechanical components are cast, sometime obtained by machining solid blocks or plates; no specific materials are normally required for water lines or for the expected nominal temperatures.

The gate valve is mainly used or installed for open or close pipes or part of the network being reduced the possibility for controlling flow.

In principle the gate valve is composed by a body where two seats are fixed (normally using a threading in the body) and by a bonnet, where a stem (threaded) is tripping in order to insert (close the valve) the disk between the seats or to remove (open the valve) the disk from the seats.

New installation

The new installation of a gate valve includes the following steps:

1. ask to the Unit Manager the Identification Data Sheet of the valve to be used
2. check in storage room the availability of the requested valve

3. check dimension, nominal pressure and type of the valve
4. clean internally the valve, using compressed air or manually, with special care for cleaning the disc and looking if something stay inside
5. clean the flanges by hand, using a clean cloth
6. transport the valve close to the installation point, being sure that no shock and no damage are in the flanges
7. check if seals (correct in size and material) and tools are available
8. check if bolts/nuts are available
9. dry and clean the flange of the pipe head, using a clean cloth
10. put on the cleaned flange some grease or oil, just for keeping in place the seal (note that some seals are cut with a side holder, for avoiding greasing)
11. place the valve, looking for correct positioning of stem/bolts
12. place the upper bolt and torque just for keeping in place the valve
13. place the other bolts and tight manually
14. shackle the valve to be sure that the connection flange-to-flange is correct
15. torque the bolts, using the appropriate tool, manually operating in clockwise direction (remember that the final or nominal torque of the bolts shall be reached in two/three cycles)
16. lubricates the stem
17. check the functionality of the valve, raising the disk and closing (better two cycles)
18. if everything is OK, go forth fixing the second pipe to the flange of the valve.
19. open the new inserted valve
20. pressurised the line smoothly
21. check leakage and if, provides for tighting the bolts and/or the sealing chamber of the stem
22. open and close under pressure the valve
23. record in maintenance book when, where, why and who changes the valve

Replacement of a damaged gate valve

The replacement of a damaged gate valve includes the following steps:

1. ask to the Unit Manager the Identification Data Sheet of the valve to be used
2. check in storage room the availability of the requested valve
3. check dimension, nominal pressure and type of the valve
4. clean internally the valve, using compressed air or manually, with special care for cleaning the disc and looking if something stay inside
5. clean the flanges by hand, using a clean cloth
6. transport the valve close to the installation point, being sure that no shock and no damage are in the flanges
7. check if seals (correct in size and material) and tools are available
8. check if bolts/nuts are available
9. check that the pipe is not under pressure (by closing the upstream valve) and discharge the water completely
10. fix the damaged valve using rope to a supporting system
11. unscrew using the correct tool the nuts/bolts of both flanges, leaving one upper bolt for keeping in place the damaged valve
12. in case of heavy oxidation of the bolts, use a liquid or grease with light petrol
13. remove the damaged valve being sure that no damage incurs in the flanges in both heads of the pipes
14. dry and clean the flange of both the pipes head, using a clean cloth

15. put on the cleaned flange some grease or oil, just for keeping in place the seal (note that some seals are cut with a side holder, for avoiding greasing)
16. place the valve, looking for correct positioning of stem/bolts
17. place the upper bolt and torque just for keeping in place the valve
18. place the other bolts and torque manually
19. shackle the valve to be sure that the connection flange-to-flange is correct
20. tight the bolts, using the appropriate tool, manually operating in clockwise direction (remember that the final or nominal torque of the bolts shall be reached in two/three cycles)
21. lubricates the stem
22. check the functionality of the valve, raising the disk and closing (better two cycles)
23. if everything is OK, go forth fixing the second pipe to the flange of the valve.
24. open the new inserted valve
25. pressurised the line smoothly
26. check leakage and if, provides for tightening the bolts and/or the sealing chamber of the stem
27. open and close under pressure the valve
28. record in maintenance book when, where, why and who changes the valve
29. fill the record for storage with the indication of possible repair and reasons for damaging the removed valve
30. deliver the removed valve to the storage for repairing.

Maintenance and storage

Storage of valve should be done according to the following considerations

1. at the arrival of the valve, ask for the documentation and make sure that the delivered is the correct requested valve
2. clean internally the valve, removing any dust or oxidated part
3. open the valve and grease disk and seats
4. close the disk very smoothly, by hand, avoiding any un-requested tight
5. grease the machined parts of both the flanges
6. cover it with paper or plastic sheet
7. cover with disc made by wood (plywood) or light metal plate, fixing its to the flanges by using two/three bolts for each flange
8. put grease on the stem and cover with paper or cloth
9. put the valve in dry area, possibly supported in scaffolding
10. fill the record for storage

The stored valve doesn't need any further maintenance.

Butterfly Valves

General Description

The butterfly valve is mainly used or installed for open or close pipes or part of the network but having a sensible capacity for controlling flow.

In principle the butterfly valve is composed by a body where only one seat is fixed (normally using a threading in the body) or directly machined and by a bonnet, where a lever (mechanically blocked and threaded) is rotating in order to put disk orthogonal to the flow (close the valve) or to put in longitudinal way to the flow (open the valve); intermediate positions are allowed by controlling the flow.

The disk is normally shaped as a real disk and is connected to the threaded stem by mechanical connection, avoiding the rotation of the disk to the stem. Please note that the butterfly valve is not supposed unidirectional, i.e. shall be placed according to both the directions of the flow of the water.

Note that even the butterfly valve is typical for having only one annular seat; the disk shall offer the minimum pressure losses during the normal flow (valve open).

New installation

The new installation of a butterfly valve includes the following steps:

1. ask to the Unit Manager the Identification Data Sheet of the valve to be used
2. check in storage room the availability of the requested valve
3. check dimension, nominal pressure and type of the valve
4. clean internally the valve, using compressed air or manually, with special care for cleaning the disc and looking if something stay inside
5. clean the flanges by hand, using a clean cloth
6. transport the valve close to the installation point, being sure that no shock and no damage are in the flanges
7. check if seals (correct in size and material) and tools are available
8. check if bolts/nuts are available
9. dry and clean the flange of the pipe head, using a clean cloth
10. put on the cleaned flange some grease or oil, just for keeping in place the seal (note that some seals are cutter with a side holder, for avoiding greasing)
11. place the valve, looking for correct positioning of lever
12. place the upper bolt and tight just for keeping in place the valve
13. place the other bolts and tight manually
14. shackle the valve to be sure that the connection flange-to-flange is correct
15. tight the bolts, using the appropriate tool, manually operating in clockwise direction (remember that the final or nominal tight of the bolts shall be reached in two/three cycles)
16. lubricates the lever
17. check the functionality of the valve, rotating the disk (better two cycles)
18. if everything is OK, go forth fixing the second pipe to the flange of the valve.
19. open the new inserted valve
20. pressurised the line smoothly
21. check leakage and if, provides for tightening the bolts and/or the sealing chamber of the lever
22. open and close under pressure the valve
23. record in maintenance book when, where, why and who install the valve

Replacement of a damaged butterfly valve

The replacement of a damaged butterfly valve includes the following steps:

1. ask to the Unit Manager the Identification Data Sheet of the valve to be used
2. check in storage room the availability of the requested valve
3. check dimension, nominal pressure and type of the valve
4. clean internally the valve, using compressed air or manually, with special care for cleaning the disc and looking if something stay inside
5. clean the flanges by hand, using a clean cloth
6. transport the valve close to the installation point, being sure that no shock and no damage are in the flanges