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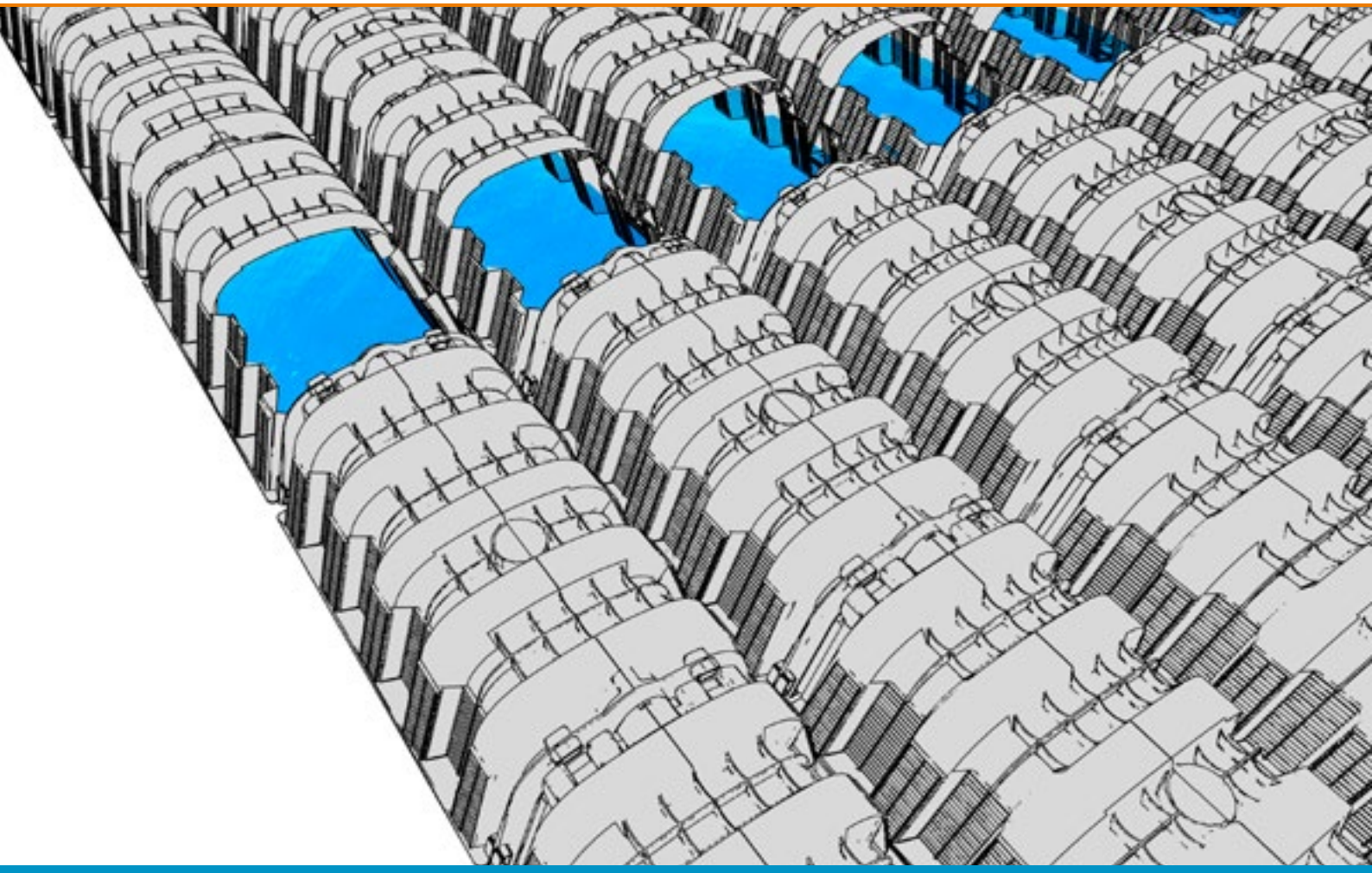
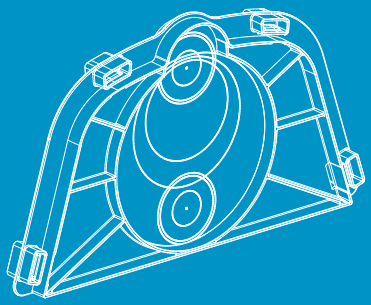
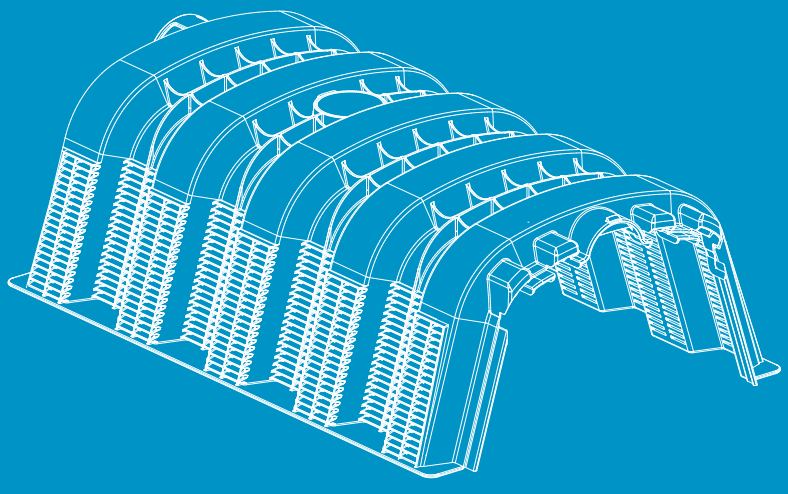


DRENING TECNICAL MANUAL

PLASTIC TUNNEL FOR RAINWATER INFILTRATION AND ATTENUATION





GEOPLAST WATER SOLUTIONS

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DRENING TECHNICAL MANUAL

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TECHNICAL DATA

1.INTRODUCTION

1.1 GENERALITIES

DRENING is a modular tunnel shaped modular element made of 100% regenerated HD PE, designed for the creation of underground systems for the dispersion in the subsoil of rainwater or pre-treated waste water.
The infiltration chambers are installed inside a medium size washed gravel bed, which has the function of:

- Allocation of applied loads.
- Water accumulation.
- Maintenance of hydraulic continuity in the system.

1.2 PRODUCT USAGE

DRENING is used for the following systems:

- Ponds or trenches for subsoil dispersion or network lamination of rainwater.
- Basins for storm water storage and reuse.
- Dispersion trenches for subsoil dispersion of waste water after a clarification treatment.

Depending on the application, the installation mode changes.

1.3 FUNCTIONALITY

1.3.1 COLLECTION AND RETURN

The dispersing chambers make it possible to build a high-capacity underground system capable of temporarily accumulating rainwater from the surface collection network or waste water from an Imhoff pit.
Depending on the type of installation and site conditions, the system is able to:

- Facilitate the soil infiltration of collected water self emptying itself.
- Release the accumulated water into a final receptor at regulated flow rate.
- Store a defined volume of water, releasing the excess portion into a final receptor.

1.3.2 STRUCTURAL CHARACTERISTICS

DRENING system makes it possible to maintain the use of the surface above, which can be left green or paved. Depending on the use, a suitable installation package must be provided for:

- A variation in the chambers depth.
- Minimum gravel thickness above tunnels
- A proper finishing.

The product is not suitable for installation below buildings.

1.3.3 ACCESSIBILITY

The width of the tunnel section allows the inspection and the cleaning of the system. Access must be made by providing suitable inspection wells that intercept the supplying/discharging pipelines, or by using the prearrangement present on the extrados of the chambers. .

1.3.4 VENTILATION

The structure must allow the air pressure to be balanced during the filling and emptying phases.
For the disposal of waste water, an air inlet is recommended for the maintenance of the microbiological processes under aerobic conditions.

1.4 COMPONENTS

1.4.1 DRENING INFILTRATION CHAMBERS

DRENING elements are available in one size only with dimensions 120x80xH=40 cm. They have a typical “tunnel” shape with transverse reinforcement ribs, a fully open bottom and lateral holes developed on both sides along the entire length of the chambers and for a height from the base of about 25 cm. They are equipped with a double overlapping coupling system that allows a simple interlocking.

1.4.2 CLOSURE CAP

At the ends of each row of hooked DRENING elements, the closing caps must be applied and fitted with a simple interlock. The cap has the function of:

- Block the possible penetration of the backfill material into the system, keeping the tunnel free.
- Facilitate the grafting of supplying/discharging pipelines.

The main pipe diameters are pre-incised on the surface of the cap for easy grafting.
The imprinted diameters are the following: Ø60 mm, Ø110 mm, Ø120 mm, Ø160 mm, Ø200 mm, Ø300 mm, Ø320 mm.

1.4.3 VENTILATION STACK

On the extrados of the DRENING chambers there is a prearrangement for the grafting of a ventilation/inspection pipe with a maximum diameter of Ø120 mm. .
The adoption of the ventilation stack is mandatory for waste water dispersion.

2. MATERIAL AND MANUFACTURING

2.1 MATERIAL

DRENING is made of high density polyethylene (HD PE), 100% regenerated.
The material is chemically inert and does not release substances into the stored water. It may suffer prolonged exposure to UV rays.
Material properties are listed in the table.

CHARACTERISTIC	METHOD	U.D.M.	VALUE
MFI (190°C / 2,16 kg)	ASTM-D-1238	g/10’	2±1
Izod Resistance	ASTM-D-256	J/m	40-60
Breaking load	ASTM-D-638	MPa	10-20
Melting temperature		°C	105-130
Density	ASTM-D-792	g/cm^3	0,95-0,96

Information on the safe use of the material is provided in Appendix A.

2.2 MANUFACTURING PROCESS

DRENING chambers and closing caps are manufactured by injection moulding at the Geoplast plant in Grantorto (PD), Italy. Geoplast is a company with UNI EN ISO 9001:2000 quality certification.

3. TECHNICAL DATA

3.1 DRENING

The technical characteristics of DRENING are shown in the table and dimensional drawings (Figure 1).
The product is grey-black, with a smooth surface without carvings, air bubbles or inclusions.

Product code	EDRENIN0040
Length	120 cm
Width	80 cm
Installed chamber length*	117 cm
Height	40 cm
Accumulation capacity	0,31 m^3
Weight	10,45 kg
Side holes	2.800 cm^2

DRENING chambers are simply interlocked together in the longitudinal direction by overlapping the ends and rotating (see photo). No fastening system required (screws, glues/ silicones, clips). Tunnels must never be cut, reduced or modified. If this happens, Geoplast is not responsible for the system's failure.

Important: the coupling overlaps Drening chambers by 3 cm. This should be taken into account when calculating the length of the basin, especially for rather large systems..

3.2 CLOSURE CAPS

The characteristics of the accessory are shown in the table and dimensional drawings (Figure 1). The product is grey-black in colour, with a smooth surface without engravings, air bubbles or inclusions.

Product code cm	EDRTAPP0040
Width	70 cm
Height	40 cm
Thickness	6 cm
Weight	1,94 kg

The cap must be hooked up by simple interlocking. If it does not lock on one side, simply turn the accessory by 180° and repeat the operation.
The use of the sealing cap is mandatory.

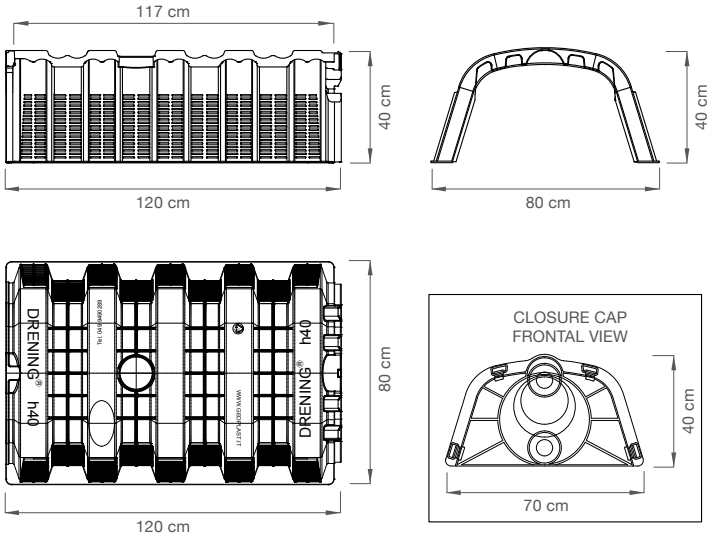


Figure 1: DRENING dimensional drawings and closing cap.

3.3 SAFETY MEASURES

The product is completely manually installed, no mechanical handling is required. The installation can be carried out by a single operator because the weight of the rooms is less than the maximum liftable weight in optimal conditions (ISO 11228).

- Possible slipping when walking above the elements in wet weather conditions or in the presence of ice.
- Risk of crushing during mechanical handling of pallets.
- Risk of crushing during dismemberment operations

4. TRANSPORT AND STORING

The DRENING infiltration chambers are stored and transported in pallets; the characteristics of the packaging are as follows:

	DIMENSIONS cm	ELEMENTS no.	SURFACE m^2
DRENING	120 x 80 x H=230	40	38,4
DRENING CAP	Depending on needs		

Mechanical means can be used for unloading and handling pallets with forks or cranes equipped with lifting straps.
For proper storage, it is advisable to choose a stable and as regular surface as possible; the product must remain protected from contact with fuels, lubricants, chemicals or acids.
Exposure to UV radiation should be as limited as possible. It must not exceed one year.

The following operations must be avoided once the elements are removed from the pallet:

- Improper storage of the chambers (overlapping pallets, bulk stacking of the elements,...).
- Inadequate handling (steering, dragging,....).
- Contact or impact with blunt or sharp bodies (stones, blades, etc.).

IMPORTANT: Before installation, it must be verified that the elements are intact (the characteristics described in paragraphs 3.1 and 3.2 must be observed). Avoid installation if there is any damage or defect in the modules or caps.

APPLICATIONS

5. RAINWATER DRAINAGE

5.1 PRELIMINARY RESEARCH

It is advisable to carry out geo-technical and geological surveys at the site where the basin will be built in order to verify its suitability. In particular, it should be assessed::

- The soil permeability.
- Load-bearing capacity of the ground.
- Maximum level of free aquifer.

If it is planned to discharge into superficial water system it is necessary to take into consideration:

- The average level.
- The maximum discharge level of the flow rate (according to the prescriptions of the Managing Authority).

With regard to the quality of waste water, reference should be made to the legal limits in force (Legislative Decree no. 152/2006 and P. T. A. regional) for discharge into the subsoil or into a receiving water system in order to provide adequate treatment plants upstream of the dispersant system.

5.2 POSITIONING

The following criteria are generally recommended:

- Distance to buildings: greater than 1.5 times the in comparison to the installation depth.
- Distance from the maximum level of groundwater: not less than 1 m from the bottom of the system (in agreement with most international guidelines). If the distance is smaller, the Competent Authority shall be consulted for approval.
- Distance from high growing trees: equal to the maximum width attainable from the tree crown.
- Distance to sub-services and other infrastructures: refer to local regulations.

Verify the possibility to install the system under impermeable floors (asphalt, cement...), as some regional regulations require the use of a surface that allows air to pass through the subsoil.

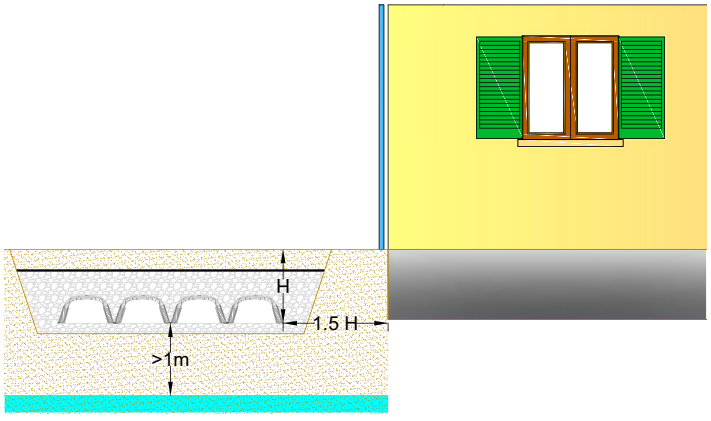


Figure 2: Positioning of the system

5.3 DIMENSIONING CRITERIA

Geoplast can provide the technical advice necessary for the pre-dimensioning of the dispersant system, based on data provided by the customer. The calculation must be validated by the work designer.

5.3.1 REQUIRED DATA

The following data are required for a correct system calculation:

- Drainage areas.
- flow rates: typical values of this parameter are indicated in the table (source: Sewerage, Da Deppo-Datei, e. g. Cortina 2005); some local regulations define the values to be adopted (e. g. D. G. R. Veneto 1322 of 10/05/2006).

SURFACE TYPE	Φ
Roofs with sheet metal or tiles	0,9 – 1
Concrete flat roofs	0,7 – 0,8
Flat green roofs	0,3 – 0,4
Paved surfaces	0,7 – 0,9
Dirt roads	0,4 – 0,6
Grass surfaces	0,1 – 0,4
Residential areas	0,3 – 0,7
Woods	0,1 – 0,3
Cultivated lands	0,2 – 0,6

- Rainfalls: data extrapolated from the rainfall analysis. The recommended parameters are the following (unless different parameters are used) regulatory requirements

Rainfall duration	30 min.
Return time	50 years

- Infiltration velocity: some internationally recognised typical values are shown in the table.

TYPE OF SOIL	INFILTRATION SPEED (m/s)
Coarse Gravel	10^{-3}
Coarse Sand	10^{-4}
Fine sand	10^{-5}
Silt	10^{-6}
Marl	$10^{-7} – 10^{-8}$
Clay	10^{-9}

- Loads applied: Variable depending on the use of the site. The load models given in EC1, Part 2 (UNI EN 1991-2) are taken as reference.

5.3.2 CALCULATION PRINCIPLE

For the dimensioning of the dispersive basin there are several international guidelines that can be taken as a reference (Germany: DWA A-138; United Kingdom: BRE Digest 365; France: Guide SAUL). The main passages, essentially common to the documents mentioned above, are the following:

1) Determination of the volume to dispose (V_{IN}).

2) Definition of the characteristic basin dimensions:
- Height of the drainage package composed by the sum of the thicknesses of gravel in the subsoil and above the extrados of the chambers
- Width B and length L of the basin. One of the two dimensions must be known, while the other will be the unknown

Example:

Width B = 5 x 0,8 = 4 m (5 rows of DRENING chambers)
Length L = N x 1,2 (with N number of DRENING chambers per row)

3) Estimation of the volume of water disposed during the rainfall (V_{OUT}), given by the sum of:
- Volume infiltrated into the ground.
- Volume discharged into the receptor (if applicable).

For the calculation of the infiltrated volume a dispersant surface equal to the bottom of the DRENING elements should be taken into consideration. This is equal to the BxL dimensions previously set.

4) Estimate the maximum volume that can be (V_{ACC}). The specific reservoir per unit of surface given by the following sum should be taken into consideration:
- Volume of water that can be filled with gravel around the chambers (porousness 30%).
- Water volume can be invaded in 1 DRENING (footprint 0,96 m²).

Below is a table with some reference values.

Basic gravel thickness [cm]	Gravel thickness at the top [cm]	Specific reservoir [m³/m²]
10	15	0,410
15	15	0,425
15	35	0,485
15	50	0,530

The table takes into account a gravel consumption of about 1 DRENING on level 0,084 m³.

5) Budget setting:

$$V_{ACC} = V_{IN} - V_{OUT}$$

with the terms identified in the previous points and resolution of the equation as a function of L.

5.3.3 DIMENSIONING CHECK

The verification is based on the estimation of the hydraulic residence time. The guidelines mentioned in the previous paragraph indicate a reference value for the emptying of a full basin equal to 48 hours, defined as the average observed time interval between two successive intense rainy events. If this value is higher, the sizing must be overhauled:
- The hydraulic residence time is set at 48 hours and the required dispersion surface is determined by an inverse formula.
- A constant discharge flow rate is expected to be maintained in the network, if it has not been expected previously.

The two solutions can also be complementary to each other. In any case, the technical feasibility of this test shall be assessed.

5.4 LOADS

DRENING infiltration chambers are manufactured and tested to withstand heavy loads, after the adoption of a correct laying stratigraphy.
Appendix B shows diagrams of the stratigraphies verified by Geoplast and load tables related to the roads category. If the design requires changes, please contact Geoplast's technical department.
Geoplast is not liable for damages to the system if the specified specifications are not observed.

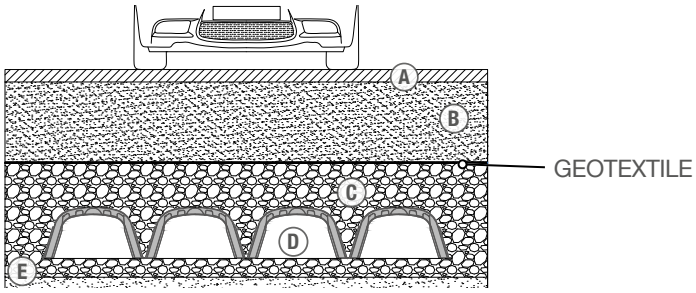


Figure 3: Laying stratigraphy of DRENING.

(A) FINISHING
(B) ROAD BACKGROUND (50-70 cm)
(C) COVERING WITH WASHED GRAVEL 20/40 mm (15-50 cm)
(D) DRENING H40 cm
(E) BACKGROUND LAYER WITH WASHED GRAVEL 20/40 mm (10-15 cm)

5.5 INSTALLATION PROCESS

5.5.1 DIGGING AND BACKGROUND PREPARATION

The recommended specifications are as follows:

- Dimensions: at least 30 cm between the plastic structure and the excavation wall.
- Laying surface: horizontal, regular and with a minimum slope of at least 0.1% in the direction of the discharge.
- Bottom: at least 10-15 cm of washed gravel with 20/40 mm grain size, well compacted. Use river gravel or crushed material.

For particularly soft substrates (cutting resistance <40 kPa or CBR<3, according to CIRIA 737 report) a thorough evaluation is required to adopt the optimal technical solution. It is generally recommended:

- Increase in the thickness of the gravel background.
- Use of geo-net or geotextile reinforcement applied at the bottom of the excavation.

Additional precautions before installing the chambers:

- Laying of the geotextile to cover the backfill in order to block at least one edge under 2-3 external rows of the elements (see the picture).
- Laying of a geotextile or a geo-net where the inlet pipelines of the chambers will be installed in order to avoid the erosion of the background.

The excavation walls should not exceed the natural slope angle of the material, on the contrary suitable measures should be chosen, in order to guarantee the safety of the opeartors during the installation and the basin's stability over time.

5.5.2 INSTALLATION OF DRENING CHAMBERS

The installation follows the instructions in chapters 3 and 4. It must be performed manually only. The rows must be placed side by side; no connection elements are provided. During the installation, it is possible to walk over the elements, but it is forbidden to use operating machines, even small ones, over the chambers. When DRENING installation is completed, the closure caps must be fastened.

5.5.3 HYDRAULIC CONNECTIONS

The system must be connected to the supply and discharge pipes according to the design specifications.
To insert the pipes, it is sufficient to drill the closure cap with a milling cutter at the level of the provided diameter. For specifications on hydraulic connections see paragraph 5.6.

5.5.4 BACKFILL AND COVERING OF DRENING CHAMBERS

The following specifications are recommended:

- Material: 20/40 mm of washed gravel, according to the expected thickness (minimum 15 cm). The inert material can be either river or crushed and must be compacted with a vibrating manual compactor.
- Procedure: The space between DRENING and the side of the excavation must be filled in at first. Subsequently, you can proceed with the filling of the chambers.
- Operating machines: during this stage, but only after the excavation backfill has been filled with a gravel covering of at least 40 cm, it is possible the passage of heavy means with a maximum weight of 10 tons.

To avoid the movement of the installed chambers, it is recommended to climb over the basin at an angle of 45° in respect to the longitudinal axes of the rows.
Avoid the access along the sides where the closing caps are placed.

5.5.5 COATING WITH GEOTEXTILE

The geotextile is necessary to separate the DRENING-gravel package from the covering aggregates and from the ground on the sides of the excavation. We recommend the use of a non-woven fabric with a minimum weight of 150-200 g/m^2.
The fabric needs to be laid by overplapping stripes at least 30-40 cm along all the surface of the basin an on the sides of the excavation.

5.5.6 FINISHING

Depending on the intended use of the area the system is backfilled up to the project level, until the expected finishing is accomplished. The minimal specifications The minimum specifications to be adopted according to the expected loads are given in Appendix B.

It should be noted that Geoplast is not liable for any damage to the system if the above prescriptions are not observed.

5.6 HYDRAULIC CONNECTIONS

5.6.1 TREATMENT OF INCOMING WATER

The incoming water in the basin must be as clean as possible in order to avoid the clogging of the system and the contamination of the final receptor.
The degree of purification to achieve, depends on :

- The quality of incoming water.
- The regulations in force (D.Lgs. 152/2006 e local implementing regulations)
- From the final receptor.

In absence of regulatory requirements, we recommend:

- Systems should be provided for the removal of coarse solids (sediment traps). It is possible to predict an increase in the depth of the input wells in order to facilitate sediment settling
- Install an oil separator if the system disposes runoff water from a car park and the final delivery is the subsoil

5.6.2 SUPPLYING PIPELINES

Dimensioning is a responsibility of the project designer. The maximum pipe diameter that can be inserted into the caps is Ø320 mm. If the collector is larger in diameter, line ramifications must be provided and the connections in the chambers must be reduced. Supplying pipes need to be inserted inside DRENING for a length of at least 40-50 cm. Collectors dimensioning is also a responsability of the project designer. In proximity of the graft it is recommended the installation of a geotextile or a geo-net on the gravel at the bottom of the chamber, to avoid erosions. It is not strictly necessary to provide a supplying pipe for each row of elements, as the lateral holes in the chambers and the gravel clogging between rows ensure hydraulic continuity within the basin. In specific cases, the supplying can be made also from above. It is possible to drill DRENING chamber from the top of the element (maximum diameter Ø120 mm). Also in this case, it is recommended to install a geotextile or a reinforcement geo-grid on the gravel at the bottom of the chamber to limit erosions. The power supply system must be interrupted with one or more wells to allow the inspection and the cleaning of the system. In Appendix C, some typical diagrams for hydraulic connections are shown.

5.6.3 EXHAUST PIPELINE

The adoption discharge network for the system must be evaluated at the design stage. It is a usual practice to provide the system with an exhaust pipeline with a regular flow rate, especially in the following cases:

- The soil has a very low draining capacity and is should be drained in reasonable times.
- The basin must work for the lamination of the flow rates
- It is recommended to guarantee the maximal hydraulic safety, during exceptional events.

The exhaust pipe must be inserted into the lower part of the closure cap. Again, it is not strictly necessary to provide a pipe for each row of chambers. It is recommended to interrupt the drainage system with one or more wells for basin cleaning operations.

5.7 MAINTENANCE

It is reccomended to provide a periodical inspection and maintenance to the basin, in order to keep its full functionality. Specific studies (Report CIRIA 737) have shown that in a time span of 50 years, without adequate maintenance of the system, it is possible to lose up to 10% of the basin capacity due to sedimentation of fine solids (silts and clays) which are difficult to remove from the upstream treatment units.

5.7.1 INPECTION

The inspection of the system can be carried out by motorized cameras on wheels, or through a push micro-camera inserted inside a flexible casing pipe. System access points must be provided during the design phase. There are two possibilities:

- Creation of inspection wells that intercept the supply pipes.
- Creation of one or more entrances to the system through the prearrangements on the top of the tunnel elements (maximum diameter Ø120 mm).

5.7.2 CLEANING

Cleaning can be carried out through the water jets normally used for sewer cleaning, accessing inside the system through the supplying pipes and the wells. Cleaning operations must start from the supplying pipes and the upstream wells, especially if they also act as a sediment trap.
It is advisable to also provide a well downstream, or access points on the top of the tunnels, in order to facilitate the inlet of the water suction pipe.

5.7.3 FREQUENCY OF INTERVENTIONS

It is advisable to draw up a system inspection and maintenance plan in order to carry out a systematic periodic inspection.
A system's check is essential during the following periods:

- The finishing of site operations.
- After particularly intense weather events.
- In case of failure or malfunction of pre-treatment units.
- At least once a year.

6. RECOVERY AND REUTILIZATION OF RAINWATER

6.1 PRELIMINARY RESEARCH

It is advisable to carry out geo-technical and geological surveys at the site where the basin will be built in order to verify its suitability. In particular, it should be assessed::

- Load-bearing capacity of the ground..
- Maximum level of free aquifer.

In order to discharge excess flow rates into a receptor, it is necessary to know:

- Average level and maximum discharge flow rate (according to the requirements of the administrator) if it is a surface water system
- Permeability of the soil in case of an underground discharge.

6.2 POSITIONING

The following criteria are recommended:

- Distance from tall trees: equal to the maximum width attainable from the tree crown.
- Distance from sub-services and other infrastructures: refer to local regulations.
- The system is not suitable for installation below buildings.

6.3 DIMENSIONINING CRITERIA

Geoplast can provide a consultancy service for the pre-dimensioning of the dispersant system, based on data provided by the customer. The calculation must be validated by the designer of the work. .

6.3.1 REQUIRED DATA

The following data are required for a correct calculation of the system:

- Drainage surfaces.
- Outflow coefficients: typical values of this parameter are indicated in the table (source: Sewerage, Da Deppo-Datei, e. g. Cortina 2005); some local regulations define the values to be adopted (e. g. D. G. R. Veneto 1322 of 10/05/2006).

SURFACE TYPE	Φ
Roofs with sheet metal or tiles	0,9 – 1
Concrete flat roofs	0,7 – 0,8
Flat green roofs	0,3 – 0,4
Paved surfaces	0,7 – 0,9
Dirt roads	0,4 – 0,6
Grass surfaces	0,1 – 0,4
Residential areas	0,3 – 0,7
Woods	0,1 – 0,3
Cultivated lands	0,2 – 0,6

- Rainfall: the average annual value obtained from a rainfall analysis or local studies (e. g. ARPA reports) is considered.
- Frequency of rainfall events: t is obtained from local studies (e. g. ARPA reports). Alternatively, the average dry weather (TSM) data should be searched.
- Water consumption: some typical values are given in the table (EN DIN 1989:2000-12).

	Daily consumption per capita [l/ab/gg]	Year consumption [l/m²]
Domestic bathrooms	24	
Office bathrooms	12	
Bathrooms in schools	6	
Irrigation of green areas		60
Irrigation of sports fields (6 months)		200
Lawn irrigation with light soil (6 months)		100-200
Lawn irrigation with heavy soil (6 months)		80-150

- Loads applied: Variable depending on the use of the site. The load models given in EC1, Part 2 (UNI EN 1991-2) are taken as reference.

6.3.2 CALCULATION PRINCIPLE

The system calculation is left to the designer of the work. The dimensioning can be carried out according to the criteria of EN DIN 1989:2000-12, concerning the sizing of tanks for rainwater recovery.

The main steps are as follows:

1) Estimation of the maximum cumulative $\mathbf{V_{ACC}}$ volume.
2) Estimation of the water demand **F**.
3) Evaluation of the average dry time[dd] through the report.

TSM = (365 – FR)/12 with FR rainfall frequency

4) Calculation of the tank volume with the following relation:

$$\mathbf{V_R = TSM \times (F/365)}$$

Valid if $\mathbf{F<V_{ACC}}$
If $\mathbf{F>V_{ACC}}$:

- Replace the **F** relation with $\mathbf{V_{ACC}}$.
- Or use the average value between **F** and $\mathbf{V_{ACC}}$.

5) Calculation of the number of Drening, dividing $\mathbf{V_R}$ by the specific reservoir per unit of surface area of the system, given by the sum of

- Volume of water that can be included in the gravel around the chambers (30% porosity).
- Volume of water that can be inserted in 1 DRENING chamber (0.96 m2 overall).
  Below is a table with some reference values.

Basic gravel thickness [cm]	Gravel thickness at the top [cm]	Specific reservoir [m^3/m^2]
10	15	0,410
15	15	0,425
15	35	0,485
15	50	0,530

The table takes into account a gravel consumption of about 1 DRENING at the edge, equal to 0,084 m^3.

6.4 LOADS

The DRENING infiltration chambers are manufactured and tested to withstand heavy loads, after the adoption of a correct laying stratigraphy.
Appendix B shows diagrams of the stratigraphies verified by Geoplast and load tables related to the road category.
If the design require changes, please contact Geoplast's technical department.
Geoplast is not liable for damages to the system if the specifications are not observed.

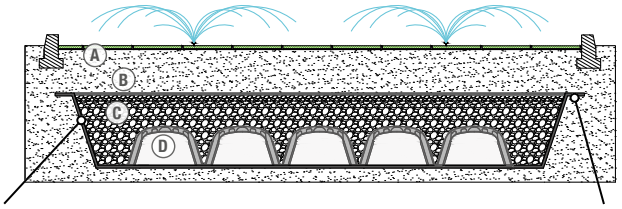


Figura 4: Figure 4: Stratigraphy of DRENING - Rainwater recovery

Ⓐ FINISHING
Ⓑ COVERING (50-75 cm)
Ⓒ WASHED GRAVEL 20/40 mm (20-50 cm)
Ⓓ DRENING H40 cm

6.5 INSTALLATION PROCESS

6.5.1 EXCAVATION AND BACKGROUND PREPARATION

The recommended specifications are as follows:

- Dimensions: at least 30 cm between the plastic structure and the excavation wall.
- Laying surface: horizontal, regular and with a minimum slope of at least 0.1% in the direction of the discharge.
- Waterproofing: spread the following geo-synthetic materials (in a) on the bottom and sides of the excavation:

• Warp weft fabric minimum weight 150-200 g/m2
- Waterproof membrane in PVC, HD PE o EDPM.
- Heavy-duty, thermally welded geotextile, minimum thickness 5 mm.

If it is planned to pass through the system, a well compacted surface of at least 10-15 cm of washed gravel with a 20/40 mm grain size must be used. River gravel or crushed material can be used. For particularly soft substrates (cutting resistance <40 kPa or CBR<3, according to CIRIA 737 report) a thorough evaluation is required to adopt the optimal technical solution. It is generally recommended:

- Increase in the thickness of the gravel floor.
- Use of geo-nets or reinforcement geotextiles laid on the bottom of the excavation.

It is recommended that the inclination of the excavation walls should not exceed the natural slope angle of the material, or that if not, suitable measures are chosen to ensure the safety of the operators during installation and the stability of the basin over time.

6.5.2 – INSTALLATION DRENING CHAMBERS

The installation follows the instructions in chapters 3 and 4. It may only be performed manually. The rows must be placed side by side; no connection elements are provided. During installation, you can walk over the elements. It is forbidden to pass operating machines, even small ones, over the chambers. When DRENING installation is complete, the end caps must be fastened.

6.5.3 HYDRAULIC CONNECTIONS

The system must be connected to the supply and exhaust pipes according to the design specifications.

To insert the pipes, it is sufficient to drill the closure cap plug with a rotating cutter at the mould of the diameter provided.

For specification of hydraulic connections see paragraph 6.6.

6.5.4 BACKFILL AND COVERING OF DRENING CHAMBERS

The following specifications are recommended:

- Material: 20/40 mm gravel washed gravel, according to the expected thickness (minimum 15 cm). The inert material can be either river or crushed and must be compacted with a vibrating manual compact
- Procedure: The margin between the DRENING and the side of the excavation must be filled in at first. Subsequently, you can proceed with the filling of the chambers.
- Operating machines: during this phase, only after the excavation side has been filled and at least 40 cm of gravel covering, heavy means weighing no more than 10 tonnes can pass over the elements. In order to avoid the moving of the chambers, it is recommended to walk over the basin with a angle of 45° in respect to the longitudinal axe of the two rows.

  Avoid access along the sides where the closing heads are aligned.

For an improvement of the characteristics of the system from an agronomic point of view, 20 cm of volcanic lapillus 3/5 mm in length, followed by at least 5 cm of volcanic sands, may be used for the covering of the chambers. This if the installation is carried out below green surfaces.

6.5.5 COATING WITH GEOTEXTILE

The geotextile is necessary to separate the draining package gravel-DRENING from the covering aggregates.
The use of a non-woven fabric is recommended, minimum weight 150-200 g/m2.
The fabric has to be laid with overlapping strips of at least 30-40 cm along the entire surface of the basin.

6.5.6 FINISHING

Depending on the intended use of the area, the system will be backfilled to the project level and the finish will be completed.
The minimum specifications to be adopted according to the expected loads are given in Appendix B.
It should be noted that Geoplast is not liable for any damage to the system if the above prescriptions are not observed.

6.6 HYDRAULIC CONNECTIONS

6.6.1 WATER TREATMENTS

The water entering the basin must be as free as possible from coarse solids in order to avoid the clogging of the system. It is therefore advisable to provide for removal systems (sediment traps), which can simply consist of filters or an increase in the depth of the input wells to facilitate decanting the material.
Depending on the end use of the water, finishing treatments must be provided to remove any impurities.
If the finish is permeable (green area or draining paving) these treatments become necessary, as the basin is not watertight by its nature.

6.6.2 SUPPLYING PIPELINES

The sizing of the collectors is the responsibility of the project designer.
The maximum pipe diameter that can be plugged into the caps is Ø320 mm. If the diameter of the collector is larger, lines must be branched and inserted into the chambers by means of reductions.
The feed hoses must be inserted into the DRENING for a length of at least 40-50 cm.
It is recommended that a geotextile or geo-grid is placed on top of the gravel at the bottom of the chamber to limit erosion.
It is not strictly necessary to provide a feed pipe for each lane of elements, as the lateral cracks in the chambers and the blockage of gravel between rows ensure hydraulic continuity within the basin.
In particular cases, the power supply can also be made from above by drilling the DRENING chamber in the top position (maximum diameter Ø120 mm).
Also in this case, it is recommended to spread a geotextile or a reinforcement geo-grid over the bottom gravel to limit erosion.
The supply system must be interrupted with one or more wells to allow inspection and cleaning of the system.

6.6.3 EXHAUST PIPES

An overflow system or by-pass must be provided to dispose of excess flow into the basin.
If overflow is expected, the pipes must be installed in the upper part of the closing plug.
Again, it is not strictly necessary to provide a tube for each chamber lane.
It is recommended to interrupt the drainage system with one or more wells for basin cleaning operations.

6.7 MAINTENANCE

It is necessary to provide for regular inspection and maintenance of the basin in order to maintain its storage capacity.
Specific studies (Report CIRIA 737) have shown that in a time span of 50 years, without adequate maintenance of the system, it is possible to lose up to 10% of the basin capacity due to sedimentation of the fine fraction of solids (limians and clays) which are difficult to remove from the upstream treatment units.

6.7.1 INSPECTION

The inspection of the system can be carried out by means of motorized cameras on wheels, or “push” micro-cameras inserted inside a flexible tube.
System access points must be provided during the design phase. There are two possibilities:

- Installation of inspection wells that intercept the supply lines;
- Creation of one or more entrances to the system by means of a prearrangement on the top of the tunnel elements (maximum diameter Ø120 mm).

6.7.2 CLEANING

Cleaning can be carried out by means of the water jets normally used for sewer cleaning, accessing inside the system through the feed piping and the foreseen wells.
Cleaning operations must start with washing the fuel lines and upstream wells, especially if they also act as a sediment trap.
It is also advisable to provide a well downstream, or access points on the top of the tunnels so as to facilitate the inlet of the washing water suction pipe.

6.7.3 PERIODICITY OF INTERVENTIONS

It is advisable to draw up a system inspection and maintenance plan in order to carry out a systematic periodic inspection.
System control is essential during the following periods:

- End of construction site operations..
- After particularly intense weather events.
- In the event of failure or malfunction of pre-treatment units.
- At least once a year.

7. WASTEWATER DISPOSAL

7.1 PRELIMINARY RESEARCH

Geological surveys should be carried out at the site where the reservoir is to be built in order to verify its suitability. In particular, they should be assessed:

- Permeability of soil (permeability percolation test, U. S. Dept. of Health - Reprint n°246)
- Maximum level of free aquifer

7.2 POSITIONING

The following criteria are recommended:

- Margin between the maximum level of the free aquifer and the bottom of the chambers not less than 1 m (according to most international guidelines). If it not possible to respect this minimum franc, the competent authority must be consulted.
- Preference should be given to positioning under green areas, however unpaved (some regional regulations impose this requirement)
- Reference distances (CITAI Resolution of 4 February 1977):

Tall trees	10 m
Buildings	10 m
Water courses	30 m
Potable water pipes	10 m
Potable water collection points	200 m

7.3 DIMENSIONING CRITERIA

Geoplast can provide a pre-dimensioning of the dispersant system on a consultancy level, based on data provided by the customer. The calculation must be validated by the designer of the work.

7.3.1 REQUIRED DATA

The following data are required for correct system calculation:

- Subsoil characterization (permeability).
- Number of equivalent inhabitants. For the calculation, reference can be made to the values shown in the table, indicated in different regional guidelines.

TYPE OF BUILDING/ACTIVITY	EI
Private dwellings	No. of residents
Companies, offices, shops	1 EI for every 3 employees
Factories and craft workshops	1 EI for every 2 employees
School buildings	1 EI for every 10 bench seats
Cinema, stadiums, theatres	1 EI for every 30 seats
Service stations	1 EI every 6 vehicles
Hotels, campsites, B&B	1 EI for every bed
Hospital facilities	1 EI for every 2 beds
Restaurants, pizzerias	1 EI for every 3 places canteen
Sports facilities	1 EI for every 5 people

7.3.2 CALCULATION PRINCIPLE

The following table should be used for the calculation:

TYPE OF SOIL	N°DRENING/ EI	INFILTRATION SURFACE [cm²]
Coarse sand, crushed stone, gravel	1	12.400
Fine sand	1,5	18.600
Sand, gravel or crushed stone with silt	2	24.800
Clay or silt with a lot of sand or rubble	3	37.200
Clay or silt with little sand or rubble	6	74.400
Argilla compatta	Not suitable	-

The table refers to a daily organic load per capita of 60 g BOD/ EI.

7.4 LOADS

The DRENING infiltration chambers are manufactured and tested to withstand heavy loads, after the adoption of a correct laying stratigraphy.
Appendix B shows diagrams of the stratigraphies verified by Geoplast and load tables related to the road category.
If the design needs require changes to the diagrams, please contact Geoplast's technical department. Geoplast is not liable for damage to the system if the specified specifications are not observed.

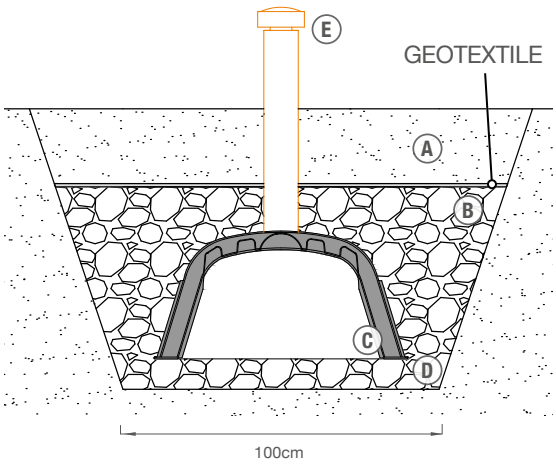


Figure 5: Stratigraphy of DRENING installation - waste water

(A) COATING (MINIMUM 25 cm)
(B) WASHED GRAVEL COATING 20/40 mm (15-20 cm)
(C) DRENING H40 cm
(D) WASHABLE GRAVEL BOTTOM LAYER 20/40 mm (10-15 cm)
(E) VENTILATION STACK

7.5 INSTALLATION PROCESS

7.5.1 DIGGING AND BACKGROUND PREPARATION

The recommended specifications are as follows:

- Trench dimensions:
- Width at base: 1 m: 1 m.
- Length: variable depending on the number of chambers to be installed.
- Minimum depth: 90-100 cm..
- Laying surface: horizontal, regular and with a minimum slope of 0.1-0.5% in the direction of discharge.
- Background: application of at least 10 cm of washed gravel with a 20/40 mm well compacted grain size. River gravel or crushed material may be used.

If the natural soil is made of granular material with a good loading capacity, the DRENING chambers can be laid directly, without applying gravel. If, on the other hand, the soil is particularly soft, the thickness of gravel must be increased.

It is recommended that the trench walls have an adequate inclination or that appropriate precautions are taken to ensure the safety of the operators during installation. The cuttings must be arranged in parallel. The minimum distance between trench and trench must be approximately 1-1.5 m unless otherwise specified by the regulations.

7.5.2 INSTALLATION OF DRENING CHAMBERS

The installation follows the instructions in chapters 3 and 4. It may only be performed manually.
During installation, you can walk over the elements. It is forbidden to pass operating machines, even small ones, over the chambers. When the DRENING installation is complete, the end caps must be hooked in place.

7.5.3 HYDRAULIC CONNECTIONS AND CONSTRUCTION OF VENTILATION CHIMNEYS

The system must be connected to the pipes according to the design specifications.
To insert the pipes, it is sufficient to drill the sealing plug with a carousel cutter at the mould of the diameter provided. For installations with particular gradients, the supply can also come from the tunnel extrados, using the summit arrangement (Appendix C2).
For specifications on hydraulic connections see paragraph 6.6. At least 1 ventilation chimney must be provided for each trench. If the trench is particularly extensive, we recommend a minimum of 1 chimney every 5-6 rooms.
To insert the chimney, the chamber must be drilled in the special top connection (maximum diameter Ø120 mm).
The chimney must emerge from the country level in such a way that it is sufficiently high to prevent clogging.

(at least 40-50 cm). The top end of the chimney should be protected with a stopper to prevent material or small animals from entering the system.

7.5.4 BACKFILL AND COVERING OF THE DRENING CHAMBERS

The following specifications are recommended:

- Material: washed grave with 20/40 mm grain size, according to the expected thickness (minimum 15 cm). The inert material can be of river or crushed material and must be well compacted with a vibrating manual compactor.
- Operating machines: during this phase, only the crawler units weighing no more than 10 tonnes can pass over the elements, after the excavation flank has been filled and with a minimum covering of 40 cm of gravel.

7.5.5 GEOTEXTILE COATING

The geotextile is necessary to separate the DRENING gravel drainage package from the covering aggregates.
The use of a non-woven fabric with a minimum weight of 150-200 g/m2 is recommended.
The fabric must be spread over the entire length of the trench.

7.5.6 FINISHING

Depending on the intended use of the area, the system is backfilled up to the project level and completed with the required finish.
As these are basically installations under green areas, the backfill can be carried out with the excavation material.
It should be noted that Geoplast is not liable for any damage to the system if the above prescriptions are not observed.

7.6 HYDRAULIC CONNECTIONS

7.6.1 WATER PRE-TREATMENTS

The system must necessarily dispose of a pre-treated wastewater with at least one clarification process in order to separate the liquid from the solid phase.
The type of treatment varies according to the number of equivalent inhabitants and the relevant legal requirements (Legislative Decree 152/2006 and local implementing regulations). The proposed scheme (Appendix C2) applies for a load of less than 50 equivalent inhabitants.
If the system also disposes of water coming from the kitchens, it is necessary to adopt a condensate-grease thermowell located upstream of the waste well.

7.6.2 SUPPLYING PIPES

The recommended diameters for the feeding pipes are generally between Ø100 and Ø120 mm, in order to guarantee a flow rate that prevents the sedimentation of solid particles.
The feed hoses must be inserted into the DRENING for a length of at least 40-50 cm.
One tube shall be provided for each trench of elements.
In special cases (installations with steep slopes, see Appendix C2) the supply can also be made from above, drilling the DRENING chamber in the top position (maximum diameter Ø120 mm).
In this case, it is recommended to spread a geotextile or geo-grid reinforcement over the bottom gravel to limit erosion.
The outlet well should always be included in the installation, also for cleaning the dispersant system.

7.7 MANTEINANCE

The periodic maintenance is essential to keep the complete functionality of the system.

7.7.1 INSPECTION

The inspection of the system can be made through motorised micro-cameras on wheels or “push “micro-cameras” inserted in a flexible casing pipe. The points of access to the system are as follows:

- Expulsion well or a distribution well at the entrance of the dispersant system.
- Ventilation stacks.

7.7.2 CLEANING

Cleaning can be carried out by means of the water jets normally used for sewer cleaning, accessing inside the system through the feed piping and the foreseen wells. The cleaning operations must start from the washing of the feed pipes and the wells located upstream; they must be carried out at the same time as the cleaning of the Imhoff pit and the greasy condensate well, or in any case of the planned treatment units.

7.7.3 FREQUENCY OF INTERVENTIONS

It is advisable to draw up a system inspection and maintenance plan in order to carry out a systematic periodic inspection. System control is essential during the following periods:

- In case of failure or malfunction of pre-treatment units.
- At least once a year.

APPENDIXES

APPENDIXES A

MATERIAL SAFETY DATA SHEET

COMPOSITION / POLYMER INFORMATION

INGREDIENTS	N° C.A.S.	%
Polyetilene Random	9010-79-1	97-99
Additives	Not available	1-3
15	35	0,485
15	50	0,530

DANGEROUS COMPONENTS

This product does not fall within the definition of hazardous material provided by EEC 1999/45 and subsequent regulatory measures.
Physical state: Solid.
Problems: If the polymer is subjected to high temperatures it can produce vapours irritating to the respiratory system and eyes.

FIRST AID MEASURES

Inhalation of decomposition products: Keep patient calm, move patient to fresh air and call for medical help.
Skin contact: parts that come into contact with molten material must be quickly brought under running water and the doctor must be contacted.
Eye contact: flush eyes for at least 15 minutes under running water while holding eyelids open. Contact with material particles does not present any particular danger, except for the possibility of abrasion wounds. Fine particles can cause irritation.
Ingestion: No particular measures to be taken.

FIRE-FIGHTING MEASURES

Extinguishing materials: water, foam or dry extinguishing materials.
Unsuitable extinguishing materials: none.
Substances released in the event of fire: carbon dioxide (CO2) and mainly steam. Other substances that may form: carbon monoxide (CO), monomers, other degradation products.
Special protective equipment: Wear breathing apparatus in case of fire.
Other requirements: Dispose of contaminated combustion slag and fire extinguishing material in accordance with local regulations.

ACCIDENTAL RELEASE MEASURES

It is not classified as a hazardous material. It can be recycled, incinerated or disposed of in landfills in accordance with local regulations.

STORAGE AND HANDLING

When the product is ground, the applicable dust regulations must be taken into account.
Keep it in a dry place.

EXPOSURE CONTROL/PERSONAL PROTECTION

Respiratory tract protection: if respirable dust forms, P1 filters (DIN 3181) must be used.
Skin protection: no special precautions.
Eye protection: safety glasses in the presence of free particles.

PHYSICO-CHEMICAL PROPERTIES

Shape	Tunnel modules
Color	Dark grey-black
Smell	Soft
Change in physical state	Melting temperature: 105 - 130°C Combustion temperature: above 300°C
Flammable properties	None
Density	0.94-0.96 kg/dm^3
Solubility in water	Insoluble
Solubility in other solvents	Soluble in aromatic solvents

STABILITY AND REACTIVITY

Conditions to avoid	non surriscaldare per evitare la decomposizione termica. Il processo inizia attorno ai 300°C
Thermal degradation products	monomers and other sub-products

TOXICOLOGICAL INFORMATION

Acute toxicity: data not available (no animal experiments due to impossibility related to product conformation).
Insoluble in water.

ECOLOGICAL INFORMATION

Degradation in nature: no data available.
Insoluble in water. Behaviour and environmental purpose: the product is environmentally friendly because it is made of recycled plastic. It is not apparently biodegradable due to its water insolubility and consistency.

DISPOSAL CONSIDERATIONS

Product 100% recyclable. It can be disposed of in landfills or incinerated in accordance with local regulations.

TRANSPORT INFORMATION

It is not classified as dangerous for transport purposes.

REGULATORY INFORMATION

It is not subject to the CE marking.

APPENDIX B

APPLICABLE LOADS

For the assessment of the maximum loads applicable to the system in order to prevent failure, reference was made to the load models described in EN 1991-2 (Eurocode 1:"Traffic loads on decks").
The following stratigraphies are already checked at loading. Please contact Geoplast Technical Department for any changes to these standard diagrams.

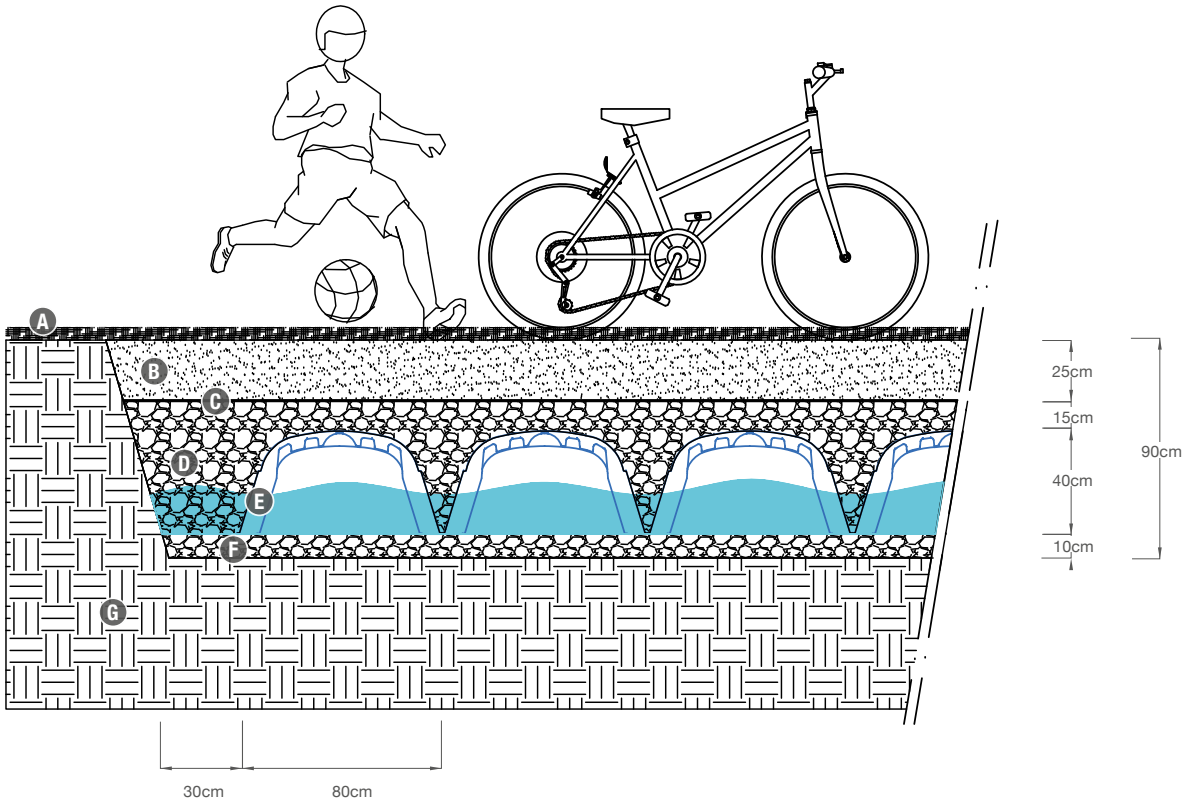
GREEN AREAS - CONSIDERED PARAMETERS

Specific ground weight	kN/m³	20
Material safety factor	-	2

VERTICAL LOADS APPLIED*

Coating thickness (m)	Installation depth (m)	Soil load (kN/m²)
0,4	0,8	8
0,8	1,2	16
1,2	1,6	24
1,6	2,0	32
2,0	2,4	40
2,4	2,8	48
2,8	3,2	56
3,2	3,6	64
3,5	3,9	70

*Loads applied on the extrados of the Drening chambers



(A) Vegetation (B) Carry-over land (C) Non-woven fabric (D) Covering in washed gravel 20/40 mm (E) DRENING (F) 20/40 mm washed gravel background ayer
(G) Existing land

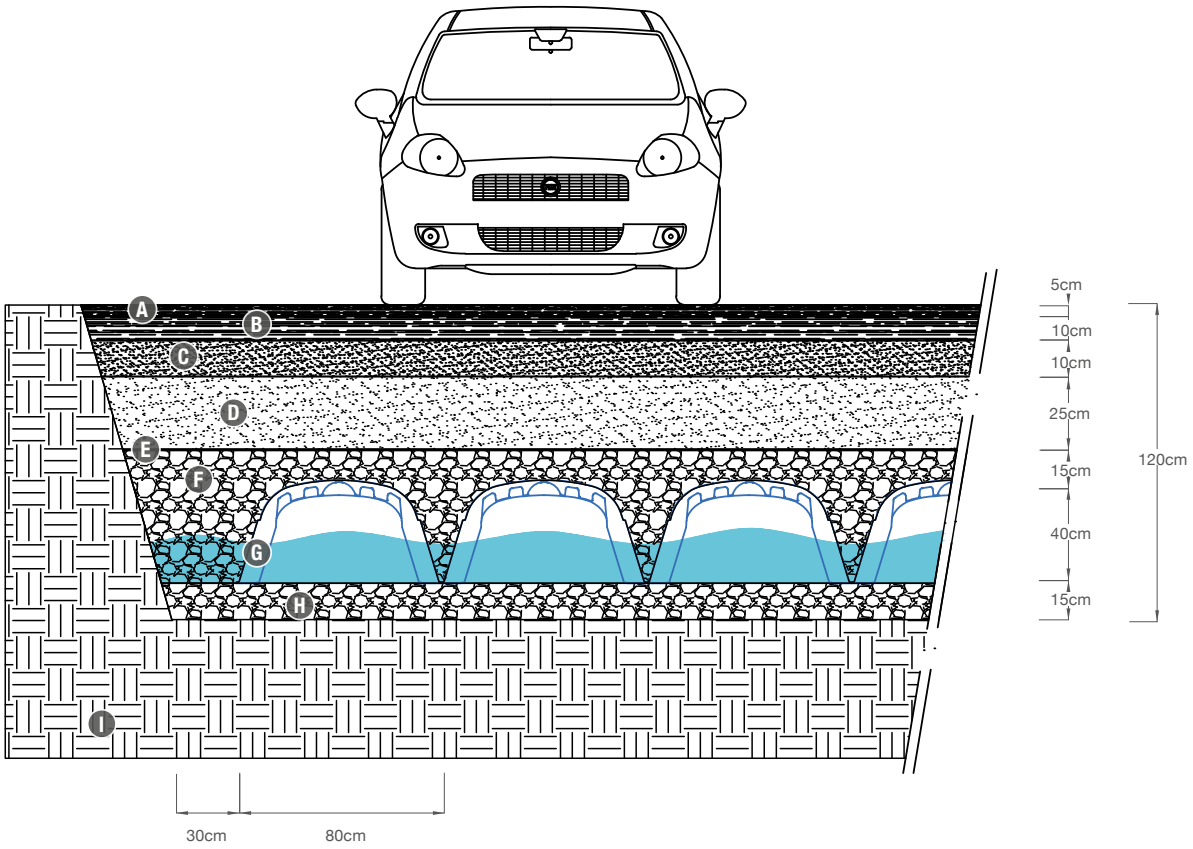
LIGHT VEHICLES - CONSIDERED PARAMETERS

Equivalent distributed load	kN/m²	5
Specific ground weight	kN/m³	20
Fattore di sicurezza del materiale	-	2

VERTICAL LOADS APPLIED*

Coating thickness (m)	Installation depth (m)	Soil load (kN/m²)	Total load (kN/m²)
0,65	1,05	13	18
0,75	1,15	15	20
1,0	1,4	20	25
1,25	1,65	25	30
1,5	1,9	30	35
1,75	2,15	35	40
2,0	2,4	40	45
2,5	2,9	50	55
3,0	3,4	60	65

*Loads applied on the extrados of the Drening chambers



(A) Asphalt - Wear Layer
(B) Asphalt - Binder
(C) Stabilized
(D) Tout venant
(E) Non-woven fabric
(F) Covering in washed gravel 20/40 mm
(H) 20/40 Washed gravel background layer
(G) DRENING
(I) Existing land

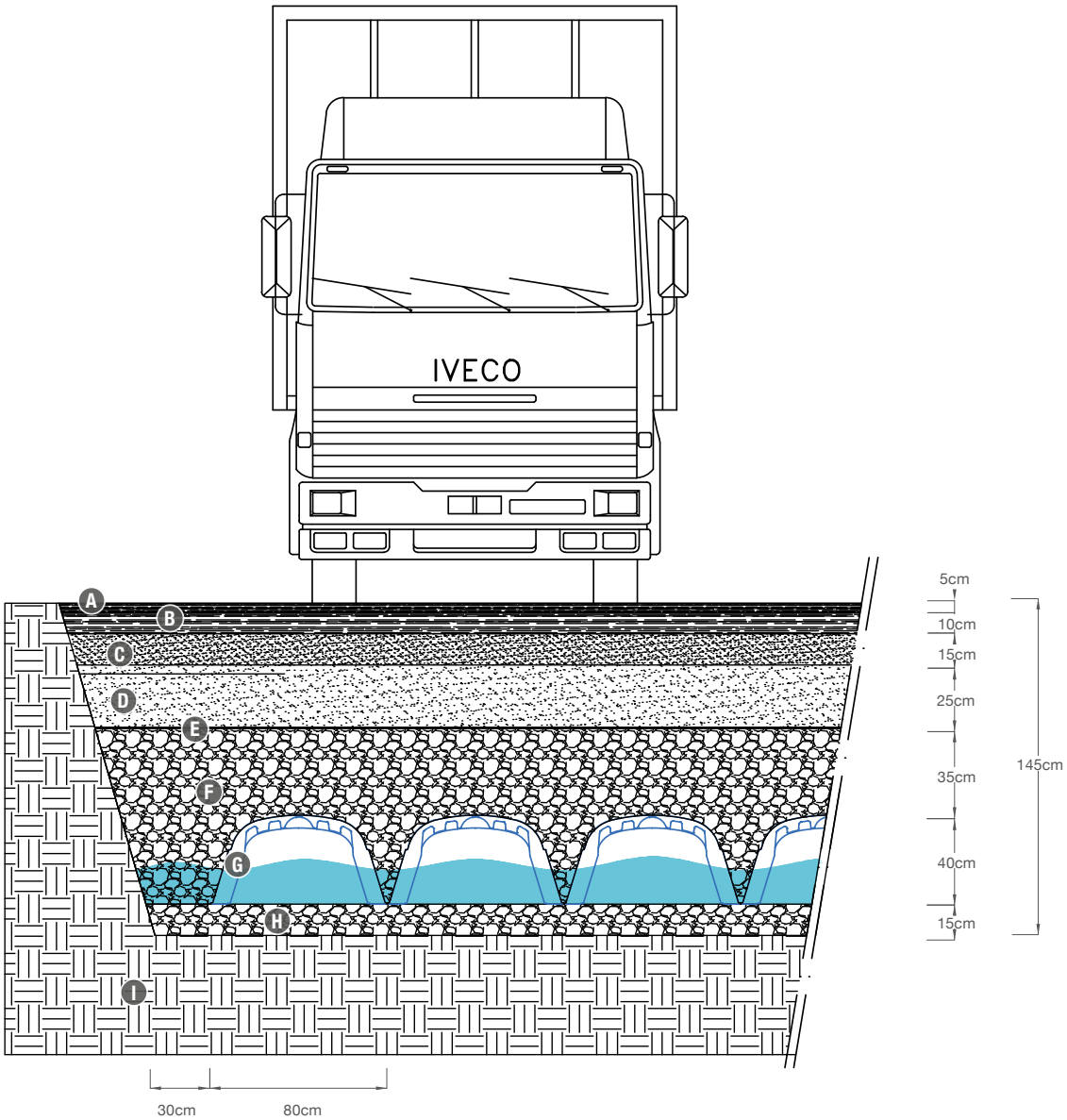
TRUCKS - CONSIDERED PARAMETERS

Equivalent distributed load	kN/m^2	7,2
Specific ground weight	kN/m^3	20
Material safety factor	-	2

VERTICAL LOADS APPLIED*

Coating thickness (m)	Installation depth (m)	Ground load (kN/m^2)	Total load (kN/m^2)
0,9	1,3	18	25,2
1,0	1,4	20	27,2
1,5	1,9	30	37,2
2,0	2,4	40	47,2
2,5	2,9	50	57,2
3,0	3,4	60	67,2

*Loads applied on the extrados of the Drening chambers



(A) Asphalt - Wear layer
(B) Asphalt - Binder
(C) Stabilized
(D) Tout venant
(E) Non-woven fabric
(F) Covering in washed gravel 20/40 mm
(H) 20/40 Washed gravel bottom layer
(G) DRENING
(I) Existing land

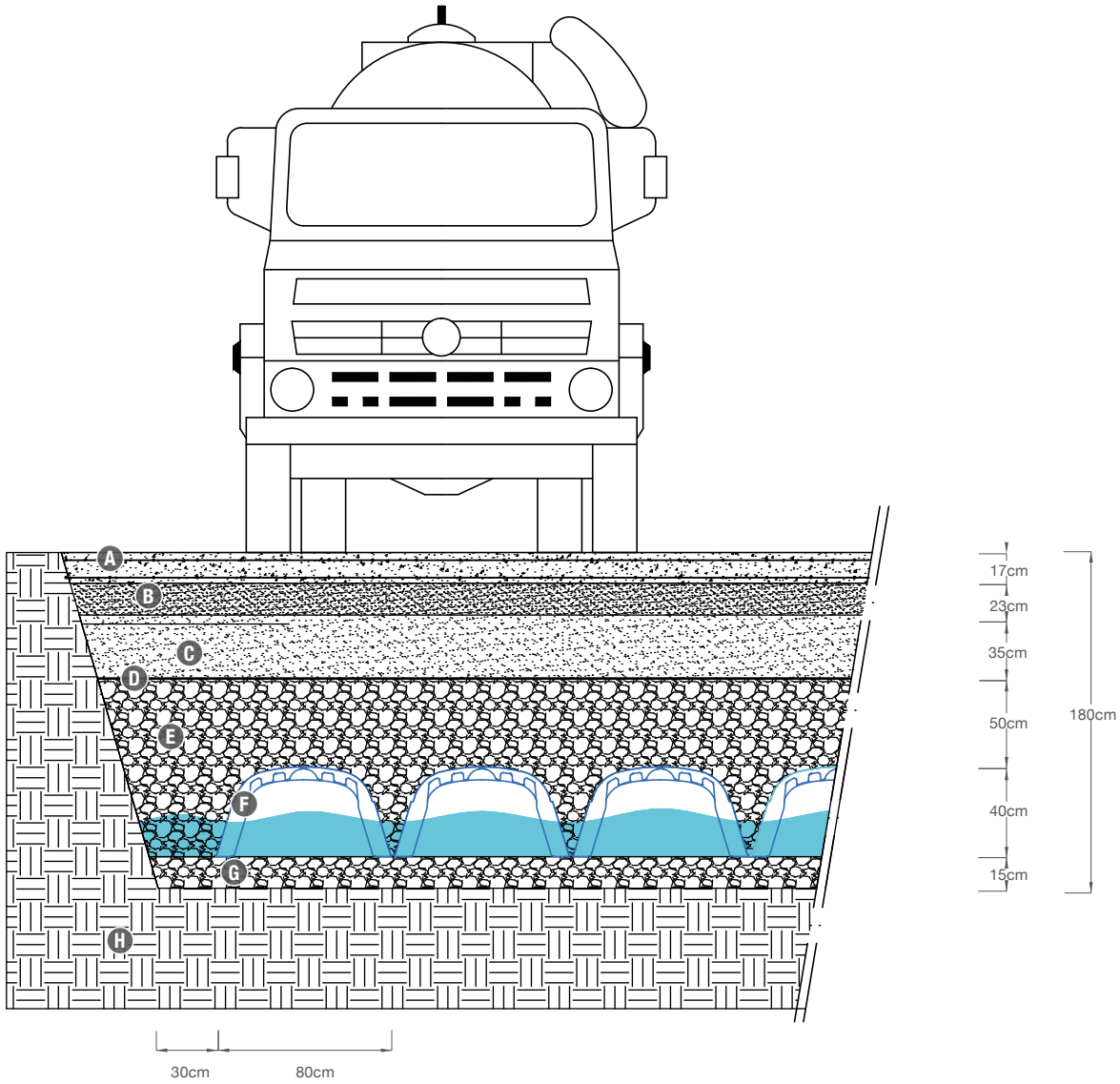
HGVS - CONSIDERED PARAMETERS

Equivalent distributed load	kN/m²	9
Specific ground weight	kN/m³	20
Material safety factor	-	2

VERTICAL LOADS APPLIED*

Coating thickness (m)	Installation depth (m)	Ground load (kN/m²)	Total load (kN/m²)
1,25	1,65	25	34
1,5	1,9	30	39
1,75	2,15	35	44
2,0	2,4	40	49
2,25	2,65	45	54
2,5	2,9	50	59

*Loads applied on the extrados of the Drening chambers



(A) Reinforced concrete with double electro welded mesh Ø8/20x20

(B) Stabilized

(C) Tout venant

(D) Non-woven fabric

(E) Covering in washed gravel 20/40 mm

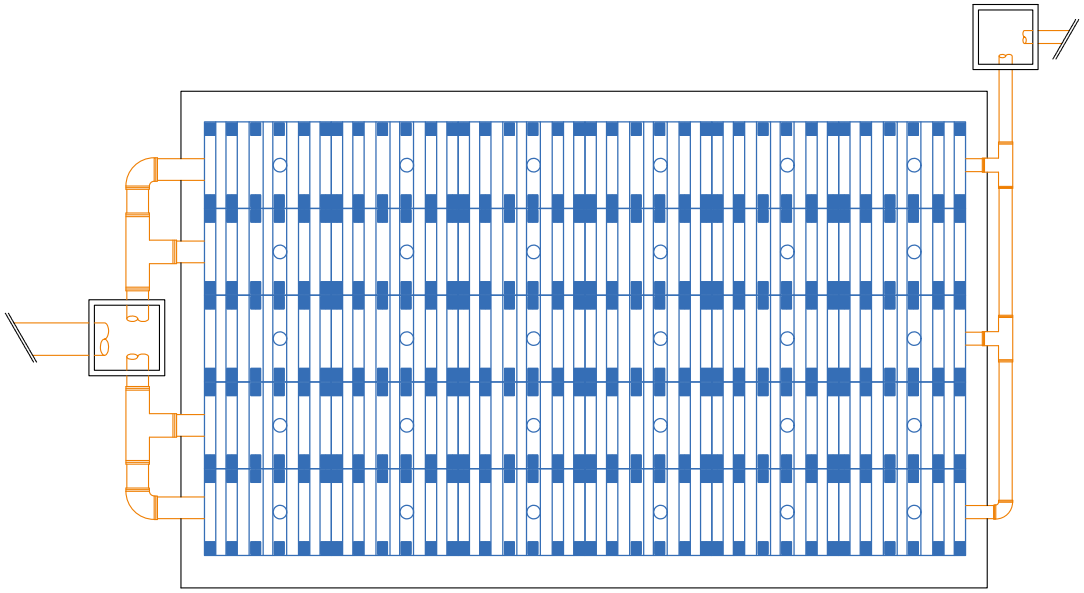
(F) DRENING

(G) 20/40 mm washed gravel bottom layer

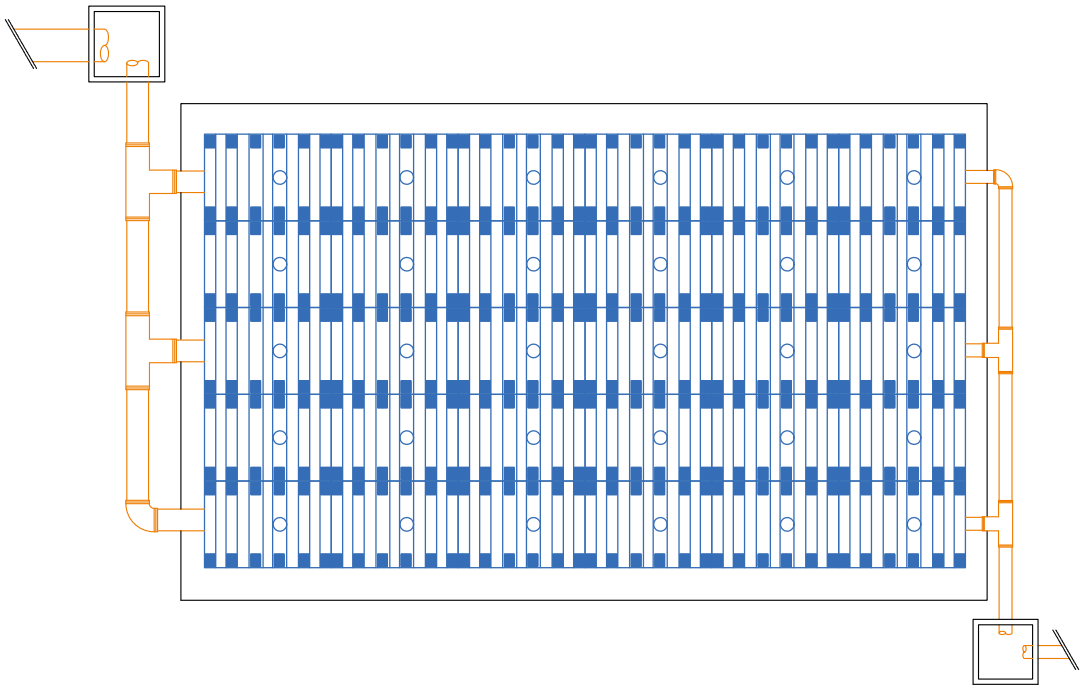
(H) Existing land

APPENDIX C1
HYDRAULIC SCHEMES

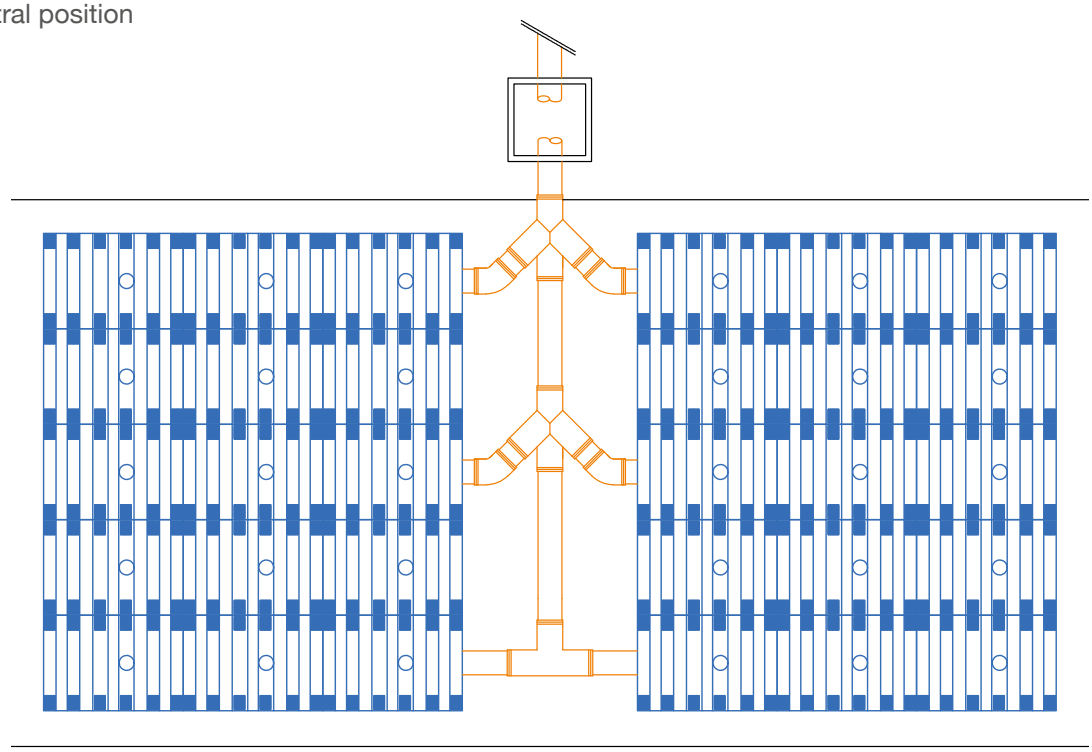
“Front “ supply and “comb” discharge.



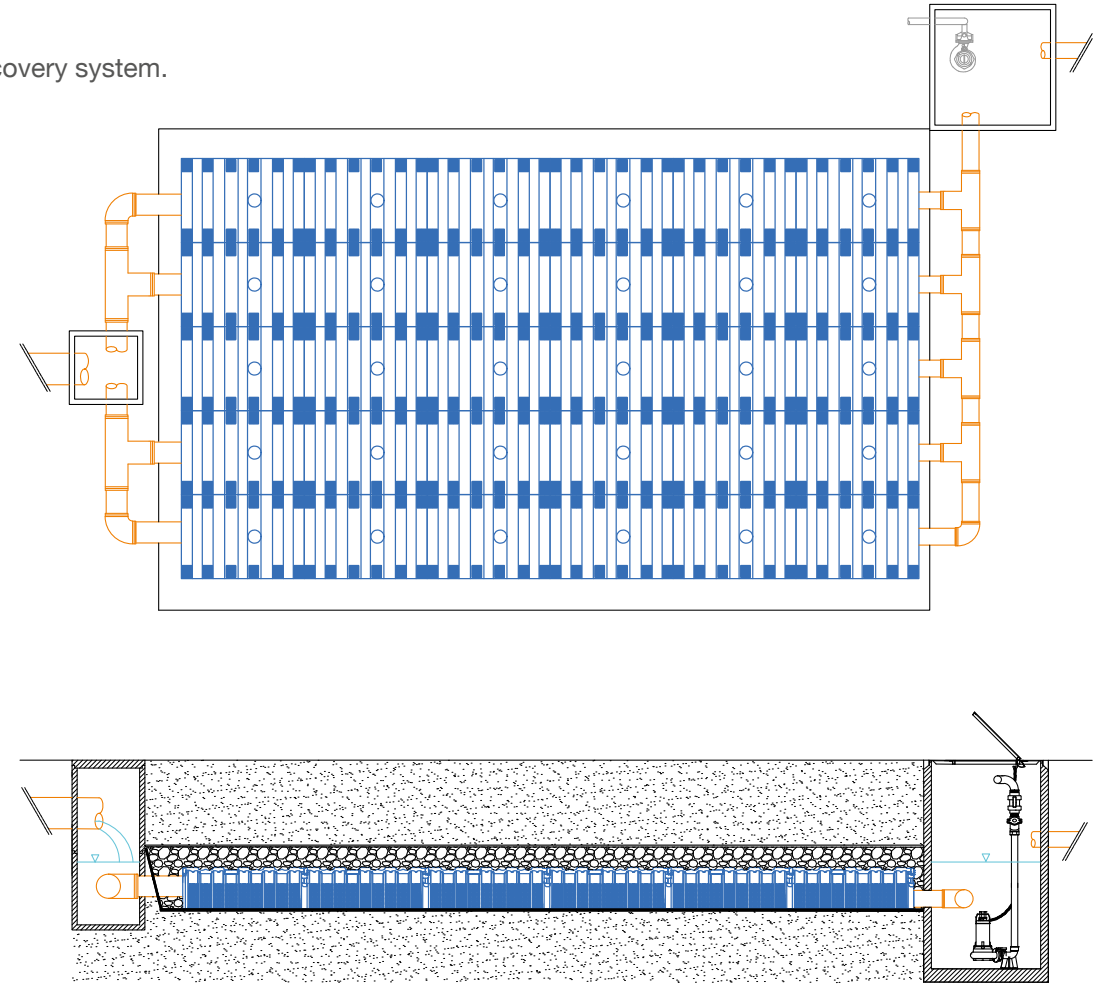
“Comb” supply and discharge.



Supply in central position

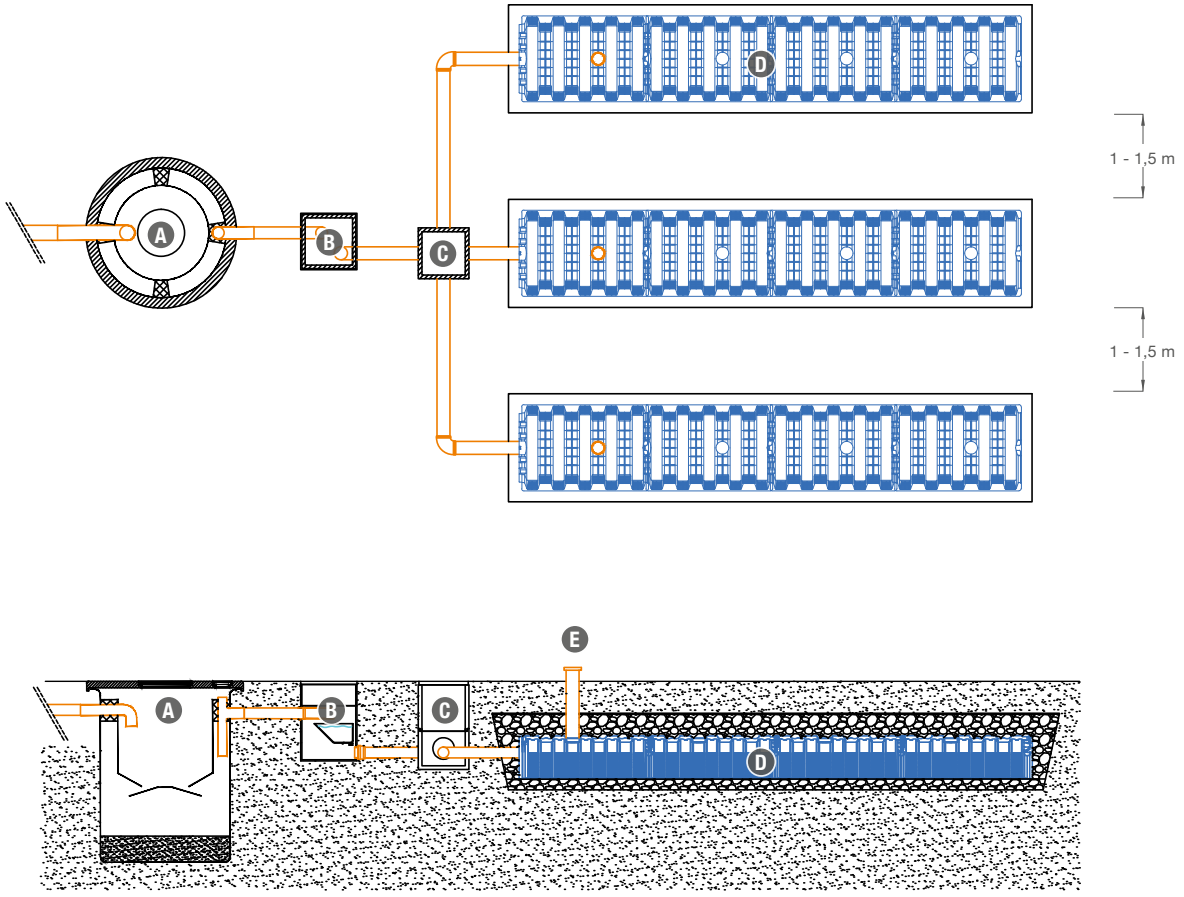


Rainwater recovery system.



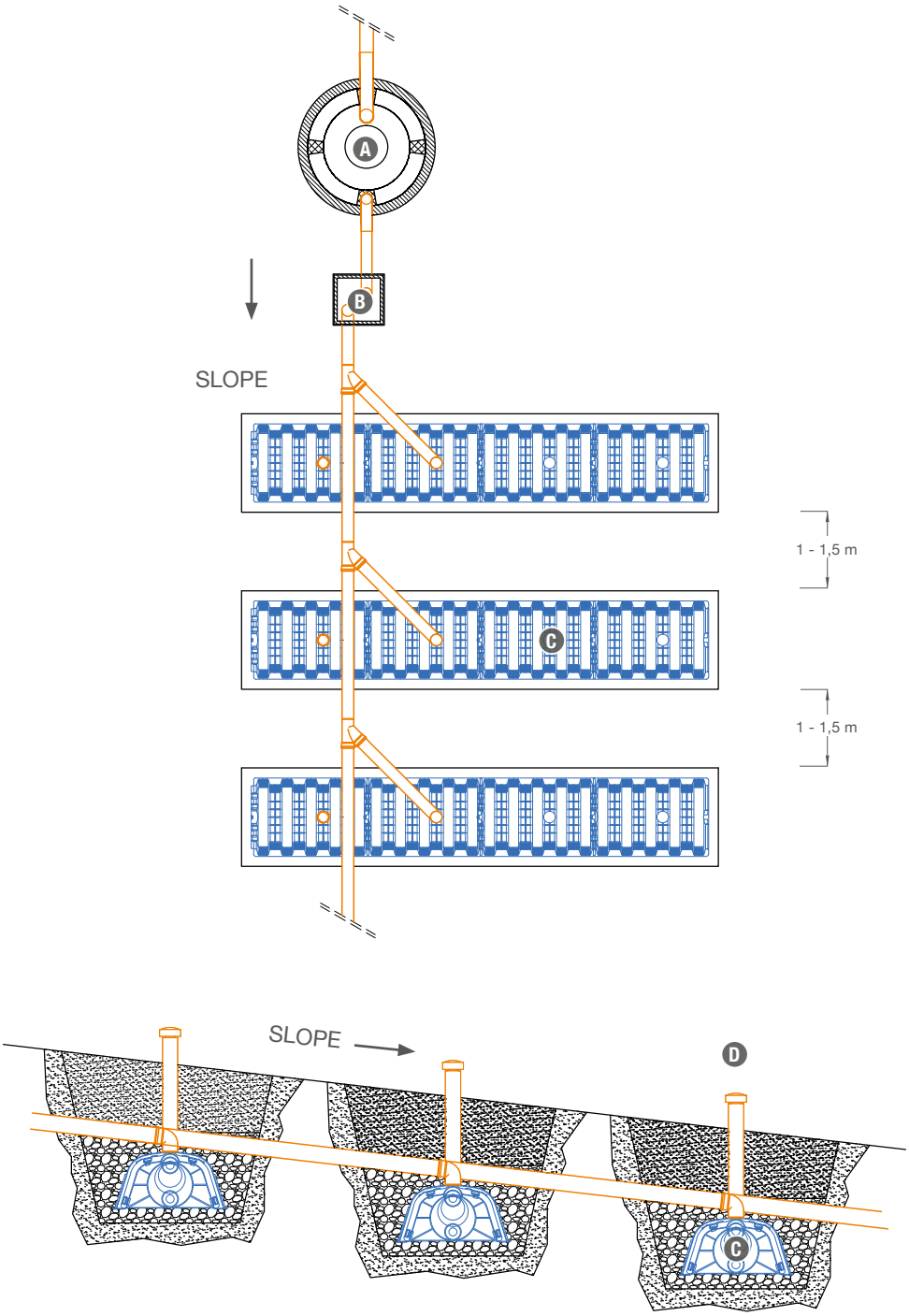
APPENDIX C2
HYDRAULIC WASTE DISPOSAL SCHEMES

Typical installation scheme for flat areas.



- (A) Imhoff pit (or clarification treatment)
- (B) Expulsion well
- (C) Divider well
- (D) Drening
- (E) Ventilation stack

Installation diagram for sloping areas with top supply.



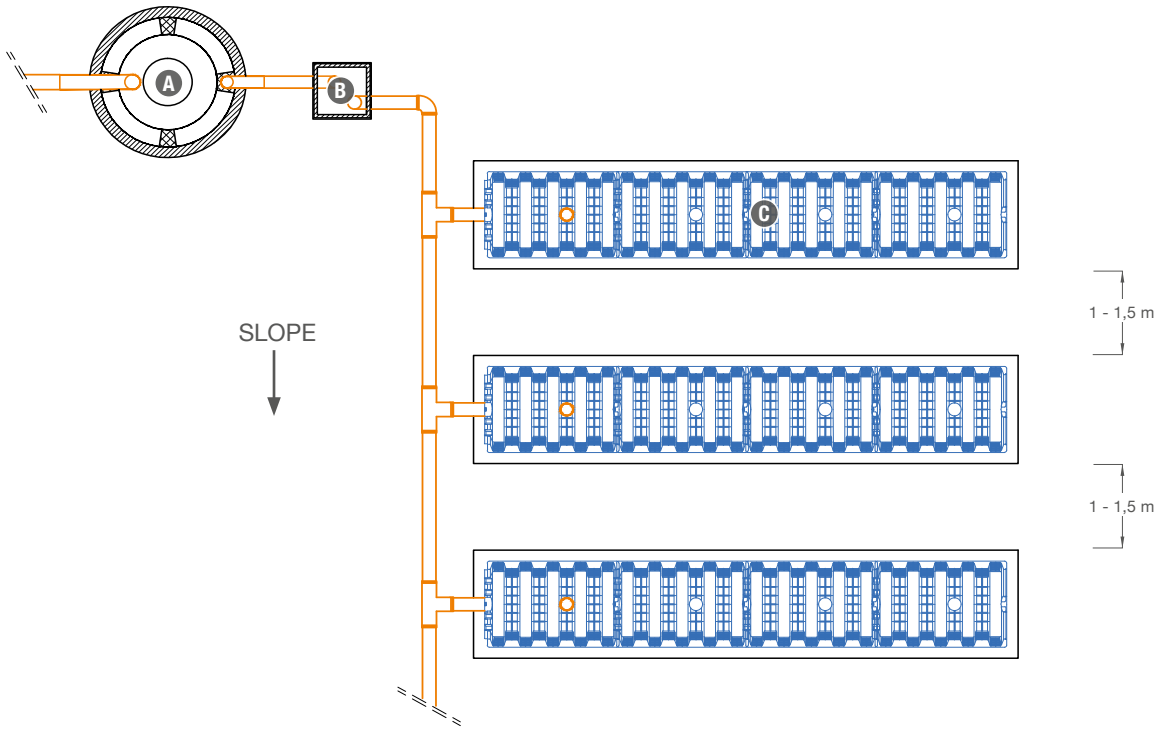
Ⓐ Imhoff pit (or clarification treatment)

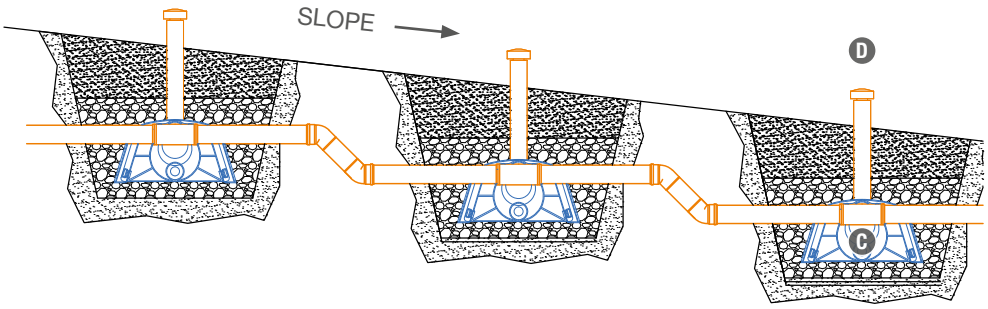
Ⓑ Expulsion well

Ⓒ Drening

Ⓓ Ventilation Stack

Installation diagram for sloping areas with frontal supply.





Ⓐ Imhoff pit (or clarification treatment)
Ⓑ Expulsion well
Ⓒ Drening
Ⓓ Ventilation stack

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Building beyond together

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