ELJEN GSF SYSTEM

MANITOBA

Design and Installation Manual

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Eljen GSF A42 System Performance Testing

The Eljen Geotextile Sand Filter (GSF) System is based on scientific principles which show that improving the effluent quality before infiltration in the native soil increases soil absorption rates and reduces risks of clogging. To ensure onsite system designers can confidently specify Eljen's GSF model A42 product, rigorous and official third-party independent testing was conducted in accordance with the NSF/ANSI Standard 40 Protocol.

A complete NSF 40 protocol was performed successfully and the Eljen GSF A42 is NSF 40 Class I certified.

A supplementary testing was also performed over a full 12 consecutive month period instead of the minimal 6 months required under the Standard 40 Protocol: this to verify the fecal coliform removal capacity and the stability of the performance and the capacity to handle colder weather conditions.

It is relevant to mention that the Eljen GSF product has been used extensively throughout the United States for decades and is also approved in four (4) Canadian provinces (BC, Ontario, Quebec and Saskatchewan) with hundreds of installations in Canada.

The intrinsic characteristics of the Eljen GSF system, combining simplicity, robustness and optimized natural biological processes, make it one of the most exceptional options for onsite wastewater treatment.

For more information on our product testing, design standards, installation procedures or how the Eljen GSF meets high effluent quality standards, please contact Enviro-STEP technologies inc. (The Manitoba Distributor) at 1-877-925-7496 or the Eljen Technical Support Department (The Manufacturer) at 1-800-444-1359.

A summary of the laboratory test results from independent third-party testing using the NSF/ANSI Standard 40 Protocol is listed below:

Table 1: NSF 40 performance Summary

Eljen GSF Treatment Performance summary NSF 40 Class I (Average temperature during testing of 7 ºC (min 2, max 13)		
	$CBOD_5$ (mg/L)	TSS (mg/L)
Average	13	10
Median	12	8
Min Value	<2	2
Max Value	62	40

Supplemental testing (12 months)

Eljen GSF A42 Modules Treatment Performance during official 12 months testing (including 12 consecutive weeks with influent temperatures below 10ºC)			
	$CBOD_5$ (mg/L)	TSS (mg/L)	Fecal Coliform (MPN/100ml)
Average	1.2	2.4	66*
Median	1.0	1.0	71*
Min Value	1.0	1.0	2*
Max Value	8.3	11.0	10,965*

*Geometric average

The Eljen GSF A42 System is described as a

Combined Advanced Treatment and Dispersal System.

Glossary of Terms

A42 GSF Module Each individual module of the GSF system has the following length (L), width (W) and height (H) dimensions, respectively: 1220 mm x 610 mm x 180 mm (48 in x 24 in x 7 in). The module is comprised of a cuspated plastic core and corrugated geotextile fabric.

Biofabric Special filter fabric within the Geotextile Sand Filter Modules upon which the primary biomat layer forms.

Cover Fabric The geotextile cover fabric that is placed over the GSF modules.

Cuspated Core The rigid plastic core of the GSF module. It separates the geotextile Biofabric and creates downward infiltration channels and upward aeration channels where primary filtration and biological treatment of the septic effluent occurs. The curvilinear shape of the cuspations offers increased treatment surface area and greater effluent storage.

Daily Design Flow The Daily Design Sewage Flow rate used for sizing a wastewater treatment system, taking into account mass loading and peak flows. The flow rate per A42 GSF module that is used to size a GSF System using residential strength waste is 95 liters per day per module.

Distribution Box (Or D-Box) A plastic or concrete box that receives effluent from a septic tank or pump tank and splits the flow to pipes placed above the GSF modules.

Flow Equalizer Special insert placed in the distribution box to self-level the flow out of the distribution box into the distribution pipes, ensuring that equal hydraulic velocities/flows are maintained between each row of pipe. Also known as speed-levelers.

GAC Filter **Granular Activated Carbon** (Charcoal) Filter used on vents to remove any septic odors.

GSF **Geotextile Sand Filter -** Includes the Eljen Geotextile Filter modules and the 150 mm (6 in) sand layer along the base and sides of the modules and the cover fabric.

LPDS **Low Pressure Distribution System** – LPDS is a mean of effluent distribution using low pressure and calibrated orifices to evenly distribute effluent over a large area.

SART **Soil Application Rate** - SART is the daily average volume of effluent applied per unit surface area of native soil, typically expressed in liters per day per square meter (L/d/m²).

SHWT **Seasonal High Water Table.**

STE **Septic Tank Effluent (STE)** is anaerobically digested effluent that is discharged to an Eljen GSF System for final treatment.

Specified Sand To ensure proper system operation, the system must be installed using ASTM C33 sand with a maximum of 5% of particles having a diameter of 75 µm or less, a maximum of 10% of particles having a diameter of 150 µm or less and a maximum of 20% of particles having a diameter of 2.36 mm or greater.

Table 2: Eljen GSF Specified Sand Requirements

Sieve Size	Sieve Square Opening Size	Specification Percent Passing
0.375”	9.5 mm	100.0
#4	4.75 mm	95.0 – 100.0
#8	2.36 mm	80.0 – 100.0
#16	1.18 mm	50.0 – 85.0
#30	600 µm	25.0 – 60.0
#50	300 µm	5.0 – 30.0
#100	150 µm	0 – 10.0
#200	75 µm	0 – 5.0
Note: *Request a sieve analysis from your material supplier to ensure that the system sand meets the specification requirements listed above.*		

Width & Length The system width is the Specified Sand dimension perpendicular to the GSF module rows. The system length is measured parallel to the rows of GSF modules.

Wire Clamps Wire Clamps are used to secure perforated pipe above the GSF modules.

Introduction

This manual provides design and installation information for the Eljen GSF System using the A42 GSF modules. Design layouts and installation instructions for gravity, bed, trench, raised, pumped systems are included. GSF systems must be designed and constructed according to the most current edition of this manual.

The Eljen GSF System technology is derived from research conducted by nationally recognized engineering scientists from the University of Connecticut. Eljen Corporation has over 30 years of success in the onsite wastewater industry, with tens of thousands of systems currently in use worldwide. The GSF is recognized and approved by regulatory officials and experts in the industry as one of the most reliable advanced treatment technologies in the marketplace today. The Eljen GSF System specifications in this manual are founded on this research and proven long term performance history.

The GSF technology is based on scientific principles which show that improving the effluent quality before infiltration in the native soil increases soil absorption rates and reduces risks of clogging. GSF's proprietary two-stage Bio-Matt™ pre-filtration process improves effluent quality while increasing reliability and ease of operation. *The Eljen GSF System is a combined treatment and dispersal system*.

Third-party independent testing data based on NSF/ANSI Standard 40 Protocol has shown that the Eljen GSF System provides Level IV Quality effluent as described in CAN/BNQ-600 standard.

The Eljen GSF (Geotextile Sand Filter) System

Eljen GSF A42 System Description

The Eljen GSF Geotextile Sand Filter system is an efficient, combined treatment and dispersion system, that produces a consistently high quality treated effluent. Comprised of a proprietary two-stage Bio-Matt™ treatment process, the geotextile modules apply a high quality pretreated effluent to the soil, increasing the soil's absorption rate, delaying/avoiding bed clogging, thus extending the life of the bed. The result is an effective wastewater treatment system that protects our drinking water and the environment.

How the Eljen GSF System Works

Primary Aerobic Filtration Treatment Zone

- Imitating a conventional leach bed, perforated pipe are centered over the GSF modules to distribute primary effluent over and into corrugations created by the cuspated core of the geotextile modules.
- Septic effluent is filtered through the Bio-Matt fabric. The module's unique accordion-shaped design provides increased surface area for biological treatment that greatly exceeds the module's footprint.
- Open-air channels within the module support aerobic bacterial growth on the modules geotextile fabric interface, surpassing the surface area required for traditional absorption systems.
- High void space within the modules offers storage during peak flows and helps to maintain close to constant hydraulic loading to the native soil. These alternating wetter (peak) and dryer (non-peak) sequences favor a controlled biomass thickness on the fabric and help minimize bacteria starvation during dryer, non-peak flow periods, assuring optimal biological sludge digestion;
- An anti-siltation geotextile fabric covers the top and sides of the GSF module and protects the Specified Sand and soil from clogging, while helping to maintain effluent storage within the module.

Secondary Granular Filtration Treatment Zone

- Effluent drips from the bottom and sides of the modules into the Specified Sand layer, resulting in unsaturated flow through the sand layer and thus into the native soil. This Specified Sand / soil interface functions to maintain the soil's structure, thereby maximizing the available absorption at the interface into the native soil.
- The highly permeable Specified Sand works to complete aerobic degradation while playing an important role in effluent disinfection.
- The Specified Sand layer also protects the soil from compaction and helps maintain natural soil fissures and crevices in the soil. This preserves the soil's natural infiltration capacity, which is especially important in finer-textured soils, where these comparatively larger channels are critical for long-term performance.
- The native soil then provides final polishing and filtration prior to groundwater recharge.

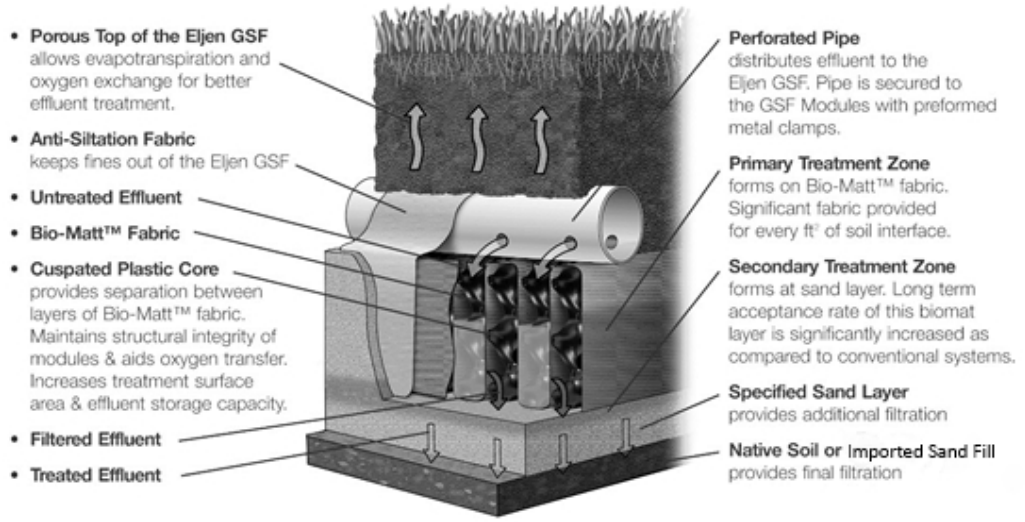

Figure 1: Eljen GSF System Operation

1.0 Basic System Design

DESIGN, INSTALLATION AND OPERATION HAS TO COMPLY TO MANUFACTURER SPECIFICATIONS AND MANITOBA REGULATION

DESIGN OF THE ELJEN GSF SYSTEM CAN ONLY BE PERFORMED BY AN APPROVED DESIGNER

INSTALLATION OF THE ELJEN GSF SYSTEM CAN ONLY BE DONE BY AN INSTALLER CERTIFIED IN MANITOBA AND TRAINED BY AN AUTHORIZED ENVIRO-STEP TECHNOLOGIES INC. REPRESENTATIVE

1.0 APPROVED DESIGNER: A person trained by an Authorized Enviro-STEP technologies inc. representative for the design of ELJEN GSF system in Manitoba.

1.1 ABSORPTION BED SIZE: The total basal area required is site specific and determined by the Daily Design Flow (DDF) and Soil Application Rate (obtained from the Soil Texture Classification) as specified in the Onsite Wastewater Management Systems Regulation and determined by an approved Designer.

Eljen GSF System is a *Combined Treatment and Dispersal System* that allows for a reduced field area in comparison to conventional beds when the following criteria are satisfied.

- The number of GSF modules required (See 1.10) fits within the required basal area and can be configured to properly cover any shape required and is the same for trench, bed or raised systems.
- In beds and raised systems, a minimum of 300 mm (1 ft.) separation is required between parallel rows of GSF modules to utilize sidewall infiltration areas.
- Modules within a same row can be spaced to increase the length of this row and cover a larger infiltration surface.
- Minimum perimeter separation between natural soil and Eljen GSF modules is 150 mm (6 in.)

1.2 VERTICAL SEPARATION: The vertical separation to be maintained below the Specified Sand layer and normal high ground water table, restrictive layer or bedrock shall be a minimum of 1 m (3.25 ft.)

When the vertical separation in the natural soil is not sufficient to meet the above criteria, it is possible to increase the thickness of the Specified sand layer under the Eljen GSF modules to meet the vertical separation criteria.

1.3 SPECIFIED SAND SPECIFICATION FOR ALL SYSTEMS: The 150 mm (6 in.) of Specified Sand immediately under, between rows and around the perimeter of the GSF system shall be **ASTM C33 SAND.** See page iv above for details on the ASTM C33 sand specification.

1.4 FILL FOR RAISED SYSTEMS: If the absorption bed requires raising such that more than 150 mm (6 in.) of Specified Sand is required to extend the vertical separation to a limiting layer or condition (e.g., normal groundwater table, restrictive layer or bedrock), the fill material below the Specified Sand shall be ASTM C-33.

1.5 PLACING GSF MODULES: Each row of modules are to be laid level and end-to-end on the above Specified Sand bed with a minimum spacing of 300 mm (1 ft.) between parallel rows. No mechanical connection is required between units. Alternatively, in all applications modules may be spaced end-to-end and edge-to-edge to increase the effective basal area. See Figure 7 and 8 (Section 13.0 Eljen GSF System Drawings) for details.

1.6 DISTRIBUTION PIPE: Place the approved perforated pipe (100 mm (4 in.) ∅) on top of GSF modules with the holes positioned at 5 and 7 o'clock. Complete system piping with solid pipe and fittings. Refer to Sections 2 and 3 below for level and sloped site piping information, respectively. Secure pipe to GSF modules with provided wire clamps, one clamp per Eljen GSF module. In all applications, any pipe distribution holes not discharging onto the GSF module must be sealed. See Figure 7 for suggested method of sealing perforated holes. See Figure 11 for pressure distribution.

1.7 DISTRIBUTION BOX: Set gravity system D-box outlet invert at a minimum of 10 mm per meter (1/8 in per ft.) above invert of distribution pipe over modules (50 mm minimum for pumped D-Box systems). The fill below the D-Box and piping must be compacted to avoid settling. Flow Equalizers (speed levelers) are required for gravity systems.

1.8 COVER FABRIC: Geotextile fabric, provided with the system, is placed over the top and sides of the module rows to prevent long-term siltation. ***Cover fabric substitution is not allowed*.** Fabric should drape vertically over the pipe and must neither block holes nor be stretched from the top of the pipe to the outside edge of the modules. "Tenting" will cause undue stress on fabric and pipe. ***Note:*** *If modules are spaced end-to-end in trench applications, fabric must be cut and allowed to drape over and protect the ends of each spaced module. A continuous run of geotextile fabric is not allowed for these applications.*

1.9 BACKFILL & FINISH GRADING: Carefully place backfill over the modules, followed by a minimum of 150 mm (6 in) of top soil to complete a total minimum depth of 300 mm (1 ft.), measured from the top of the module. Systems with a total cover that exceeds 450 mm (1.5 ft) as measured from the top of the module shall be vented at the far end of the system. Backfill material should be a well-graded sandy loam fill and needs to be clean, porous, and devoid of rocks larger than 50 mm (2 in.). Divert surface runoff from the effluent disposal area. Finish grade to prevent surface ponding. Seed loam to protect from erosion.

1.10 NUMBER OF GSF MODULES REQUIRED: Each Eljen GSF A42 modules is designed to a standard loading for residential strength effluent of 95 liters per day per module.

For all systems with Daily Design Flows (DDF) of residential effluent the number of A42 GSF modules needed is calculated by dividing the DDF in Liters/day by 95 L/day/module.

- For trench, bed and raised configuration drawings see Section 13.0 Eljen GSF A42 System Drawings.
- For information on commercial or high strength systems see Section 6.0 Commercial Systems, from pages 8 - 10.

1.11 ADDITIONAL FACTORS AFFECTING RESIDENTIAL SYSTEM SIZE: Homes with an expected higher than normal water use should increase septic tank capacity. Increasing the minimum effluent dispersal area should also be considered.

Factors that may affect system size:

- Luxury homes, homes with a Jacuzzi style tubs, and other high use fixtures.
- Homes with known higher than normal occupancy.

Designers should use discretion when there are multiple additional factors involved and should, as applicable, increase the size of the system in proportion to excess flows.

1.12 SYSTEM GEOMETRY: Design systems as long and narrow as practical along or parallel to site topographic contours to minimize groundwater mounding especially in poorly drained, low-permeability soils, such as clays. If possible, design level systems with an equal number of modules per row.

1.13 GARBAGE DISPOSAL: Garbage Disposal units (garburators) increase the organic loading to the system by 50%. If the owner wishes to use a garburator then the Daily Design Flow (DDF) must be increased by 50% which subsequently increases the size of all components of the system including the number of Eljen GSF modules and the overall field size. Design Drawings and Owners O&M manual must include a note that clearly indicates **"Garbage Disposals ARE (or ARE NOT) allowed to be used with this system."**

1.14 DOMESTIC WATER TREATMENT DEVICES: Backwash from domestic water treatment devices may adversely affect septic tank treatment and the Eljen GSF system. However, if designed properly, most backwash waters can be safely handled by the Eljen GSF treatment train. **Note:** Please consult with the supplier before discharging any drinking water wash water to the Eljen GSF System.

1.15 SAMPLING DEVICE: The sampling device refers to the assembly required on every Eljen GSF System (3 per system) and allows for the collecting of a sample of the treated effluent. The sampling device is a sampling tray containing a suction pipe protected by filter fabric. The suction pipe is long enough to bring it close to the surface for sampling. Each of the three (3) sampling devices must be placed right under the Specified Sand layer, each directly under its own Eljen module. We recommend placing the sampling trays at the beginning, center and end of a row. Each device is completed with an elbow and extended to grade using solid 100mm (4 in.) pipe and a threaded cap, allowing access for sampling. The flexible tubing of the sampling device is accessible directly under the threaded cap. To sample, connect the tubing to the sampling flask assembly and pour a sample using a drill-pump, hand pump or vacuum pump. See Figure 12.

Note: *The detailed sampling procedure is available from the supplier.*

1.16 SYSTEM VENTING: All systems require sufficient oxygen supply to the effluent dispersal area to maintain proper long-term effluent treatment. Therefore, the following situations require venting at the far end of the system:

- Any system with more than 450 mm of total cover as measured from the top of the module.
- Areas subject to compaction.
- Any system where there is no free air movement from the Eljen System and building vent. When a pump station is present an equilibrium pipe to allow free air movement may be required.

1.17 VEHICULAR TRAFFIC & OTHER: All vehicular traffic is prohibited over the Eljen GSF System. This is due to the compaction of material required to support traffic loading. This compaction greatly diminishes absorption below the Eljen GSF system, and diminishes the void spaces that naturally exist in soils which provide oxygen transfer to the Eljen GSF system. The “other” refers to placing the system in locations where the field could be subject to compaction from the pasturing of farm animals.

1.18 SEPTIC TANKS: Use a septic tank in compliance with the Manitoba regulation. The tank must:

- Have at least two (2) compartments;
- If prefabricated, conform to CSA B66-10 standard and bear a valid stamp or mark;
- The septic tank shall be sized to provide a minimum working volume equivalent to 2 – 3 times the estimated daily sewage flow (e.g., for a three bedroom home: 2 x 1,500 litres/day = 3,000 litres). The minimum septic tank volume shall be 3,000 litres. The septic tank volume does not include the pump chamber. If a pump is required, it can be installed in the second compartment of the septic tank provided the first compartment meets the minimum working volume requirement. Alternatively, a separate pump tank can be used

1.19 SEPTIC TANK FILTERS AND RISERS: Wastewater Effluent filters are required to prevent solids from leaving the septic tank. Access risers are required with septic tanks.

1.20 POINT OF APPLICATION: The Point of Application is the interface surface(s) where the secondary treated effluent passes from the Eljen GSF System Specified Sand to the native receiving soils. See Figures 4 and 8, respectively.

1.21 PROTECTION AGAINST FREEZING: The maximum installation depth of an Eljen system is 1 metre; thus in situations where the citing location may be at risk of deep frost penetration, hay bales are recommended and may be used to provide temporary insulation bales.

2.0 Level or Raised Site Systems

2.1 SYSTEM LAYOUT CONFIGURATION: Design level in-ground or raised systems with 150 mm (6 in.) minimum spacing between the outside perimeter and the modules, as shown in Figure 9: Level Bed Plan View on page 21. Provide 300 mm (1 ft.) minimum spacing between rows as shown in the aforementioned figure. The modules forming a row can be evenly spaced end-to-end to increase the area covered. The specified Sand, GSF modules, and distribution pipes are installed level at their design elevations.

2.2 DISTRIBUTION PIPE LAYOUT: Approved perforated pipe (100 mm (4 in.) ∅) runs along the center of the modules. Ends of rows are connected together with approved (100 mm (4 in.) ∅) solid pipe. If rows are longer than 15 meters, intermediate connections will need to be made at mid-point. See Note below Figure 9. Solid pipe is used to connect perforated lines to the distribution box. Maximum length of distribution pipe is 30 meters.

3.0 Sloped Site Systems

3.1 SYSTEM CONFIGURATION: Gravity or dosed GSF systems may be used on sloped sites where applicable.

3.2 ROW SPACING: For systems with up to 150 mm (6 in.) elevation drop between adjacent module rows, use 300 mm (1 ft.) minimum spacing. If over 150 mm (6 in.) drop, use 2 times the elevation drop as the minimum spacing between module rows.

3.3 DISTRIBUTION BOX: Provide a distribution box at the beginning of the first row of modules for effluent velocity reduction and a system inspection port, as shown in Figure 9. For each run, provide an individual solid pipe from the distribution box.

4.0 Pumped Systems

4.1 PUMP TO DISTRIBUTION BOX: Specify an oversized distribution box for pumped systems. Incoming pressure pipe to the distribution box must be transitioned to 100mm gravity pipe at least 1 m before the distribution box to allow significant velocity reduction. Provide additional velocity reduction in the D-box with a horizontal tee or baffle. Set D-box invert a minimum of 50 mm (2 in.) higher than the invert of the perforated pipes over the GSF modules. Do not use flow equalizers or other restricting devices in the outlet lines of the D-box. Pump chamber shall be vented.

4.2 PRESSURE DISTRIBUTION: Pressure distribution piping is configured as shown in Figures 2 and 11, respectively. A smaller pressure pipe is inserted inside the larger perforated pipe. Distribution is assured through small diameter pressurized orifices. Drainage of the line after each pump cycle is assured through drainage orifices. One distribution orifice is drilled at the 12 o'clock position for each Eljen GSF A42 module. One draining orifice is drilled at the 6 o'clock position at the beginning of the first module of each row and at the end of the last module of each row. The orifice size is determined using low pressure distribution calculations, ensuring that the flow is equally divided to each orifice and the residual pressure results in a minimum 900mm squirt height.

4.3 DOSING DESIGN CRITERIA: For all pump systems, use a maximum of 10 liters per dose per GSF A42 module in the system. Adjust pump flow and run time to achieve the above maximum dose or less. Longevity of currently available effluent pumps is not affected by shorter run times. Choose force main diameter to minimize percentage of dose drain back.

Effluent velocity in force main should not exceed 3 m/sec. In all cases design for a minimum of 7 doses per **day. For Commercial systems refer to Section 6.0.**

Note: *When pumping to D-box do not exceed D-box manufactures maximum flow rate.*

5.0 System Venting

5.1 VENTED SYSTEM: Air vents are only required on absorption systems with more than 450 mm (1.5 ft.) of cover material, as measured from the top of the GSF module to finished grade, or when there is no free air movement between the building vent and the Eljen System.

The GSF has aeration channels between the rows of GSF modules connecting them to the cuspations within the GSF modules. Under normal operating conditions, only a small portion of the GSF module is in use. The unused channels remain open for intermittent peak flows and the transfer of air. Under normal depth conditions (300 mm (1 ft.) to 450 mm (1.5 ft.) of cover), the supply of air in the Eljen GSF system is provided by air movement in the permeable soil.

When venting is required, one (1) vent is needed per bed. When a trench is used, one (1) vent is needed per trench. The vents provide adequate differential pressure to ensure delivery of air into the GSF system, as shown in Figure 2 below.

For pumped systems when no free movement of air is possible between the Eljen GSF and the building vent, it is possible to install an equilibrium pipe (by-pass line) with a minimal diameter of 75 mm (3 in.) between the Eljen GSF distribution network and the lift station to recreate free air movement as shown in Figure 3 below. This maintains the continuity of airflow from the field into the house plumbing.

The vents, when needed, are typically a 100 mm (4 in.) diameter pipe extended to a convenient and esthetical location (behind shrubs for example), as shown in Figure 2 below. Corrugated pipe can be used with the placement and grade such that any condensation that may accumulate in a pipe does not fill and thus close off this line. If the vent is extended, the pipe must not drain effluent and must have an invert higher than the system. Elevated (mounded) systems requiring venting must elevate the vent line above the top of the GSF modules with fittings to prevent effluent from migrating down the vent. The vent can then be pitched away from the system to a discrete area. A drain hole must be installed at the lowest point to drain any condensation.

We recommend that vent be a minimum height of 300 mm (1 ft.) above the snow height.

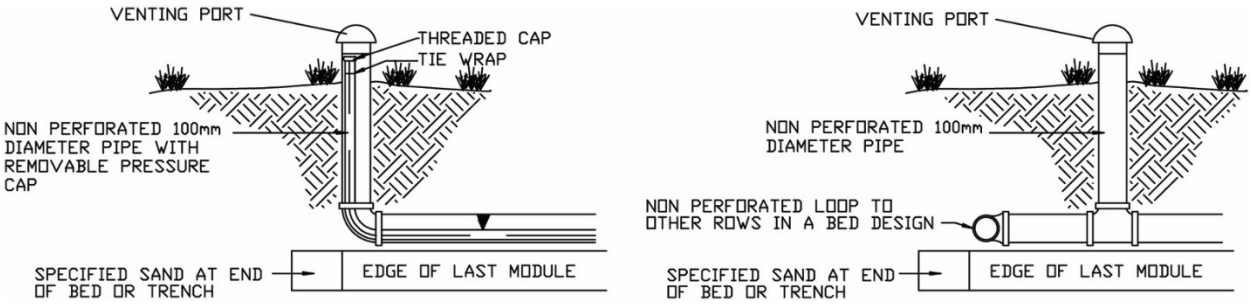

Figure 2: Vent Details for Gravity / Dosed and Pressure Distribution Systems (where specified)

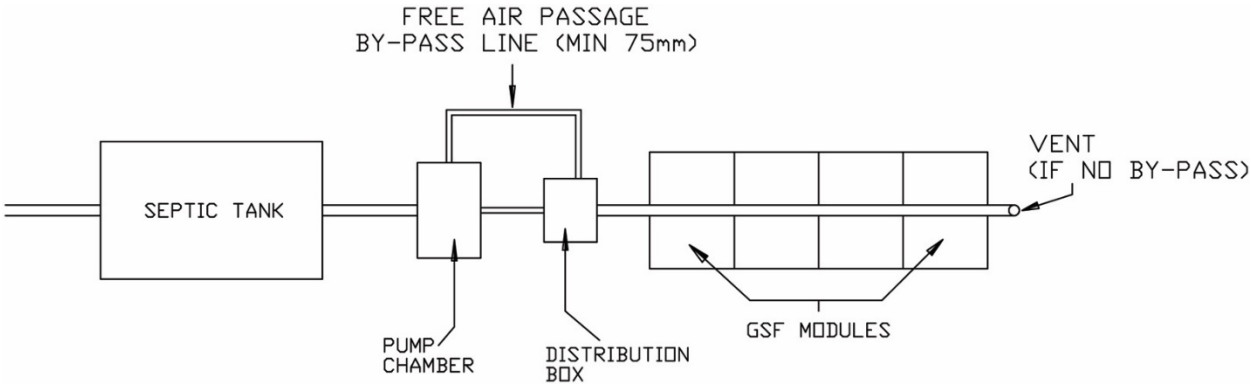

Figure 3: Air By-Pass Line Detail for Venting of Pumped Systems (where specified)

6.0 Commercial Systems

DESIGN OF COMMERCIAL SYSTEM HAS TO BE APPROVED BY THE SUPLIER ENGINEERING DEPARTMENT

IT IS RECOMMENDED TO USE LOW PRESSURE DISTRIBUTION OF EFFLUENT IN COMMERCIAL APPLICATIONS

IT IS MANDATORY TO USE LOW PRESSURE DISTRIBUTION OF EFFLUENT IN HIGH STRENGTH APPLICATIONS

6.1 DESIGN CONSIDERATIONS: Commercial systems differ from residential systems relative to wastewater characteristics, effluent distribution strategies, peak flows, system size and geometry. As these systems are normally larger, the designer must also consider the dispersal systems and their integrity, groundwater hydrology, drainage above and below the Eljen GSF System, and thus design accordingly.

Designers should carefully review and document with their client, effluent BOD_5 and TSS concentrations and water use numbers. The designer should document that the system installation meets the technology supplier's specifications to ensure long-term performance. In addition, designers must be attentive to special details of the system, conduct follow-through start-up and document technical capabilities for personnel required for Operation and Maintenance of the system.

Owners can expect operational issues when: occupants are not educated in the operation of the system, there is a discharge of excessive wastewater flows due to leaks, there is excessive water use, there is an installation of illegal items such as garbage grinders, and when routine maintenance is not performed on grease traps and septic tanks. Since the system owners and users may not know the costs associated with these types of problems, they will unlikely not be motivated to limit effluent problems and should be educated in these types of systems. Designers must provide an oversight of system installation and associated system equipment.

We strongly recommend that the designer validate each commercial design with Enviro-STEP technologies inc. Engineering and Field Support staff.

6.2 MAXIMUM UNIT LOADING: For commercial applications the design must be verified to ensure that not only the hydraulic loading rate per GSF module is respected but also the organic loading rate, taking the more stringent or onerous of the two criteria. See section 6.10 on page 8 above.

6.3 DESIGN FLOW: To determine design flow for commercial systems, please refer to Manitoba Minimum Expected Volume of Sewage per Day Table found in the Supplementary Information Package. When using water meter readings, Eljen recommends an adequate safety factor to account for expansion, unusual events and reflects the full occupancy of the facility. We strongly recommend that the designer validate each commercial design with Enviro-STEP technologies inc. Engineering staff.

6.4 EFFLUENT APPLICATION: Dispersion of effluent across a bed system or down a row of GSF modules must be specifically addressed in the design plans. A variety of wastewater delivery options exists and includes pressure distribution, pressure dosing, and gravity dispersed type systems. Wastewater volume and strength, system size, and site conditions often dictate which type of system is designed.

Designers must also consider that longer systems are naturally preferred as this geometry reduces the linear loading rate. Water table mounding must be considered to ensure that an adequate layer of unsaturated soils is maintained at all times.

Extremely large Eljen GSF systems should be designed as several smaller systems, allowing for independent management of the wastewater treatment system. Designs typically include indexing valves to rotate zones into service.

6.5 SITE DRAINAGE AND STORMWATER: Very large onsite absorption beds can be impacted by site drainage from upslope to the bed area. Larger effluent flows can also increase the groundwater mound downslope. Large recharge systems must be designed and located so that they can accept precipitation and the specified wastewater volume. Control and diversion of upslope storm water is normally included in the design. Understanding the stormwater flows onto and out of the system is essential to successful management of these systems.

Landscape position (i.e., the location on a slope where the citing of the system is proposed) and slope can impact the drainage because the gradient frequently changes with the configuration or geometry of the land, especially if a system is placed above a restrictive layer. The depth and permeability of each soil layer above the restrictive horizon impacts the groundwater mound, where such may exist. For example, upper horizons may be fairly permeable and accept precipitation easily. If these layers are above a more restrictive horizon, a perched water table can develop in response to a rainfall event. Movement of this perched groundwater can impact the disposal system; and if not recognized, can result in the breakout or the surfacing effluent. Interception and diversion or rerouting of the groundwater is therefore necessary with larger systems especially over restrictive soils to ensure acceptance of the treated effluent under wet conditions.

Downslope hydraulic capacity is also an important consideration with larger Eljen GSF Systems. For example, a system may be located on a free-draining slope while downslope conditions reveal that perched water table conditions exist due to a reduced hydraulic gradient. Design limits and linear loading must be considered and these limits should be based on the limitations of these downslope soils and gradient. Ideally, systems located in areas with relatively long, uniform slopes, help to reduce the linear loading, resulting in the effluent moving downslope.

6.6 MULTI-FAMILY DWELLINGS: Condominiums, apartments, vacation resorts, trailer parks, RV campgrounds and other systems with domestic type wastewater may use the design formula in Section 6.10 below with the maximum loading specified in Section 1.10. Note: Ensure that garbage disposals are not being installed or specified. Appropriately sized septic tank and effluent filters are required for all commercial systems. If the design formula in Section 6.10 is not used, a 1.5 safety factor should be added to the DDF.

6.7 RESTAURANTS: Restaurant or food preparation systems shall use the design formula in Section 6.10. Designs shall in all cases include an appropriately sized grease interceptor. Wastewater from the kitchen shall be piped separately from the rest of the sewage and discharged to the grease interceptor. The reminder of the sewage is discharged to the septic tank where the effluent from the grease interceptor will also be connected on the kitchen plumbing.

Designers may strongly consider the use of a pretreatment unit to reduce the organic loading to conventional domestic sewage strength. These designs must consider the additional sludge produced and ensure an adequate settling and storage capacity between pumpouts.

6.8 LAUNDROMATS: Laundromat systems shall use the design formula in Section 6.10. Designs shall use an effluent filter in the septic tank with filtration openings no larger than 0.8 mm.

6.9 OTHER COMMERCIAL SYSTEMS: Other non-residential systems, e.g. schools, butcher shops, milk or ice cream facilities, etc. will require more detailed design. The designer is advised to contact Enviro-STEP Technologies Inc. for recommendations on sizing prior to design and submission of plans for permitting.

6.10 FORMULA FOR DESIGN FLOW ADJUSTMENT: Any application where the **average** raw sewage is stronger than conventional domestic wastewater range of typical concentrations (e.g., raw sewage with BOD of 210 mg/L, TSS of 210 mg/L as defined by Crites and Tchobanoglous, 1998) **must be designed by taking into consideration both hydraulic and organic loading rates of the GSF A42 modules. The most stringent number of modules must be considered.**

Since the Eljen GSF system receives primary effluent, the primary effluent BOD concentration is to be considered in the calculation. Approximately 30% of the raw sewage BOD is considered to be removed by the septic tank.

Eljen GSF daily average hydraulic loading rate: **95 litres/modules/day (daily average)**

Eljen GSF maximum hourly peak loading rate: **300 litres/modules/day (hourly peak)**

Eljen GSF daily average organic loading rate: **22 g CBOD litres/modules/day (daily average)**

6.11 SYSTEM VENTING: It is recommended that all commercial systems be designed with vents. Systems with high waste strength and systems with more than 450 mm (1.5 ft.) of cover material as measured from the top of the GSF modules to the finished grade require venting. Designers that include vents in their designs often specify the use of Granular Activated Carbon or Charcoal (GAC) filters to ensure that septic odors do not become a nuisance. Designers should verify with the GAC filter manufacturer or supplier to ensure that the filter will allow airflow from both directions of the filter, otherwise the filter will block airflow and the vent will not effectively supply enough oxygen that the system demands for long term performance.

6.12 COMMERICAL SYSTEM PLANS REVIEW: Enviro-STEP technologies inc. Engineering and Field Support staff, will review at no cost all commercial Eljen GSF System plans prior to submission for approval from the local approving authority. Overall responsibility for system design remains with the licensed designer and / or professional.

7.0 GSF Design Considerations for Replacing Failed Systems

Before designing an Eljen GSF System to replace a failed system, ***IDENTIFY THE CAUSE OF FAILURE*** and adjust the new system design accordingly. Listed below are some of the most common reasons why septic systems fail:

1. Leaking plumbing fixtures.
2. Pump settings incorrect or not working properly.
3. More occupants or bedrooms than the system was designed for.
4. Excessive water usage.
5. Garbage disposal device.
6. Water softener backwash.
7. Detrimental chemicals being used.
8. Excessive grease in system.
9. Failed or missing septic tank outlet baffle.
10. Infiltration of groundwater into a leaky septic tank or pump chamber.
11. Infiltration of surface water into the system.
12. Specified Sand that does not meet the requirements as outlined in this manual.
13. Poor quality backfill over system (no oxygen flow to system).
14. System too close to water table.
15. Mounding due to poor drainage or low permeability soils.
16. Part of system not used because of blockage or excessive settling.
17. System is undersized.
18. Excessive backfill over system (more than 45” requires venting).
19. Crushed distribution pipe(s).
20. Distribution pipes not level.
21. Loam not removed prior to construction.
22. No vent installed or improper venting.
23. Clogged septic tank effluent filter.
24. Septic Tank needs to be pumped.
25. Wiring or electrical problems with pump systems.
26. Supply line to septic tank or D-Box needs repair.

8.0 Required Notes on Design Plans

Enviro-STEP technologies inc. strongly recommend that the following notes appears on Eljen GSF System design plans:

1. General excavation guidelines such as (marking the bed before excavating, removal of loose soil, provide a leveled excavation, etc.)

2. This system (is/is not) designed for the use of a garbage disposal.

3. This system is not designed to receive backwash from a domestic water treatment device unless specifically authorized by the supplier technical department.

4. For raised or mounded systems, the soil must be scarified on the first 150 mm to 225 mm (6 in to 9 in). The organic layer must be left in place unless it is greater than 150 mm (6 in) in which case it needs to be removed.

5. All fill material shall be clean and permeable and meet Eljen design manual requirements. The 150 mm (6 in.) of Specified Sand underneath and surrounding the GSF modules shall comply with ASTM C33 sand.

6. Backfill material can be native soil with no stones larger than 50 mm (2 in.) in any dimension to a maximum depth of 30 cm (1 ft.) over the GSF modules and covered with a minimum 150 mm (6 in.) of clean loam.

7. Any Eljen GSF System that is more than 450 mm (1.5 ft.) below finish grade as measured from the top of the module shall be vented.

8. This design complies with and must be installed in accordance with the most recent Eljen GSF System Design and Installation Manual for Manitoba.

9.0 Eljen GSF System Installation Guidelines

1. The design plans should present the system layout and details. The Installers must detail the system layout with respect to surface cover, spacing, number of modules, type of material, elevations, wastewater distribution, primary treatment, etc.

2. For raised or mounded systems, the soil must be scarified on the first 150 mm to 225 mm (6 in to 9 in). The organic layer must be left in place unless it is greater than 150 mm (6 in) in which case it needs to be removed.

3. Place a 150 mm (6 in.) minimum level surface of Specified Sand (ASTM C33 sand). You must use the Specified Sand as listed on page iv above to ensure proper system operation.

4. Place GSF modules with ***PAINTED STRIPE FACING UP***, on top of the Specified Sand following the design plans in regards to number of rows, spacing between rows, spacing around the Specified Sand perimeter, end-to-end modules spacing and number of GSF modules per row.

5. Specified Sand placed along both sides and between rows of GSF modules ensures aeration of the modules.

6. Use the provided clamps to secure the approved perforated pipe to the top of each GSF module.

7. In applications where modules are spaced out end-to-end to increase the effective basal area, all perforated holes not discharging at least 150 mm (6 in.) onto a GSF module must be sealed. See Figure 7 for details.

8. Cover the tops and sides of the modules along the entire length of each row with Eljen geotextile cover fabric.

9. If modules are spaced end-to-end, fabric must be cut and allowed to drape over and protect the ends of each spaced module. A continuous run of geotextile fabric is not allowed for these applications.

10. Backfill the installation with sandy loam material free of debris. If native soil quality allows it for backfill use, it has to be free of clay chunks, debris and stones 50 mm (2 in.) or larger.

11. Finish by grading the area to divert storm water runoff away from the system.

12. Do not drive backhoe wheels over GSF modules or any portion of the Specified Sand area. Light-weight track rigs may cross system area sparingly with a minimum of 300 mm of cover over the distribution pipe. System area should only be crossed perpendicularly.

13. Do not drive over any Eljen GSF System.

14. It is also permissible to back-blade the soil to set final minimum cover. Perimeter landscape timbers are also recommended to locate the shallow beds, thereby keeping vehicles off the system.

15. Seeding and stabilizing the soil cover is required to protect the system from soil erosion.

16. Where the elevation of the surface exceeds the natural grade, a block or landscape timber frame or sloping soil toe at a maximum 4:1 grade can be used to help eliminate soil erosion and support maintenance of the stabilizing grass cover adjacent to the GSF modules.

17. For pumped systems, provide a well-anchored D-box with a velocity reduction tee or baffle. Vent system at the far end of the trench or bed when more than 450 mm (1.5 ft.) of cover material is used, measured from the top of the GSF modules to finished grade.

10.0 In-Ground Bed System Installation Instructions

1. The design plans should present the system layout and details. The Installers must reproduce the system layout with respect to surface cover, spacing, number of modules, type of material, elevations, wastewater distribution, primary treatment, etc.

2. Carefully lay out the system components and boundaries. Define the location and elevation of the bed and distribution box based on the septic tank outlet elevation and pipe grades required to maintain flow to each component.

3. Prepare the site according to Manitoba regulations and this manual. Do not install a system on saturated ground or wet soils that are smeared during excavation. Keep heavy machinery off clay-type soils used for the Eljen GSF System as well as downslope from the system where soil structure is critical for absorption and drainage of the treated effluent.

4. Plan all drainage requirements above (upslope) the system so as to not adversely affect the system area. Set soil grades to ensure that stormwater drainage and groundwater is diverted away from the absorption area once the system is complete.

5. Place a minimum of 150 mm (6 in.) layer of Specified Sand above the native soil grade. Gently hand compact, level and rake the Specified Sand on grade. A hand tamper is sufficient to stabilize the Specified Sand below the GSF modules. The finished height below the GSF module must be 150 mm (6 in.) minimum. Check the zero grades with a laser level before placing the GSF modules.

6. Place GSF modules with ***PAINTED STRIPE FACING UP***, on top of the Specified Sand following the design plans in regards to number of rows, spacing between rows, spacing around the Specified Sand perimeter, end-to-end modules spacing and number of GSF modules per rows.

7. If using a D-box(s), installation must follow the manufacturer's recommendations and any applicable regulation. The soil underneath the D-box must be a layer of 150 mm (6 in.) of compacted granular material (sand, gravel) to assure adequate settling and avoid movement. Flow equalizer or Speed leveler type of device are mandatory when using a D-Box.

8. Use approved 100 mm (4 in.) ∅ non-perforated pipe from the distribution box to the GFS modules.

9. Center approved 100 mm (4 in.) ∅ perforated distribution pipe lengthwise over modules with orifices at the 5:00 and 7:00 pm positions. For Gravity Systems, connect mid points on level bed systems on rows over 15 meters long. See Figure 9.

10. In applications where modules are spaced end-to-end to increase the effective basal area, all perforated holes not discharging at least 150 mm (6 in.) onto a GSF module, must be sealed. See Figure 7 for details on page 20.

11. Secure pipe to GSF modules using one Eljen clamp per module. Push clamp ends straight down into up-facing core, through the fabric and into the underlying sand.

12. Spread Eljen cover fabric lengthwise over the pipe and drape over the sides of the GFS module rows. Secure in place with Specified Sand between and along the sides of the modules. Avoid blocking holes in perforated pipe by placing the cover fabric over the pipe prior to placing fill over the modules. ***Note:*** *If modules are spaced end-to-end, fabric must be cut and allowed to drape over and protect the ends of each spaced module. A continuous run of geotextile fabric is not allowed for these applications.*

13. Place Specified Sand along the sides of the modules and at the ends of each module row up to the height of the GSF modules (180 mm).

14. Complete backfill with permeable soil (E.g., Sandy Loam) to a minimum of 150 mm (6 in.) over the GSF modules. Place a minimum of 150 mm (6 in.) of top-soil on top of the fill. Total backfill exceeding 450 mm (1.5 ft.) requires venting at the far end of the trench. Fill should be clean, porous and devoid of debris, large rocks and organic matter. Do not use wheeled equipment over the system. A light track machine may be used with caution, avoiding crushing or shifting of pipe assembly. Backfill in direction of perforated pipe.

15. Divert surface runoff. Finish grade to prevent surface ponding. Seed surface of fill material and protect from erosion.

11.0 Raised System Installation Instructions

Note: *Refer to Figure 10 for design illustration.*

1. The design plans should present the system layout and details. The Installers must reproduce the system layout with respect to surface cover, spacing, number of modules, type of material, elevations, wastewater distribution, primary treatment, etc.

2. Carefully lay out the system components and boundaries. Define the location and elevation of the raised bed and distribution box based on the septic tank outlet elevation and pipe grades required to maintain flow to each component.

3. Prepare the site according to Manitoba regulation and this manual. Do not install a system on saturated ground or wet soils that are smeared during excavation. Keep heavy machinery off clay soils used for the GSF system as well as downslope from the system where soil structure is critical for absorption and drainage of the treated effluent.

4. Plan all drainage requirements above (upslope) of the system so as to not adversely affect the system area. Set soil grades to ensure that stormwater drainage and groundwater is diverted away from the absorption area once the system is complete.

5. For raised or mounded systems, the soil must be scarified on the first 150 mm to 225 mm (6 in to 9 in). The organic layer must be left in place unless it is greater than 150 mm (6 in) in which case it needs to be removed.

6. Place fill material meeting regulatory requirements onto the soil interface as you move down the excavated area. If this is done in two steps, bring in the fill material from the upslope side of the excavation. Place 150 mm (6 in.) layer of Specified Sand to 25 mm (1 in.) above the sand fill grade. Gently hand compact, level and rake the sand on grade.

7. A hand tamper is sufficient to stabilize the Specified Sand below the GSF modules. Check the zero grade on the top of the Specified Sand using a 2 x 4 and carpenter's level or a laser before placing the modules.

8. Place GSF modules, with ***PAINTED STRIPE FACING UP***, on top of the Specified Sand following the design plans in regards to number of rows, spacing between rows, spacing around the Specified Sand perimeter, end-to-end modules spacing and number of GSF modules per row.

9. Use approved 100 mm (4 in.) ∅ non-perforated pipe from the distribution box to the GFS modules.

10. Center approved perforated distribution pipe lengthwise over modules with orifices at 5:00 and 7:00 pm positions.

11. Secure pipe to GSF modules using one Eljen clamp per module. Push hoop ends straight down into up-facing core, through the fabric and into the underlying sand layer.

12. Spread Eljen cover fabric lengthwise over the pipe and drape over the sides of the GFS module rows. Secure in place with Specified Sand between and along the sides of the modules. Avoid blocking holes in perforated pipe by placing the cover fabric over the pipe prior to placing fill over the modules. ***Note:*** *If modules are spaced end-to-end, fabric must be cut and allowed to drape over and protect the ends of each spaced module. A continuous run of geotextile fabric is not allowed for these applications.*

13. Place Specified Sand along the sides of the modules and at the ends of each module row up the height of the GSF modules (180 mm).

14. Complete backfill with permeable soil (E.g., Sandy Loam) to a minimum of 150 mm (6 in.) over the GSF modules. Place a minimum of 150 mm (6 in.) on top-soil on top of the fill. Total backfill exceeding 450 mm (1.5 ft.) requires venting at the far end of the trench. Fill should be clean, porous and devoid of debris, large rocks and organic matter. Do not use wheeled equipment over the system. A light track machine may be used with caution, avoiding crushing or shifting of pipe assembly. Backfill in direction of perforated pipe.

15. Divert surface runoff. Finish grade to prevent surface ponding. Seed surface of fill material and protect from erosion.

12.0 Absorption Bed System Sizing and Details

Design Parameters Summary

Septic tank:

Every Eljen GSF System shall be preceded by a two (2) compartment septic tank. The tank shall comply with the Manitoba regulation and meet the following requirements:

- Have at least two (2) compartments;
- If prefabricated, conform to CSA B66-10 standard and bear a valid stamp or mark;
- The septic tank shall be sized to provide a minimum working volume equivalent to 2 – 3 times the estimated daily sewage flow (e.g., for a three bedroom home: 2 x 1,500 litres/day = 3,000 litres). The minimum septic tank volume shall be 3,000 litres. The septic tank volume does not include the pump chamber. If a pump is required, it can be installed in the second compartment of the septic tank provided the first compartment meets the minimum working volume requirement. Alternatively, a separate pump tank can be used
- The tank must be equipped with an effluent filter approved by NSF and providing filtration orifices no less than 1.6 mm (1/16 in.)

Vertical Separation:

The vertical separation to be maintained below the Specified Sand layer and normal high groundwater table, restrictive layer or bedrock must be a minimum of 1 m (3.25 ft.).

When the vertical separation in the natural soil is not sufficient to meet the above criteria, it is possible to increase the thickness of the Specified sand layer under the Eljen GSF modules to meet the vertical separation criteria.

Number of Eljen GSF A42 modules Required:

Each Eljen GSF A42 module has the capacity to treat 95 L of wastewater per day. Thus, the number of Eljen GSF modules required can be determined, using the Daily Design Flow (DFF), from the following formula:

- $Q_{DDF}/95$.
- ***Note:*** *The number of Eljen GSF modules obtained must be rounded up at all times.*

Modules Spacing Requirements:

The Eljen GSF modules shall be spaced using the following criteria:

- Each modules of a given row are placed end-to-end or can be evenly spaced to increase the total area covered.
- Each row of modules are spaced at a minimum of 300 mm (1 ft.), measured side-to-side.
- Each row begins and ends at a minimum of 150 mm (6 in.) inside the perimeter defined by the Specified Sand.
- Modules can be placed at an angle (from the horizontal plane) to follow site topographic contours (See Figure 11).

Total Area Field Type – In-ground, partially raised, or above ground

The area (m^2) to be covered by the Specified Sand in the Eljen GSF System shall be equal or larger than the area (A) determined by the formula

A = 1.13 x Q ÷ R

in which Q is the total Daily Design Flow in L/day and R is the Application Rate (as per Manitoba Soil Texture Classification Triangle in the Supplementary Information). The 1.13 factor is the combination of a safety factor of 1.5 (gravelless system) multiplied by a 0.75 reduction factor equivalent to a size reduction of 25% as granted to advanced systems.

- In all Eljen GSF System designs the minimum spacing requirement shall be met.
- Where the area determined using 1.13 x Q ÷ R is larger than that required by the minimum spacing required above, the Eljen GSF modules may be evenly spaced over the entire area of the Eljen GSF Specified Sand.
- The dispersal surface shall have the long dimension perpendicular to the direction in which effluent entering the soil will move horizontally.
- When the native soil does not meet the required vertical separation to the water table, restrictive layer or bedrock or bed rock, the Eljen GSF System must be raised, and the vertical separation compensated by adding the Specified Sand to meet the requirement.

Trench Field Type – In-ground, partially raised:

The total length of trench (m) to be covered by the Specified Sand in the Eljen GSF System shall be equal to or larger than the length (L) determined by the following formula:

L = 0.75 x Q ÷ (R x (W + 0.325))

in which Q is the total Daily Design Flow in L/day and R is the Application Rate (as per Manitoba Soil Texture Classification Triangle in the Supplementary Information)., W is the trench width. The 0.75 factor is equivalent to a size reduction of 25% as granted to advanced system.

- In all Eljen GSF System designs the minimum spacing requirement shall be met.
- Where the length determined using 0.75 x Q ÷ (R x (W + 0.325)) is larger than that required by the minimum spacing required above, the Eljen GSF modules may be evenly spaced over the entire area of the Eljen GSF Specified Sand.
- The dispersal surface shall have the long dimension perpendicular to the direction in which effluent entering the soil will move horizontally.
- When the native soil does not meet the required vertical separation to water table, restrictive layer or bedrock or bed rock, the Eljen GSF System must be raised, and the vertical separation compensated by adding Specified Sand to meet the requirement.

Other:

The Eljen GSF System shall be designed, installed, operated, and maintained using these criteria:

- No System shall be installed in an area in which the original ground has a slope in excess of 4 horizontal to 1 vertical (25%).
- All pumped systems not having an equilibrium pipe ensuring free air movement, shall use differential venting (See section on venting);
- Except when used with a “Low Pressure Distribution System”, all Eljen GSF Systems that have a pump must use a velocity reducer located in the distribution box.
- The Eljen GSF System shall have a sampling device for the purpose of sampling the effluent and it shall be installed as described in the Eljen / Enviro-Step Technologies Inc. “Eljen GSF System: Sampling Manual – Manitoba”, available from the supplier.
- The site shall be protected from erosion by proper grading, mulching, seeding, and runoff control.
- The distance measured from the edge of the trench wall or the bed edge, shall meet the setback requirements outlined in the regulation.
- No reduction in size of the Eljen GSF System is permitted with the use of the treatment device beyond that of a septic tank.

13.0 Eljen GSF A42 System Drawings

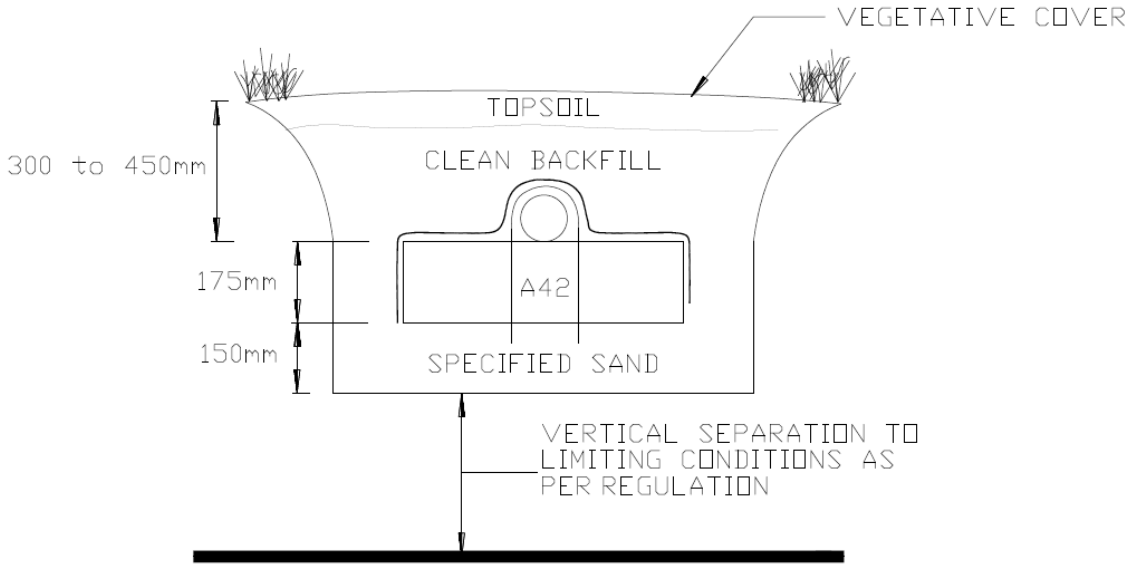

Figure 4: Vertical Separation to Limiting Conditions

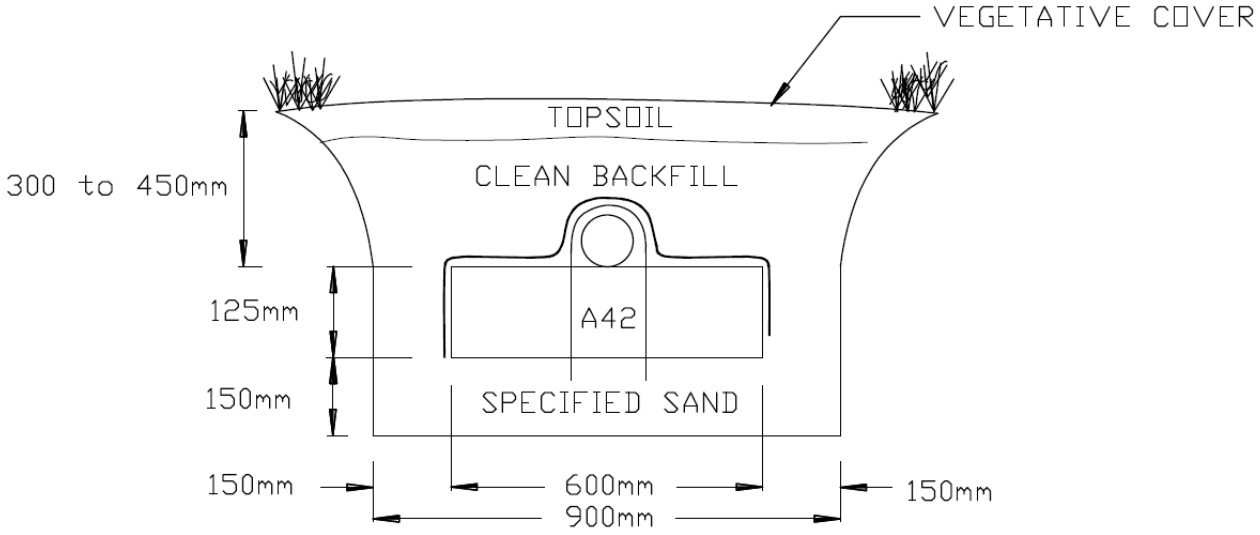

Figure 5: A42 Single Trench Cross Section

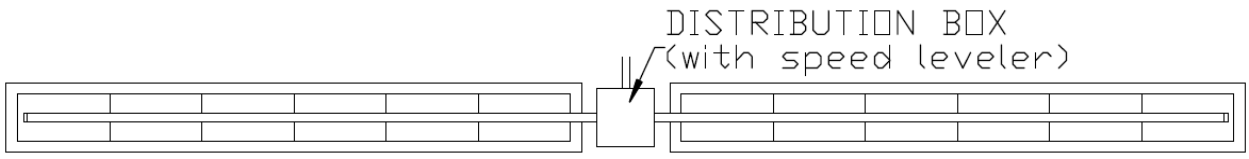

Figure 6: A42 Butterfly Trench (or bed) Configuration

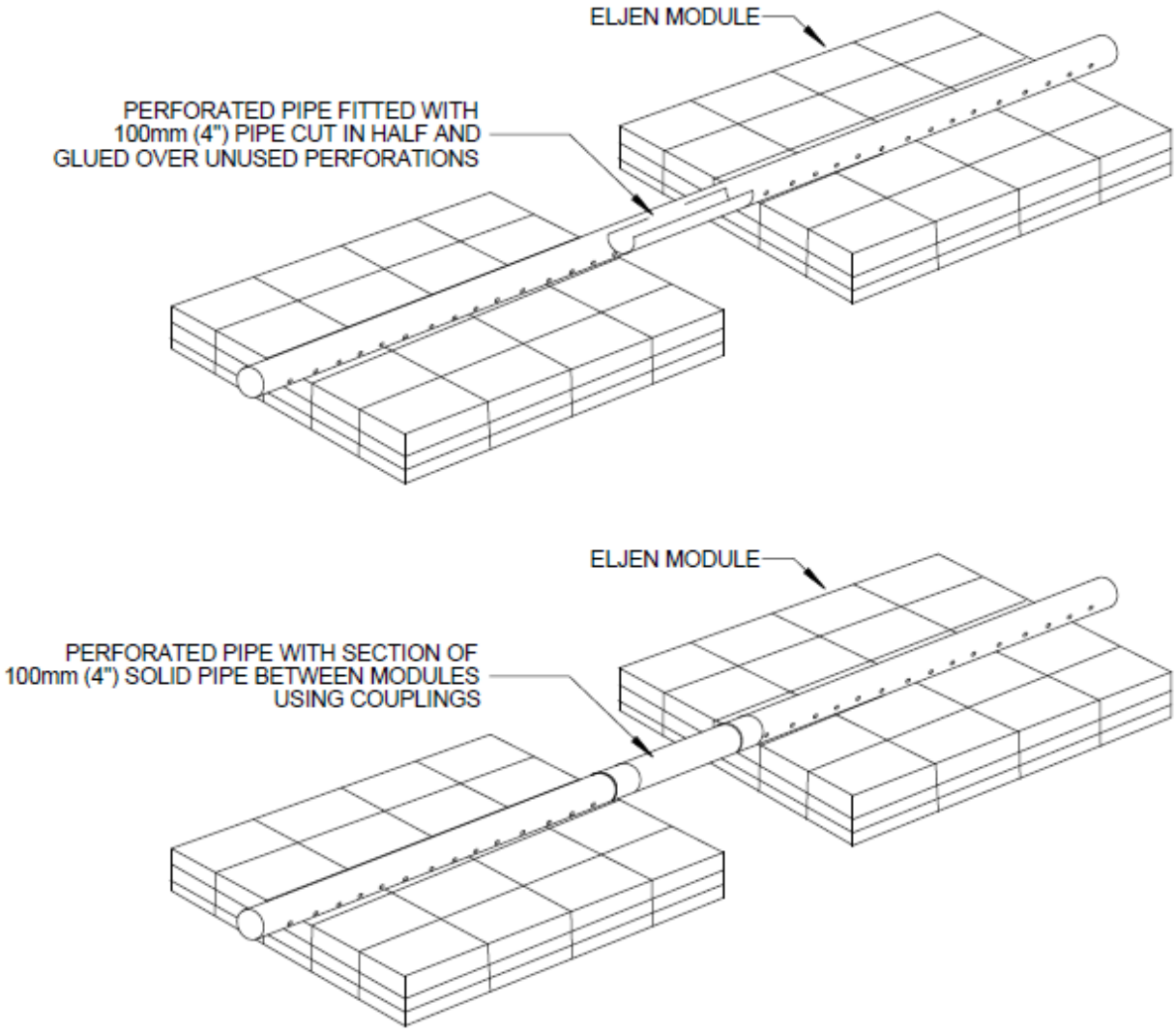

Figure 7: A42 Module End-to-End Separation for All Applications

NOTE: *The half-pipe must cover any hole above the A42 module that is within 150 mm of the edge. If modules are spaced end-to-end, fabric must be cut and allowed to drape over and protect the ends of each spaced module. A continuous run of geotextile fabric is not allowed for these applications.*

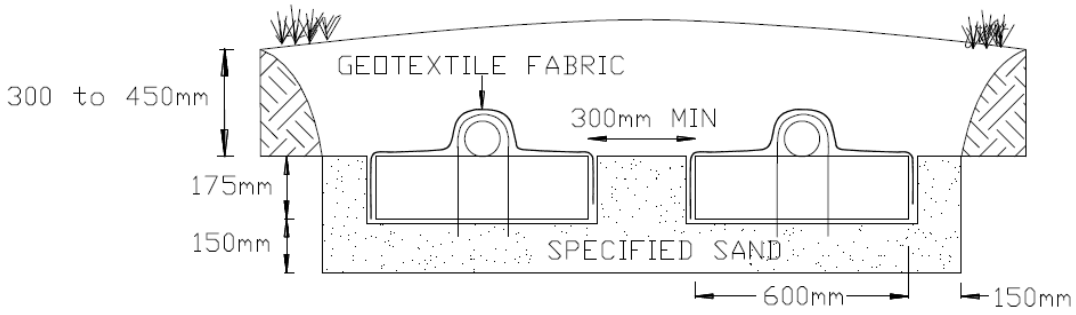

Figure 8: A42 Bed Cross Section

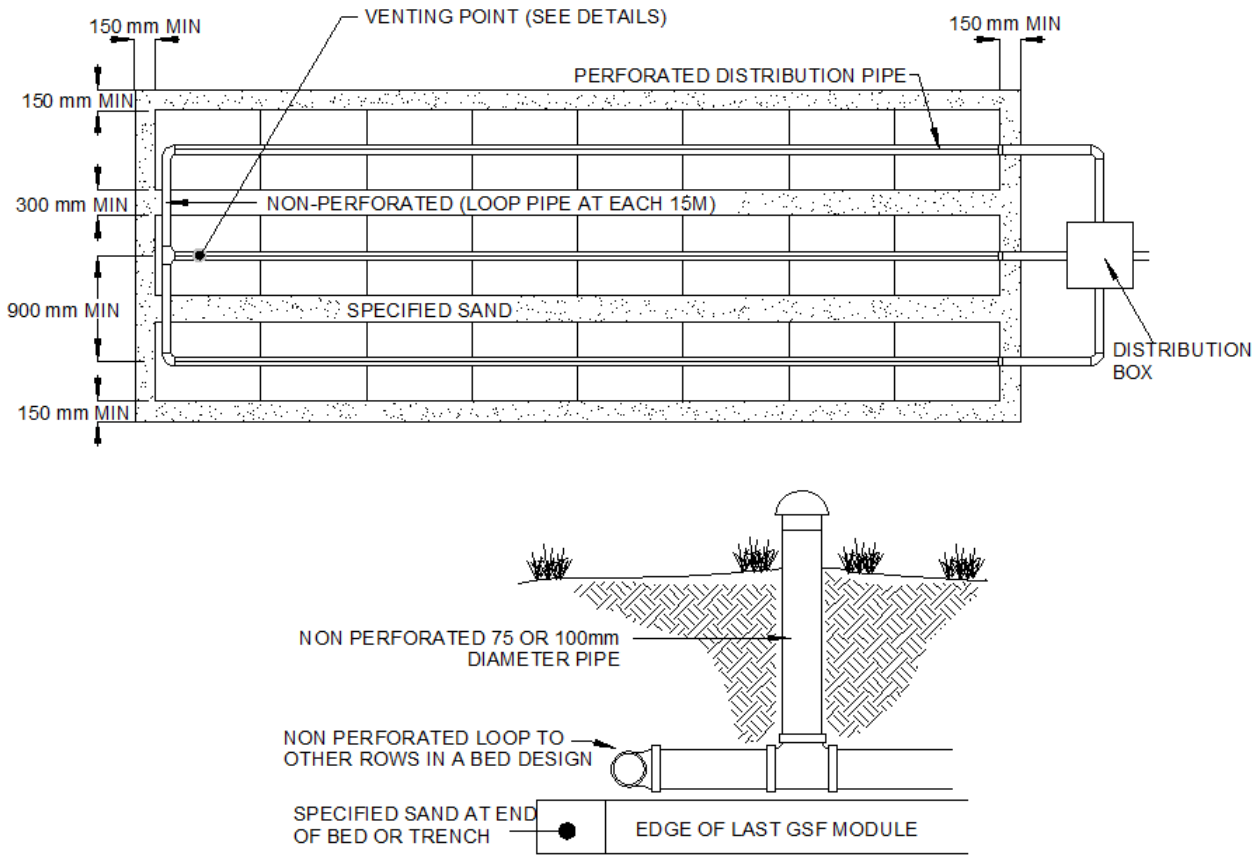

Figure 9: Level Bed Plan View

Note: *Middle cross-over pipes are recommended for systems over 15m long. Contact Eljen for Cross-Over pipe details if needed. Cross-Over & end loop pipes are not required on Pressure or Serial Bed Systems.*

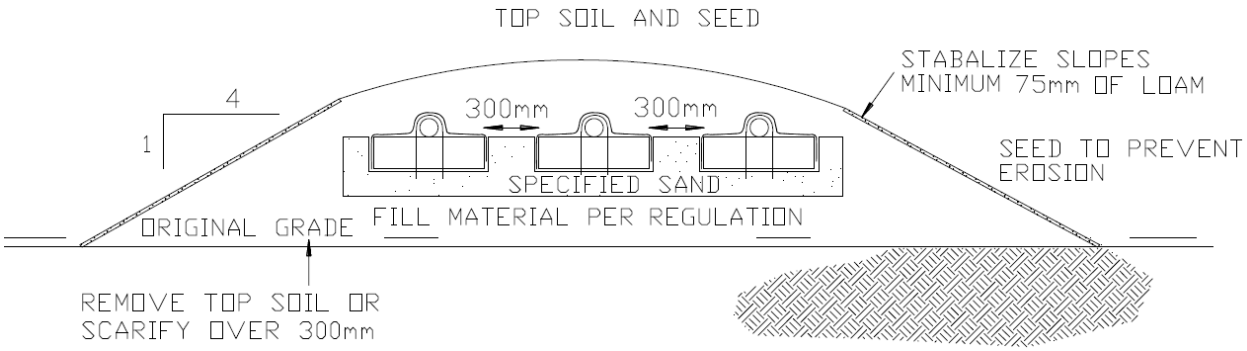

Figure 10: A42 Raised Bed Cross Section

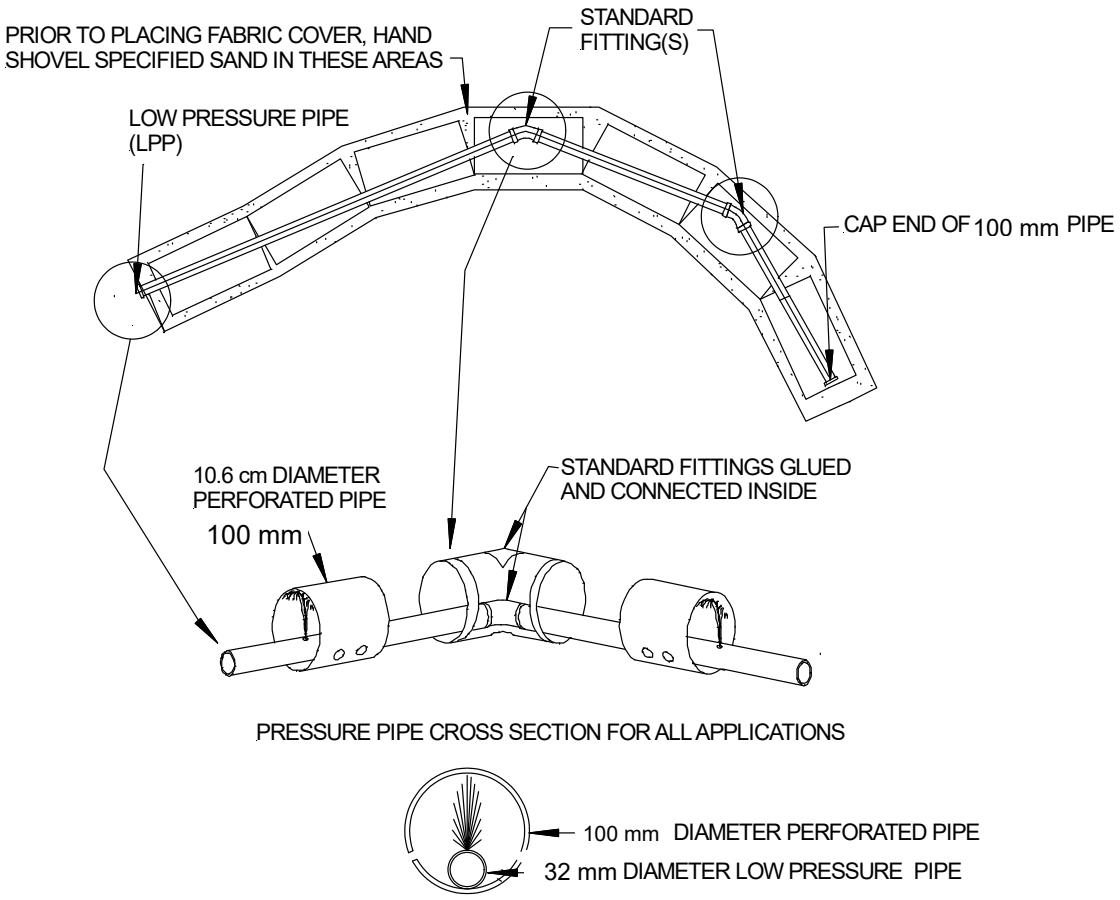

Figure 11: Pressure Distribution Lateral Layout

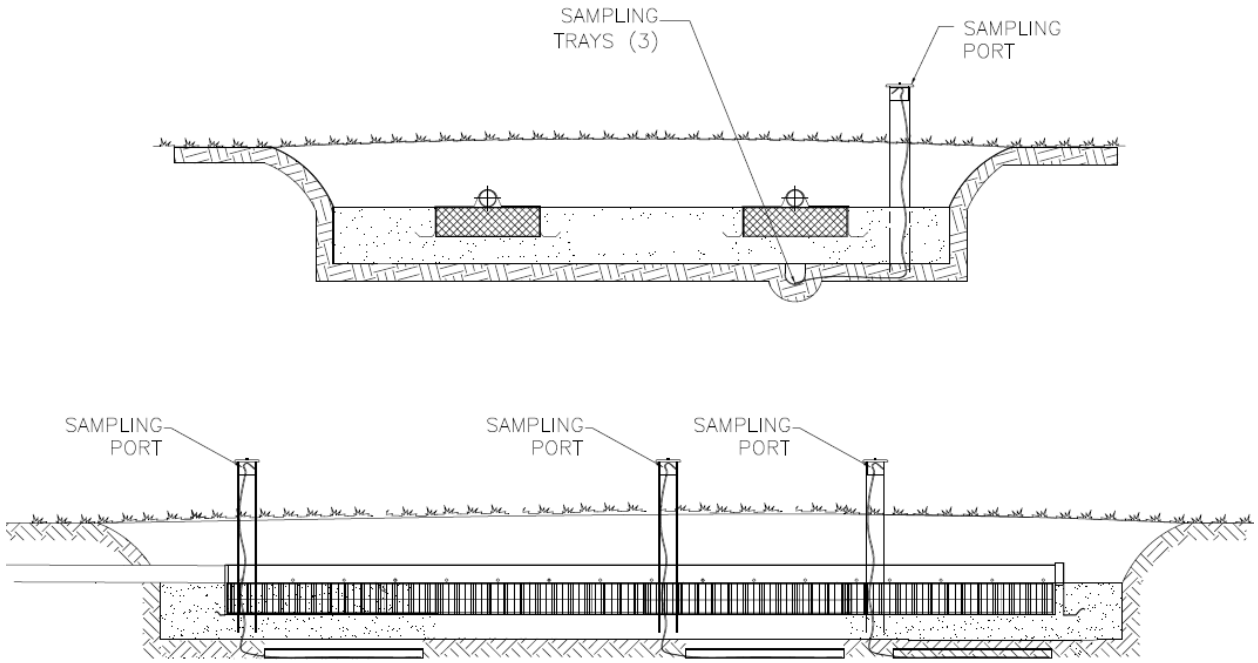

Figure 12: Effluent Sampling Pipe