

Low Pressure Sewer Systems Using Environment One Grinder Pumps

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Introduction

E/One low pressure sewer (LPS) systems offer the designer new freedom in solving many problem situations that have defied reasonably economical solutions using the conventional approach.

Each LPS system design should be considered on the basis of its own unique circumstances. On such a basis, a sound choice between gravity and low pressure systems can be made.

General criteria aid the engineer in making a preliminary choice between several alternative systems: entirely low pressure, entirely gravity, entirely vacuum or a combination of systems. These criteria are presented and are intended to serve as a general guide. The final decision and design are the responsibility of the project consulting engineer, whose knowledge of local conditions, including construction costs, regulatory requirements and the client's particular needs, become vital to the preparation of the final designs and specifications.

Advantages of LPS Systems

LPS systems have low initial (front end) cost compared to gravity systems, which have nearly all the total investment allocated in the first stage. With the LPS system, grinder pump costs are incurred only as construction progresses. These costs will be deferred for many years in certain types of development programs.

An LPS system is not subject to infiltration from ground water or from surface storm water entering through leaking pipe joints and manholes. With zero infiltration, treatment plants need not be sized to handle the peak flow rates caused by infiltration. Treatment efficiencies can be more consistent, and treatment plant operating costs decrease.

An LPS system may become the critical factor in determining whether "marginal" land can be economically developed. Many attractive sites have been considered unsuitable for development because of the excessive costs typically associated with conventional sewer systems — sites with hilly terrain, land with negligible slope, high water tables, poor percolation characteristics, rock, seasonal occupancy or low population density.

Many communities are planning to convert from septic tanks to central sewage collection and treatment systems to minimize health hazards and/or environmental deterioration. The major reduction in cost and the simplicity of installation of an LPS system have strong appeal for such community improvement programs. Small-diameter pipe pressure mains can be laid along existing roadways with minimum disruption to streets, sidewalks, lawns, driveways and underground utilities. Surface restoration costs are similarly minimized. Sewage delivered to the treatment plant (because it contains no infiltration) is more uniform in "strength," the volume is smaller, and peaks are greatly reduced.

Description and Operation

Grinder pumps of approved design accomplish all pumping and sewage-grinding processes for small-diameter LPS systems.

The system consists of conventional drain, waste and vent (DWV) piping within the residence connected to the grinder pump inlet. The grinder pump may be installed above or below grade, indoors or outdoors. Depending on flow factors and model used, it may serve one or more residences, or several families in the case of apartment buildings.

Grinder pumps discharge a finely ground slurry into small-diameter pressure piping. In a completely pressurized collection system, all the piping downstream from the grinder pump (including laterals and mains) will normally be under low pressure. Pipe sizes will start at 1 1/4 inches for house connections (compared to 4 or 6 inches in gravity systems) and will be proportionally smaller than the equivalent gravity pipeline throughout the system. All pipes are arranged as zone networks without loops.

Depending on topography, size of the system and planned rate of buildout, appurtenances may include valve boxes, flushing arrangements, air release valves at significant high points, check valves and full-ported stops at the junction of each house connection with the low pressure sewer main.

Pump Operation

Low pressure sewer systems have become feasible with the availability of the Environment One grinder pump, the reliability of which has been proven in more than 50 years of service. The grinder pump station provides adequate holding capacity, reliable grinding and pressure transport of a fine slurry to an existing gravity sewer, pump station or directly to a wastewater treatment plant.

In operation, the grinder pump station will handle sewage and many items that should not, but often do, appear in domestic wastewater. For example, plastic, wood, rubber and light metal objects can be routinely handled without jamming the grinder or clogging the pump or piping system. The grinder pump will discharge this slurry at a maximum rate of 15 gpm or 11 gpm at a pressure of 40 psig. Transporting sewage several thousand feet to a discharge point at a higher elevation is possible as long as the sum of the static and friction losses does not exceed design limits of 185 feet TDH (80 psig).

The grinder pump is actuated when the depth of the sewage in the tank reaches a predetermined "turn-on" level, and pumping continues until the "turn off" level is reached. The pump's running time is short, power consumption is low, and long pump life is ensured. The unit is protected against backflow from discharge lines by an integral check valve. Several grinder pump station models are available to satisfy various total and peak demand conditions.

Pump Type

The semi-positive displacement pump in the grinder pump station has a nearly vertical H-Q curve. This is the best type of pump for successful parallel operation of many pumps into a system of common low pressure mains. Since each pump will be located at a different point along common low pressure mains and at various elevations, each pump should operate in an efficient and predictable manner, whether one pump or numerous pumps are operating at a given moment; the pumps in such a system do not have a single fixed "operating point," but must operate consistently over a wide range of heads that are continually, and often rapidly, changing.

The Environment One grinder pump has the capability of operating above the LPS system design criteria of 80 psig, or 185 feet (Figure 1). Based on the maximum daily number of pumps operating simultaneously (Table 3) versus the number of pumps connected to the system at the design pressure of 185 feet, the capability to operate significantly above the system's design pressure is mandatory in order for the system to operate properly during the approximately bimonthly peaks when the "absolute maximum" numbers of pumps are operating. This feature also ensures that pumping will continue under those conditions when higher-than-normal pressure occurs in the pipeline.

System designs with calculated heads approaching the upper limits of recommended heads should be reviewed by Environment One application specialists. Contact your local Environment One Regional Sales Office or authorized distributor for a no-cost, computerized review of your design.

Occasionally during “normal” operation, there will be short periods when higher-than-design pressures will be experienced. These can result from a variety of causes including solids buildup (obstructions) or air bubbles.

Deposits of solids or air accumulation will be purged from the line since the pump continues to produce an essentially constant flow, even though the cross section of the pipeline has temporarily been reduced. Higher velocities through the reduced cross section will provide the scouring action needed to correct such conditions as soon as they start to appear.

These higher-than-expected pressure conditions are transitory occurrences. The only requirement is that no damage be done to the pumping equipment, pipelines or appurtenances during these occasional short periods. Environment One grinder pumps are driven by motors rated for continuous operation at 104 F/40 C above ambient temperature. They can operate at 50 percent above rated pressure for at least 5 minutes without excessive temperature rise. Based on the Albany, New York, demonstration project, for this type of overload to last even as long as one minute would be rare.

Motor Selection

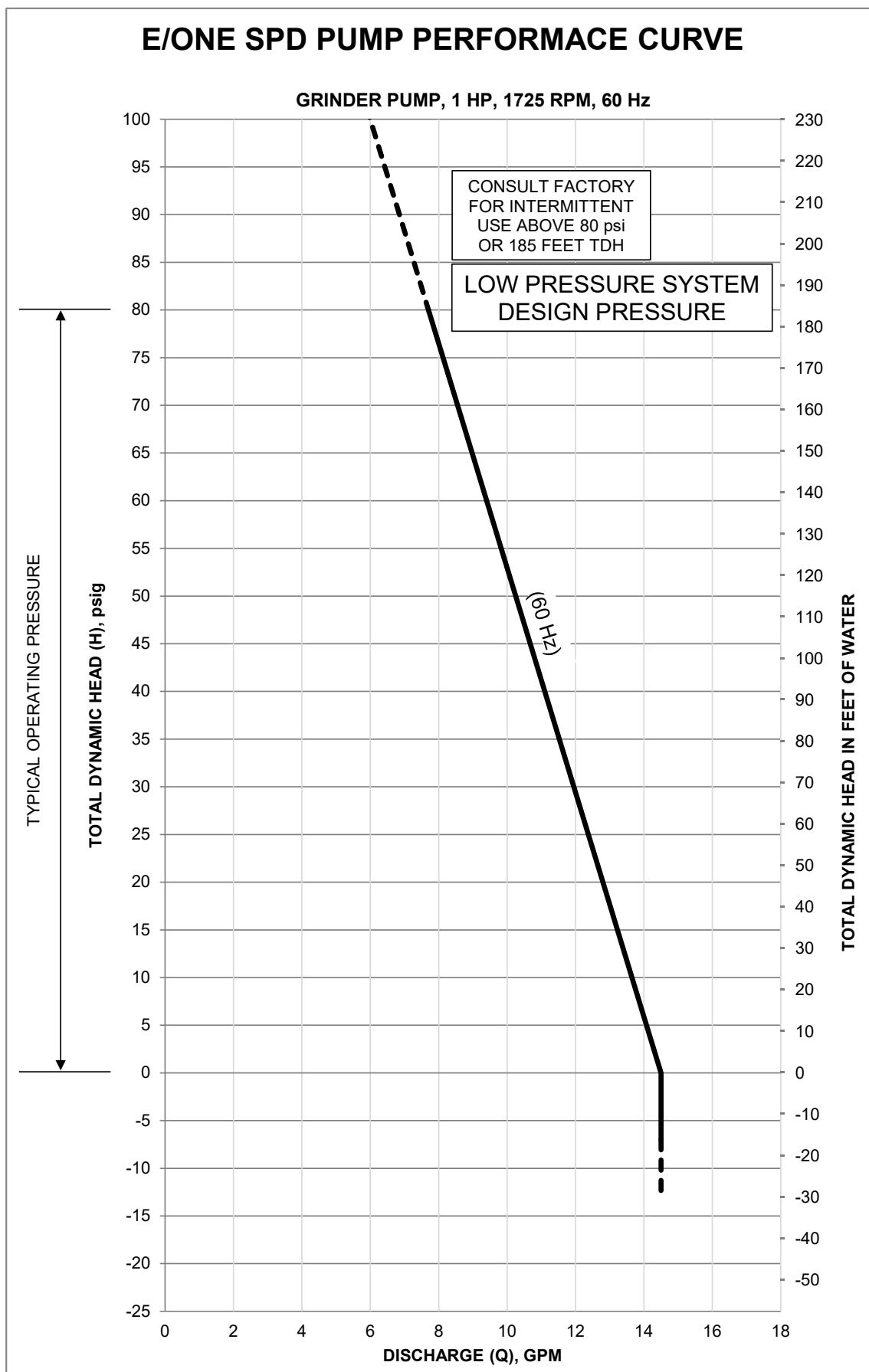
A grinder pump station is an electromechanical system that depends on electric power for its operating, control and alarm functions. The design and selection of Environment One’s pump, motor, grinder and level-sensing controls were accomplished by optimizing the wastewater transport function of the unit within the necessary constraints for unattended, trouble-free operation in a residential environment.

A single grinder pump core is common to all models of Environment One grinder pumps (D-Series, W-Series, Gatorgrinder, and Indoor). This central core contains all of the working and control elements of the unit and is powered by a 1 hp, 240v (or 120v), 1,725 rpm capacitor start, thermally protected induction motor. Each of these motor features was carefully considered in the design of the grinder pump station.

The pump should be considered as a residential appliance. For this reason, performing the grinding and pumping functions using no more than 1 hp to permit occasional use at 120v in older homes not wired for 240v is desirable. In order to achieve the high heads desired and provide constant flow at varying heads, the 1-hp motor is coupled to a pump of semi-positive displacement design (Figure 1).

At a rating of 1 hp and 1,725 rpm, the Environment One grinder pump develops more than 8.4 footpounds of torque. Motors used to drive centrifugal pumps are often rated at 2.0 hp at 3,450 rpm and may produce less torque. When handling residential sewage, grinding torque may be demanded during any portion of the starting or running cycle. When the pump stops (controlled by level) in the midst of grinding hard objects (e.g. tongue depressors, plastic items, etc.), it must, upon restarting, be able to provide sufficient torque to the grinder to overcome the resistance of any object remaining from the previous cycle.

Figure 1



Power Outages

Environment One grinder pump stations have adequate excess holding capacity to provide wastewater storage during most electrical power outages (Figure 2). This excess holding capacity is shown on curve A. Data from the Federal Power Commission on national electrical power outages is plotted as a cumulative distribution function (curve B). Note that only volume above the normal "turn-on" level was counted as available storage. The average flow of 1.54 gallons/hour/person is based on the actual measured flow over a one-year period at the Albany Demonstration Project.

The local electrical power utility should be contacted to obtain a history on the power interruptions of the feeder(s) scheduled to serve the low pressure sewer site. From this data, curve B should be replotted to reflect local conditions. In those rare local areas where the frequency and/or the duration of outages exceed 7.5 hours, the use of Model DH151, with its greater holding capacity than that of the DH071, could be considered.

When power has been restored after a power outage, it is likely that nearly all the pumps in the system will try to operate simultaneously. Under these conditions, the dynamic head loss component of the total head will rise significantly. A number of pumps in the system would see a total back pressure high enough to cause the thermal overload protectors to automatically trip in a few minutes. Operation under conditions that could cause damage to the pumps or the system would be avoided. While these pumps are offline, other pumps in the system would be able to empty their tanks. After one to two minutes, the group that tripped off on thermal overload would cool and restart. The system back pressure would have been reduced and the group would be able to pump down normally. This process repeats itself automatically under the influence of each unit's own thermal protector, reliably restoring the system to normal operation.

Power Consumption

Monthly power consumption of a residential grinder pump station is substantially less than that of other major appliances. The power consumption will vary based on the system operating parameters. The monthly cost can be approximated using the following equation and operating data:

$$\begin{aligned} * \text{ Watts} &\times D \times \text{Days/Mo} \\ ** \text{ GPM} &\times 60 \text{ min} \times 1000 \end{aligned} = \text{kwhr per month}$$

Discharge Pressure (PSI)	0	25	60	80
* Watts	690	770	1100	1400
** Flow (GPM)	15	12.4	9.3	7.7

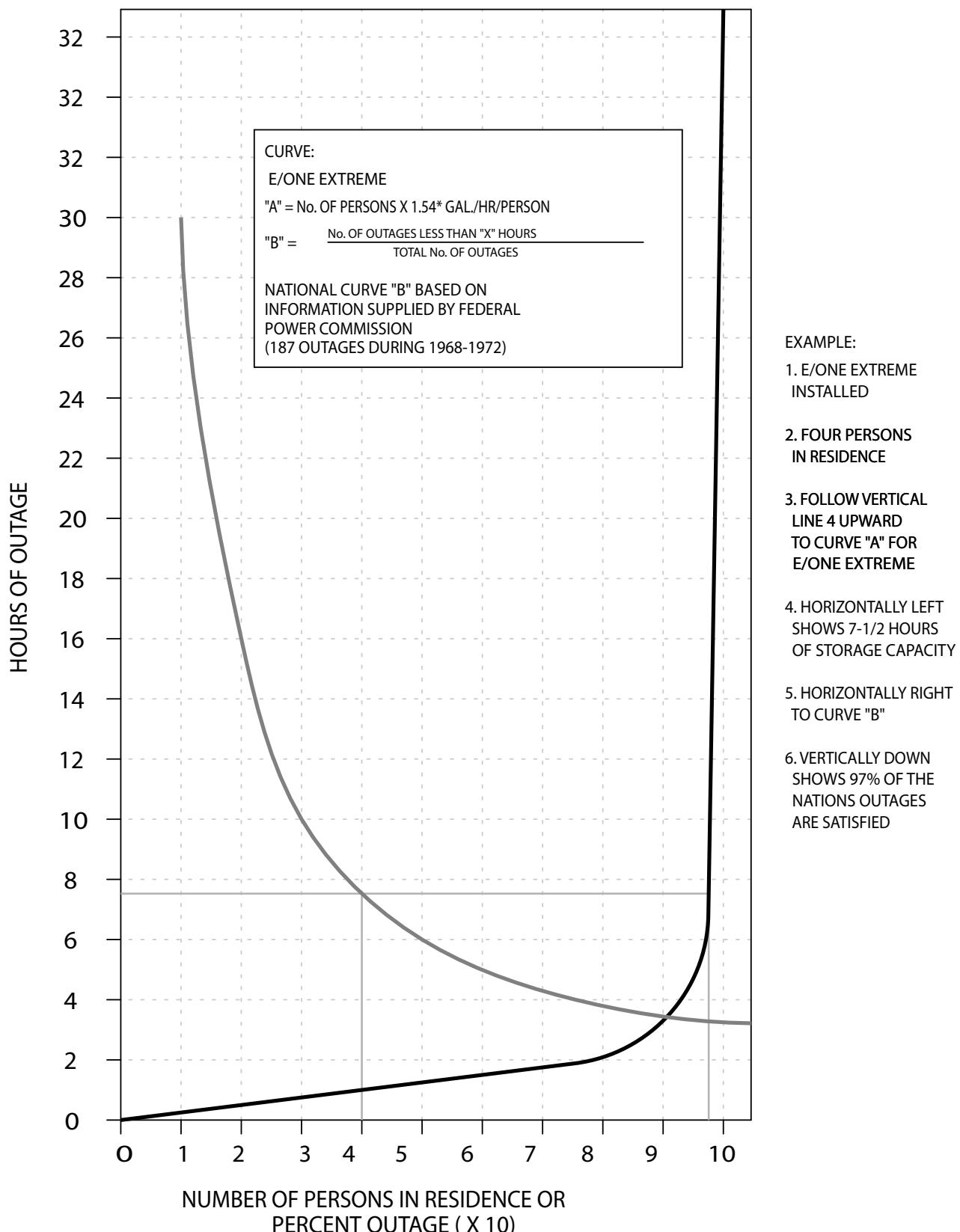
As an example of the calculation for a typical single-family home using 250 GPD, pumping at 25 psi is:

$$\frac{770 \text{ W} \times 250 \text{ GPD} \times 30 \text{ Days}}{12.4 \text{ GPM} \times 60 \text{ min} \times 1000} = 7.76 \text{ kwhr per month}$$

Then, multiply the kilowatt hours by the current cost of electricity and you will have an approximate monthly cost of running the unit.

Figure 2

Relationship of GP Storage Capacity to Power Outage Experience



LPS System Design

Once the initial analysis of a project has confirmed the feasibility of using the low-pressure approach, the completion of a preliminary system design is straightforward. This is primarily a result of two characteristics of E/One's semi-positive displacement pump: near-constant flow over the entire range of operating pressures and the ability of the pump to handle transient overpressures.

The balance of this section outlines a systematic approach to LPS system design, leading from pump model and pipe selection to a detailed zone and system analysis.

Information Required

The information that should be assembled prior to initiation of the LPS system design includes:

- Topography map
- Soil conditions
- Climatic conditions (frost depth, low temperature and duration)
- Water table
- Applicable codes
- Discharge location
- Lot layout (with structures shown, if available)
- Total number of lots
- Dwelling type(s)
- Use and flow factors (seasonal occupancy or year-round, appliances, water supply sources)
- Area development sequence and timetable

Grinder Pump Station Size Selection

See the Station Sizing Reference Guide located at eone.com/sewer-systems/design-center to select grinder pump models for the types of occupancy to be served.

Considerations include:

- Wetwell and discharge piping must be protected from freezing
- Model and basin size must be appropriate for incoming flows, including peak flows
- Appropriate alarm device must be used
- Suitable location

Daily flows above those recommended may exceed the tank's peak flow holding capacity and/or shorten the interval between pump overhauls. Please contact the E/One factory if higher inflows are expected.

Grinder Pump Placement

The most economical location for installation of the grinder pump station is in the basement of the building it will serve. However, due consideration must be given when choosing an indoor location. If there is a risk of damage to items located in the basement level, other provisions should be made during basement installation or an outdoor unit should be considered.

Considerations such as ownership of the pumps by a municipality or private organization and/or the need for outdoor accessibility frequently dictate outdoor, in-ground installations. For outdoor installations, all GP models are available with high density polyethylene (HDPE) integral accessways ranging in height up to 10 feet. By keeping the unit as close as possible to the building, the lengths of gravity sewer and wiring will be minimized, keeping installation costs lower while reducing the chances of infiltration in the gravity flow section.

AC power from the building being served should be used for the grinder pump. Separate power sources add to installation and O&M costs, decrease overall reliability and frequently represent an aesthetic issue.

When two dwellings are to be served by a single unit, the station is usually placed in a position requiring the shortest gravity drains from each home. With multi-family buildings, more than one grinder pump may be required.

Pipe Selection

The final determination of the type of pipe to be used is the responsibility of the consulting engineer. In addition, the requirements of local codes, soil, terrain, water and weather conditions that prevail will guide this decision.

Although pipe fabricated from any approved material may be used, most LPS systems have been built with PVC and HDPE pipe. Continuous coils of small-diameter, HDPE pipe can be installed with automatic trenching machines and horizontal drilling machines to sewer areas at lower cost.

Table 1 compares the water capacity of two types of PVC pipe commonly used: SDR-21 and Sch 40, and one type of HDPE, SDR-11. All three have adequate pressure ratings for low pressure sewer service.

Although both types of PVC pipes are suitable, the three parameters compared in Table 2 illustrate why SDR-21 is suggested as a good compromise between capacity, strength, friction loss characteristics and cost.

Table 1 PIPE WATER CAPACITY <i>Gallons/100 feet of Pipe Length</i>			
Nominal Pipe Size (in.)	Sch 40 PVC	Sch 21 PVC	SDR 11 HDPE
1 1/4	7.8	9.2	7.4
1 1/2	10.6	12.1	9.9
2	17.4	18.8	15.4
2 1/2	23.9	27.6	-
3	38.4	40.9	33.5
4	66.1	67.5	55.3
5	103.7	103.1	84.5
6	150.0	146.0	119.9
7	260.0	249.0	203.2

Table 2 PVC PIPE COMPARISONS <i>Nominal Pipe Size = 2 in.</i>		
Parameter	Sch 40	Sch 21
Wall Thickness, in.	0.154	0.113
Inside Diameter, in.	2.067	2.149
50 gpm Friction Loss, ft/100 ft	4.16	3.44

System Layout

A preliminary sketch of the entire pressure sewer system should be prepared (Figure 3). Pump models should be selected and their location (elevation) should be noted. The location and direction of flow of each lateral, zone and main, and the point of discharge should be shown.

The system should be designed to give the shortest runs and the fewest abrupt changes in direction. "Loops" in the system must be avoided as they lead to unpredictable and uneven distribution of flow.

Although not shown in Figure 3, the elevation of the shutoff valve of the lowest-lying pump in each zone should be recorded and used in the final determination of static head loss. Since Environment One grinder pumps are semi-positive displacement and relatively insensitive to changes in head, precisely surveyed profiles are unnecessary.

Air/vacuum valves, air release valves and combination air valves serve to prevent the concentration of air at high points within a system. This is accomplished by exhausting large quantities of air as the system is filled and also by releasing pockets of air as they accumulate while the system is in operation and under pressure. Air/vacuum valves and combination air valves also serve to prevent a potentially destructive vacuum from forming.

Air/vacuum valves should be installed at all system high points and significant changes in grade. Combination air valves should be installed at those high points where air pockets can form. Air release valves should be installed at intervals of 2,000 to 2,500 feet on all long horizontal runs that lack a clearly defined high point.

Air relief valves should be installed at the beginning of each downward leg in the system that exhibits a 30-foot or more drop. Trapped pockets of air in the system not only add static head, but also increase friction losses by reducing the cross sectional area available for flow. Air will accumulate in downhill runs preceded by an uphill run.

Long ascending or descending lines require air and vacuum or dual-function valves placed at approximately 2000-foot intervals. Long horizontal runs require dual function valves placed at approximately 2000-foot intervals.

Pressure air release valves allow air and/or gas to continuously and automatically released from a pressurized liquid system. If air or gas pockets collect at the high points in a pumped system, then those pressurized air pockets can begin to displace usable pipe cross section. As the cross section of the pipe artificially decreases, the pump sees this situation as increased resistance to its ability to force the liquid through the pipe.

Air relief valves at high points may be necessary, depending on total system head, flow velocity and the particular profile. The engineer should consult Environment One in cases where trapped air is considered a potential problem.

Cleanout and flushing stations should be incorporated into the pipe layout. In general, cleanouts should be installed at the terminal end of each main, every 1,000 to 1,500 feet on straight runs of pipe, and whenever two or more mains come together and feed into another main.

A lateral assembly consisting of a ball and check valve are required to be installed on each individual grinder pump station discharge pipe. This is to allow for isolation of individual discharges from the rest of the system to facilitate maintenance as well as prevent any backflow.

Zone Designations

The LPS system illustrated in Figure 3 contains 72 pumps and is divided into 14 individually numbered zones. Division into zones facilitates final selection of pipe sizes, which are appropriate in relation to the requirements that flow velocity in the system is adequate and that both static and dynamic head losses are within design criteria. Assignment of individual zones follows from the relationship between the accumulating total number of pumps in a system to the predicted number that will periodically operate simultaneously (Table 3).

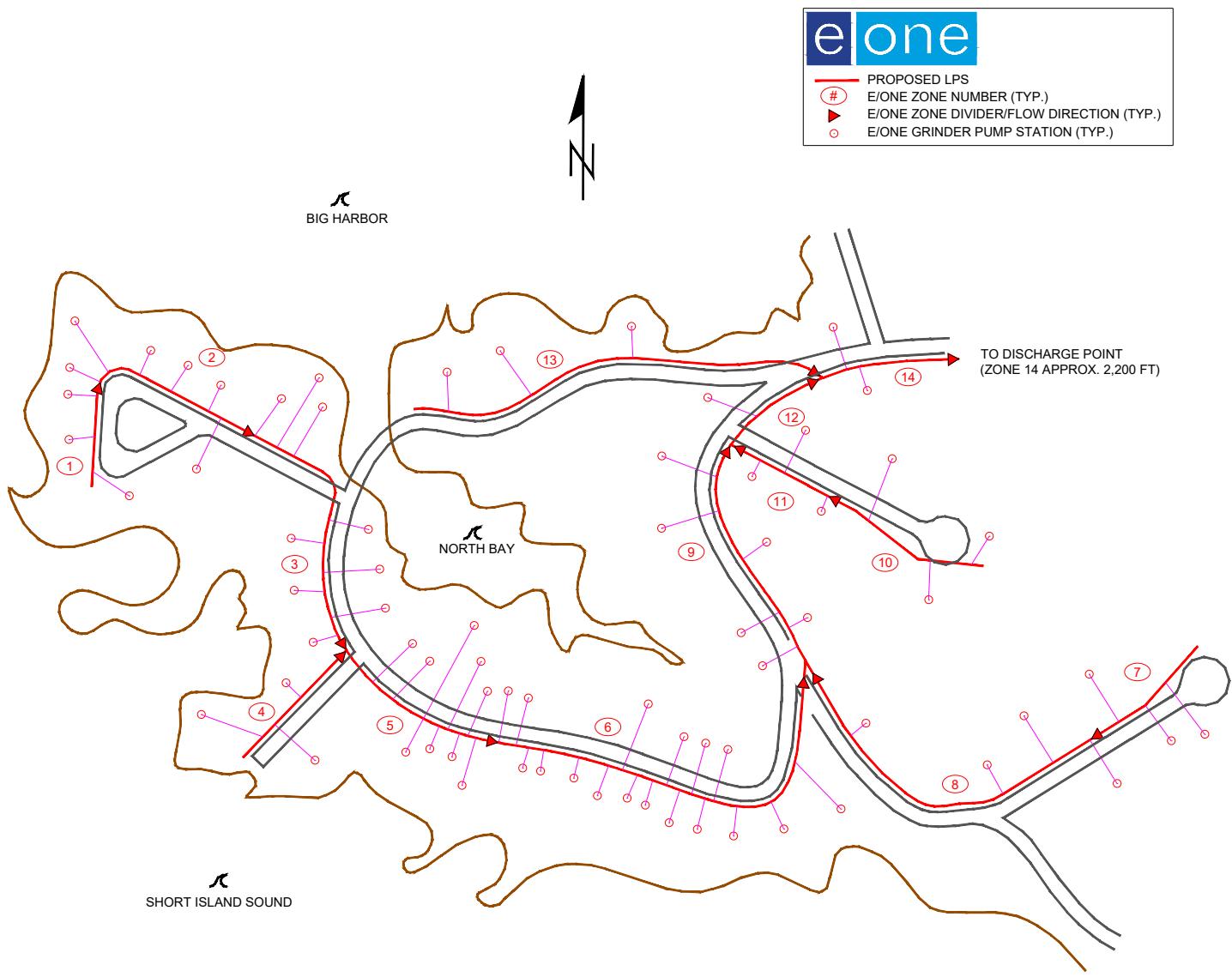
Table 3 was initially developed after careful analysis of more than 58,000 pump events in a 307-day period during the Albany project. It was extended for larger systems by application of probability theory. The validity of this table has since been confirmed by actual operating experience with thousands of large and small LPS systems during a more than 50 year period.

Using Figure 3, the actual exercise of assigning zones is largely mechanical. The single pump farthest from the discharge point in any main or lateral constitutes a zone. This and downstream pumps along the main are accumulated until their aggregate number is sufficient to increase the number of pumps in simultaneous operations by one, i.e., until the predicted maximum flow increases by 11 gpm.

Figure 3 shows that zones 1, 2 and 3 end when the number of pumps connected total 3, 6 and 9, and the number of pumps in daily simultaneous operation are 2, 3 and 4, respectively.

Any place where two or more sections of main join, or where the outfall is reached, also determines the end of a zone. This design rule takes precedence over the procedure stated above, as seen in zones 6, 8, 9, 12, and 14.

Figure 3



LPS SYSTEM LAYOUT DIAGRAM
ILLUSTRATED EXAMPLE

Completion of Pipe Schedule and Zone Analysis

The data recorded on the System Flow Diagram (Figure 3) is then transferred to Table 4.

Table 4 Column No.	Designation
1	Zone Number
2	Connects to Zone
3	Number of Pumps in Zone
4	Accumulated Pumps in Zone
11	Length of Main this Zone in Feet

Column 4 is completed by referring to Table 3, where the maximum number of pumps in simultaneous operation is given as a function of the number of pumps upstream from the end of the particular zone. The output of each zone will vary slightly with head requirements, but under typical conditions, the flow is approximately 11 gpm. Calculate the maximum anticipated flow for each zone by multiplying the number of simultaneous operations in Column 7 by 11 gpm and record the results in Column 8.

To complete columns 9, 10, 12 and 13, refer to Flow Velocity and Friction Head Loss table for the type of pipe selected — in this case, Table 5 for SDR-21. It will be seen that the engineer will frequently be presented with more than one option when selecting pipe size. Sometimes a compromise in pipe size will be required to meet present needs as well as planned future development. As a general rule, pipe sizes should be selected to minimize friction losses while keeping velocity near or above 2 feet per second.

For example, Zone 1 has a maximum of two pumps running (Column 7). Table 5 offers a choice of 1.25-inch, 1.5-inch or 2-inch pipe. 1.5-inch pipe is selected since flow velocity equals 3.04 ft/sec and friction loss equals 2.15 ft/100 ft. Since the zone is 205 feet in length (Column 11), the total friction loss (Column 13) is:

Table 3
MAXIMUM NUMBER OF GRINDER PUMP CORES OPERATING DAILY

Number of Grinder Pump Cores Connected	Maximum Daily Number of Grinder Pump Cores Operating Simultaneously
1	1
2-3	2
4-9	3
10-18	4
19-30	5
31-50	6
51-80	7
81-113	8
114-146	9
147-179	10
180-212	11
213-245	12
246-278	13
279-311	14
312-344	15
345-377	16
378-410	17
411-443	18
444-476	19
477-509	20
510-542	21
543-575	22
576-608	23
609-641	24
642-674	25
675-707	26
708-740	27
741-773	28
774-806	29
807-839	30
840-872	31
873-905	32
906-938	33
939-971	34
972-1,004	35

BY:		DATE:		PRELIMINARY LOW PRESSURE SEWER SYSTEM PIPE SCHEDULE AND ZONE ANALYSIS OF:		eOne		AE		REV							
PREPARED FOR:				ILLUSTRATED EXAMPLE		TABLE 4		SHEET NO. OF									
1 ZONE NO.	2 CONN. TO ZONE	3 NO. PUMPS IN ZONE	4 ACCUM. PUMPS IN ZONE	5 GAL/ DAY PER CORE	6 MAX. FLOW PER CORE	7 MAX. SIM. OPS	8 MAX. FLOW (gpm)	9 PIPE SIZE (in)	10 MAX. VELOCITY (fps)	11 LENGTH OF MAIN THIS ZONE	12 FRICTION LOSS FACTOR (ft/100 ft)	13 FRICTION LOSS THIS ZONE	14 ACCUM. FRICTION LOSS (ft)	15 MAX. MAIN ELEV.	16 MIN. PUMP ELEV.	17 STATIC HEAD (ft)	18 TOTAL DYNAMIC HEAD (ft)
1	2	3	3	200	11	2	22	1.5	3.04	205	2.15	4.41	73.41	40	10	30	103.41
2	3	6	9	200	11	3	33	2.0	2.92	380	1.54	5.86	69.00	40	10	30	99.00
3	5	9	18	200	11	4	44	2.0	3.89	630	2.63	16.56	63.14	40	5	35	98.14
4	5	3	3	200	11	2	22	1.5	3.04	310	2.15	8.46	53.25	40	5	35	88.25
5	6	9	30	200	11	5	55	3.0	2.24	800	0.60	4.83	46.58	40	5	35	81.58
6	9	17	47	200	11	6	66	3.0	2.69	1,000	0.85	8.46	41.75	40	5	35	76.75
7	8	3	3	200	11	2	22	1.5	3.04	175	2.15	3.77	49.56	40	5	35	84.56
8	9	4	7	200	11	3	33	2.0	2.92	810	1.54	12.50	45.80	40	30	10	55.80
9	12	6	60	200	11	7	77	3.0	3.14	520	1.12	5.85	33.30	40	10	30	63.30
10	11	3	3	200	11	2	22	1.5	3.04	230	2.15	4.95	37.03	40	10	30	67.03
11	12	3	6	200	11	3	33	2.0	2.92	300	1.54	4.63	32.08	40	10	30	62.08
12	14	1	67	200	11	7	77	3.0	3.14	240	1.12	2.70	27.45	40	10	30	57.45
13	14	3	3	200	11	2	22	1.5	3.04	985	2.15	21.19	45.94	40	5	35	80.94
14	14	2	72	200	11	7	77	3.0	3.14	2,200	1.12	24.75	24.75	40	30	10	34.75

$$HF = (2.15 \text{ ft}/100 \text{ ft})(205 \text{ ft}) = 4.41 \text{ ft}$$

For Zone 14, with 72 upstream pumps, it is seen that a maximum of seven pumps can be running simultaneously. Table 5 provides options of:

3-inch pipe: $V = 3.14 \text{ ft/sec}$; $HF = 1.12 \text{ ft}/100 \text{ ft}$

or

4-inch pipe: $V = 1.90 \text{ ft/sec}$; $HF = 0.33 \text{ ft}/100 \text{ ft}$

The smaller-diameter 3-inch pipe is selected because of the increased velocities, especially with the TDH below 185 feet. A choice of 3-inch pipe would lead to a friction loss in this zone of:

$$HF = (1.12 \text{ ft}/100 \text{ ft}) (2200 \text{ ft}) = 24.75 \text{ ft}$$

Accumulated friction loss (Column 14) for each zone is next determined by adding the friction loss for each zone from the system outfall (Zone 14) to the zone in question. Thus, from Figure 3 it is seen that the accumulated friction loss for Zone 1 is:

Zone Number	Friction Loss (ft)
14	24.75
12	2.70
9	5.85
6	8.46
5	4.83
3	16.56
2	5.86
1	4.41

$$73.41 \text{ ft} = \text{Accumulated friction loss, Zone 1}$$

The same summation is completed for each zone.

To complete the hydraulic analysis, refer to the drawing contours and record in Column 15 the maximum line elevation between the point of discharge and the zone under consideration. In Column 16, record the elevation of the lowest pump in the zone. Subtract the values in Column 16 from those in Column 15 and record only positive elevation differentials in Column 17. Add the values in Column 14 to those in Column 17 and record the total in Column 18 to show the maximum combination of friction and static head a pump will experience at any given point in the system.

Review

The accumulated data in Table 4 should finally be reviewed for conformity with the criteria of flow velocity of at least 2.0 ft/s (0.6 m/s) once per day and total design head loss less than 185 feet (56 meters).

Data should be reviewed to determine whether system improvements could result from construction modifications. As an example, deeper burial of pipe in one or two critical high-elevation zones might bring the entire system into compliance with design criteria. Environment One should be consulted in marginal cases and/or concerning:

- Odor control issues
- Frost protection issues
- Excessive static head conditions
- Excessive total dynamic head conditions
- Unusual applications

Table 5
SDR 21 PVC PIPE
Flow Velocity and Friction Head Loss vs Pumps in Simultaneous Operation (C = 150)

	1 1/4 in.		1 1/2 in.		2 in.		2 1/2 in.		3 in.		4 in.		5 in.		6 in.		8 in.			
N	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	N	
1	1.99	1.15	1.52	0.60															1	
2	3.99	4.16	3.04	2.15	1.95	0.73													2	
3	5.98	8.82	4.56	4.56	2.92	1.54	1.99	0.61											3	
4	7.97	15.02	6.08	7.77	3.89	2.63	2.66	1.04	1.79	0.40									4	
5					4.87	3.97	3.32	1.57	2.24	0.60									5	
6					5.84	5.57	3.99	2.20	2.69	0.85									6	
7					6.81	7.41	4.65	2.93	3.14	1.12	1.90	0.33							7	
8							5.32	3.75	3.59	1.44	2.17	0.42							8	
9							5.98	4.66	4.04	1.79	2.44	0.53							9	
10							6.64	5.67	4.49	2.18	2.71	0.64							10	
11									4.93	2.60	2.98	0.76	1.95	0.27					11	
12									5.38	3.05	3.25	0.90	2.13	0.32					12	
13									5.83	3.54	3.52	1.04	2.31	0.37					13	
14									6.28	4.06	3.80	1.19	2.48	0.43					14	
15									4.07	1.36	2.66	0.48	1.88	0.21					15	
16									4.34	1.53	2.84	0.55	2.00	0.23					16	
17									4.61	1.71	3.02	0.61	2.13	0.26					17	
18									4.88	1.90	3.19	0.68	2.25	0.29					18	
19									5.15	2.10	3.37	0.75	2.38	0.32					19	
20									5.42	2.31	3.55	0.82	2.50	0.35					20	
21									5.69	2.53	3.73	0.90	2.63	0.39					21	
22									5.96	2.76	3.90	0.98	2.75	0.42					22	
23									6.24	2.99	4.08	1.07	2.88	0.46					23	
24											4.26	1.16	3.00	0.49					24	
25											4.44	1.25	3.13	0.53					25	
26											4.61	1.34	3.25	0.57					26	
27											4.79	1.44	3.38	0.61	1.99	0.17				27
28											4.97	1.54	3.50	0.66	2.07	0.18				28
29	Head Loss Calculations																			29
30	From Modified Hazen - Williams Formula																			30
31	$H_F = .2083 \left[\left(\frac{100}{C} \right)^{1.852} \cdot \frac{q^{1.852}}{d^{4.8655}} \right]$																			31
32	$V = .3208 \frac{q}{A}$																			32
33	$A = \frac{d^2}{4}$ = cross-sectional flow, sq. in.																			33
34	$C = 150$																			34
35	$q = \text{flow in gallons per minute}$																			35
36	$d = \text{I.D. of pipe in inches} =$																			36
37	$[\text{average O.D.} - (2 \times \text{min. wall thickness})]$																			37
38	$N = \text{Number of pumps operating at 11 gpm}$																			38
39	$V = \text{Flow velocity in ft/sec}$																			39
40	$H_F = \text{Friction head loss in ft/100 ft of pipe}$																			40
41																5.13	1.33	3.03	0.37	41
42																5.26	1.39	3.10	0.39	42
43																5.38	1.45	3.17	0.40	43
44																5.51	1.52	3.25	0.42	44
45																5.63	1.58	3.32	0.44	45
46																5.76	1.65	3.40	0.46	46
47																5.88	1.72	3.47	0.47	47
48																6.01	1.78	3.54	0.49	48
49																6.13	1.85	3.62	0.51	49
50																6.26	1.92	3.69	0.53	50

Table 6
SCHEDULE 40 PVC PIPE
Flow Velocity and Friction Head Loss vs Pumps in Simultaneous Operation (C = 150)

	1 1/4 in.			1 1/2 in.			2 in.			2 1/2 in.			3 in.			4 in.			5 in.			6 in.			8 in.		
N	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	N		
1	2.36	1.74	1.73	0.82	1.05	0.24																				1	
2	4.72	6.28	3.47	2.97	2.10	0.88	1.47	0.37																	2		
3	7.08	13.31	5.20	6.29	3.15	1.86	2.21	0.79																	3		
4																									4		
5																									5		
6							6.31	6.73	4.42	2.83	2.87	0.99														6	
7													5.16	3.77	3.34	1.31	1.94	0.35								7	
8													5.89	4.83	3.82	1.68	2.22	0.45								8	
9													6.63	6.01	4.30	2.09	2.49	0.56								9	
10													4.78	2.54	2.77	0.68										10	
11													5.25	3.03	3.05	0.81	1.94	0.27								11	
12													5.73	3.56	3.33	0.95	2.12	0.32								12	
13													6.21	4.13	3.60	1.10	2.29	0.37								13	
14																3.88	1.26	2.47	0.42						14		
15																4.16	1.43	2.65	0.48						15		
16																4.44	1.62	2.82	0.54	1.95	0.22					16	
17																4.71	1.81	3.00	0.60	2.08	0.25					17	
18																4.99	2.01	3.17	0.67	2.20	0.27					18	
19																5.27	2.22	3.35	0.74	2.32	0.30					19	
20																5.54	2.44	3.53	0.81	2.44	0.33					20	
21																5.82	2.67	3.70	0.89	2.56	0.36					21	
22																6.10	2.91	3.88	0.97	2.69	0.40					22	
23																		4.06	1.05	2.81	0.43					23	
24																		4.23	1.14	2.93	0.47					24	
25																		4.41	1.23	3.05	0.50					25	
26																		4.59	1.32	3.17	0.54					26	
27																		4.76	1.42	3.30	0.58					27	
28																		4.94	1.52	3.42	0.62	1.98	0.16			28	
29																		5.11	1.62	3.54	0.66	2.05	0.17			29	
30	Head Loss Calculations																		5.29	1.72	3.66	0.70	2.12	0.19		30	
31	From Modified Hazen - Williams Formula																		5.47	1.83	3.79	0.75	2.19	0.20		31	
32	$H_F = .2083 \left[\left(\frac{100}{C} \right)^{1.852} \cdot \frac{q^{1.852}}{d^{4.8655}} \right]$																		5.64	1.94	3.91	0.79	2.26	0.21		32	
33	$V = .3208 \frac{q}{A}$																		5.82	2.06	4.03	0.84	2.33	0.22		33	
34																			6.00	2.17	4.15	0.89	2.40	0.23		34	
35																			6.17	2.29	4.27	0.94	2.47	0.25		35	
36	$A = \frac{d^2}{4}$ = cross-sectional flow, sq. in.																		4.40	0.99	2.54	0.26				36	
37	$C = 150$																		4.52	1.04	2.61	0.27				37	
38	q = flow in gallons per minute																		4.64	1.09	2.68	0.29				38	
39	d = I.D. of pipe in inches =																		4.76	1.15	2.75	0.30				39	
40																			4.88	1.20	2.82	0.32				40	
41	$[\text{average O.D.} - (2 \times \text{min. wall thickness})]$																		5.01	1.26	2.89	0.33				41	
42																			5.13	1.31	2.96	0.35				42	
43																			5.25	1.37	3.03	0.36				43	
44	$N = \text{Number of pumps operating at 11 gpm}$																		5.37	1.43	3.11	0.38				44	
45	$V = \text{Flow velocity in ft/sec}$																		5.49	1.49	3.18	0.39				45	
46	$H_F = \text{Friction head loss in ft/100 ft of pipe}$																		5.62	1.56	3.25	0.41				46	
47																			5.74	1.62	3.32	0.43				47	
48																			5.86	1.68	3.39	0.44				48	
49																			5.98	1.75	3.46	0.46				49	
50																			6.11	1.81	3.53	0.48				50	

Table 7
SDR 11 PVC PIPE
Flow Velocity and Friction Head Loss vs Pumps in Simultaneous Operation (C = 155)

	1 1/4 in.			1 1/2 in.			2 in.		3 in.		4 in.		5 in.		6 in.		8 in.			
N	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	V	H _F	N	
1	2.47	1.84	1.86	0.92															1	
2	4.95	6.63	3.72	3.32	2.38	1.12			1.64	0.36									2	
3	7.42	14.04	5.58	7.03	3.57	2.37			2.19	0.61									3	
4			7.44	11.98	4.76	4.04			2.74	0.92									4	
5					5.95	6.11			2.74	0.92									5	
6					7.14	8.56	3.29	1.30	1.99	0.38									6	
7							3.83	1.72	2.32	0.51									7	
8							4.38	2.21	2.65	0.65									8	
9							4.93	2.75	2.98	0.81	1.95	0.29							9	
10							5.48	3.34	3.31	0.98	2.17	0.35							10	
11							6.03	3.98	3.65	1.17	2.39	0.42							11	
12									3.98	1.38	2.60	0.49							12	
13									4.31	1.60	2.82	0.57	1.99	0.24					13	
14									4.64	1.83	3.04	0.65	2.14	0.28					14	
15									4.97	2.08	3.25	0.74	2.29	0.32					15	
16									5.30	2.35	3.47	0.84	2.45	0.36					16	
17									5.63	2.63	3.69	0.94	2.60	0.40					17	
18									5.97	2.92	3.90	1.04	2.75	0.44					18	
19									6.30	3.23	4.12	1.15	2.90	0.49					19	
20										4.34	1.27	3.06	0.54						20	
21										4.56	1.39	3.21	0.59						21	
22										4.77	1.51	3.36	0.64	1.98	0.18					22
23										4.99	1.64	3.52	0.70	2.08	0.19					23
24										5.21	1.77	3.67	0.76	2.17	0.21					24
25										5.42	1.91	3.82	0.82	2.26	0.23					25
26										5.64	2.06	3.98	0.88	2.35	0.24					26
27										5.86	2.21	4.13	0.94	2.44	0.26					27
28										6.07	2.36	4.28	1.01	2.53	0.28					28
29												4.43	1.08	2.62	0.30					29
30												4.59	1.15	2.71	0.32					30
	Head Loss Calculations																			
31	From Modified Hazen - Williams Formula																			
32	$H_F = .2083 \left[\left(\frac{100}{C} \right)^{1.852} \cdot \frac{q^{1.852}}{d^{4.8655}} \right]$																			
33	$V = .3208 \frac{q}{A}$																			
34	$A = \frac{d^2}{4}$ = cross-sectional flow, sq. in.																			
35	$C = 155$																			
36	$q = \text{flow in gallons per minute}$																			
37	$d = \text{I.D. of pipe in inches} =$																			
38	$N = \text{Number of pumps operating at 11 gpm}$																			
39	$V = \text{Flow velocity in ft/sec}$																			
40	$H_F = \text{Friction head loss in ft/100 ft of pipe}$																			
41																3.70	0.57	41		
42																3.79	0.59	42		
43																3.88	0.62	43		
44																3.97	0.65	44		
45																4.06	0.67	45		
46																4.15	0.70	46		
47																4.24	0.73	47		
48																4.33	0.76	48		
49																4.42	0.79	49		
50																4.51	0.82	50		

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Manufacturer Evaluation List

General Requirements for Low Pressure Sewer Systems	
Service and Maintenance Check List	<ul style="list-style-type: none">• Local fast-response service and maintenance organization has been designated• Manufacturers of all equipment specified for the system have supplied all installation details• Warranties for all equipment specified for the system have been evaluated• Fast replacement parts availability for all equipment in the system has been ensured by each equipment manufacturer• User instructions have been supplied to homeowners
Grinder Pump	<ul style="list-style-type: none">• Designated for the specific purpose of grinding and pumping domestic wastewater• Suitable for parallel operation in a system containing thousands of pumps connected to a common discharge line• Has a history of reliable operation• Compatible with existing power sources and provides economical operation• Simple to service and troubleshoot, easily accessible for removal of grinder pump core; designed with simple wiring and controls; easily disassembled and reassembled• Warranty covering parts and labor for a reasonable length of time• Supported by a thoroughly detailed installation manual, service manual and facilities for service training
Certifications	<ul style="list-style-type: none">• Canadian Standards Association• Underwriters Laboratories, Inc.• National Sanitation Foundation
Required Features	<ul style="list-style-type: none">• Non-clogging pump• Non-jamming grinder• Anti-siphon valve integral with grinder pump• All valves of non-clogging design: integral check valve, anti-siphon valve and redundant check valve• High-level warning alarm
Motor	<ul style="list-style-type: none">• Low rpm (1,725)• Overload protection, built-in, automatic reset• High torque, low starting current
Tank	<ul style="list-style-type: none">• Self scouring• Completely sealed• Non-corroding material
Level Sensing Control	<ul style="list-style-type: none">• Non-fouling type• No moving parts in contact with sewage
Motor Controls	<ul style="list-style-type: none">• Completely protected• Simple to service or replace• UL-listed alarm panel



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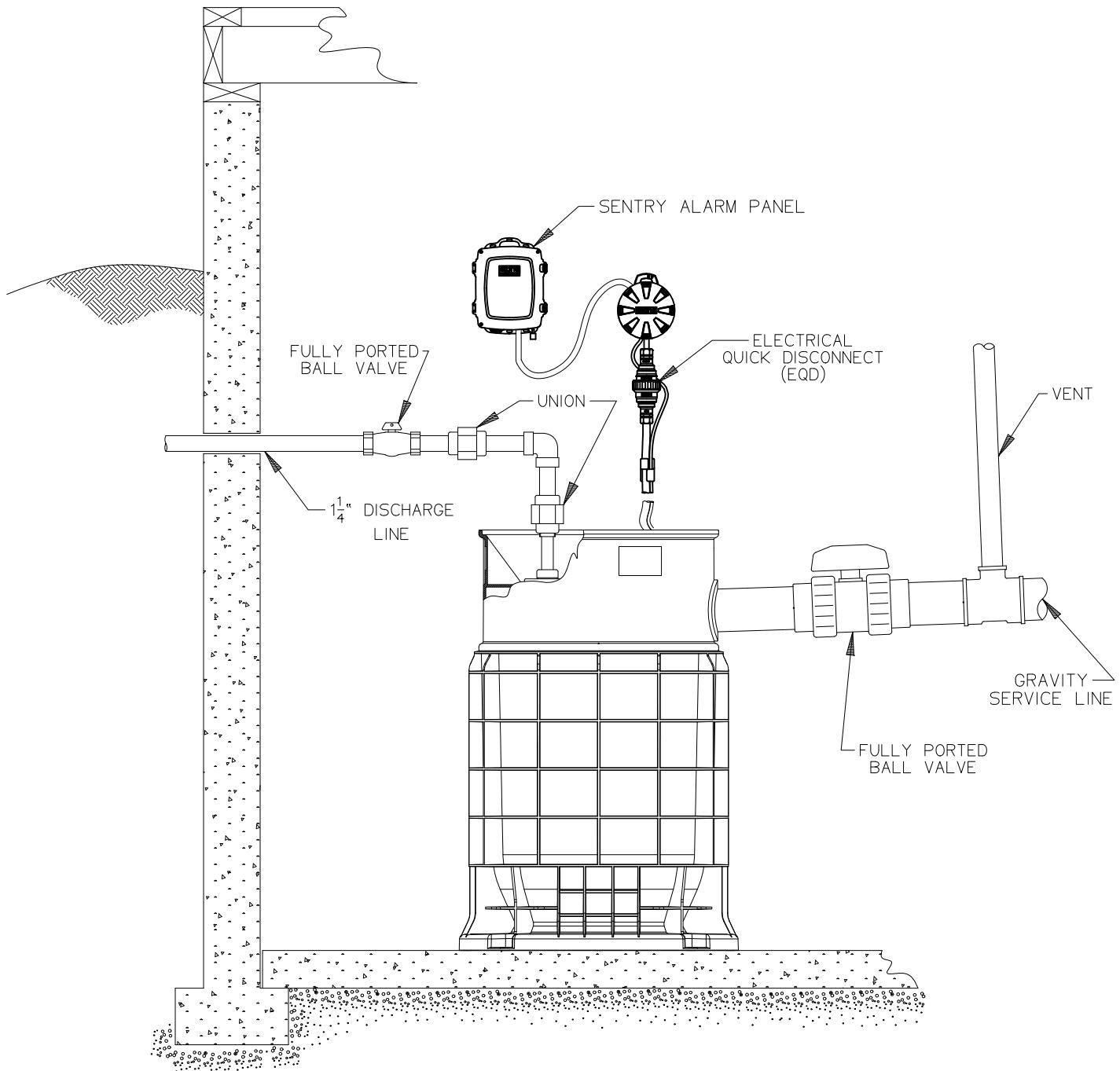
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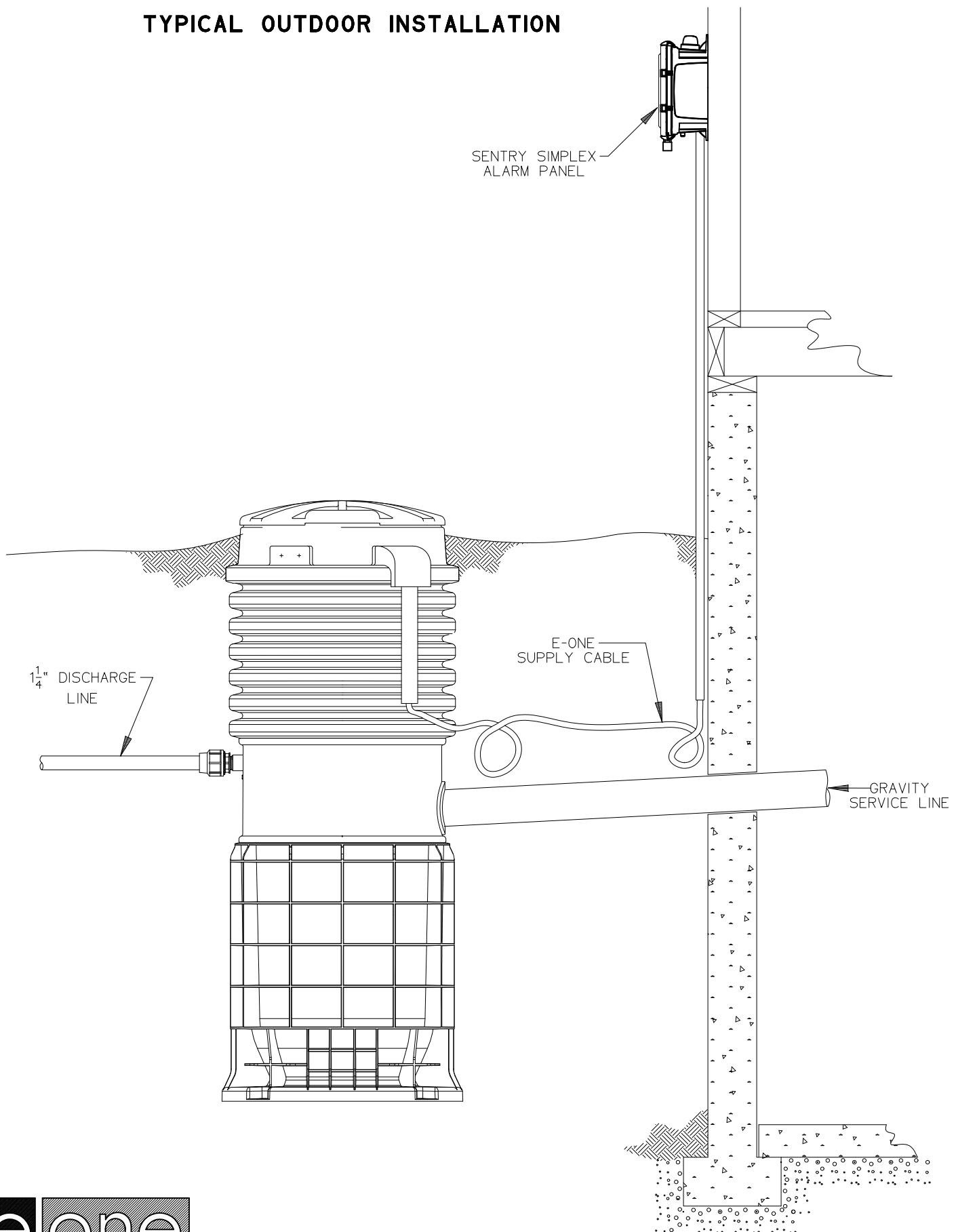
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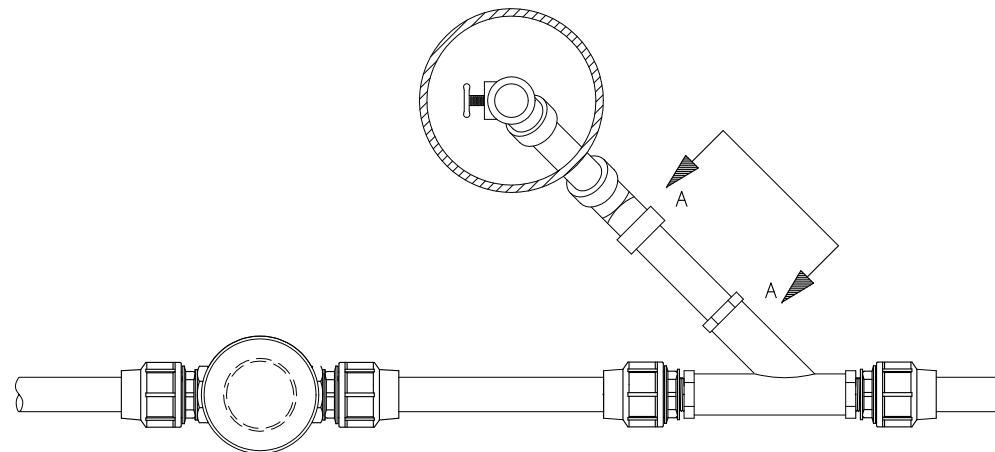
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TYPICAL INDOOR INSTALLATION

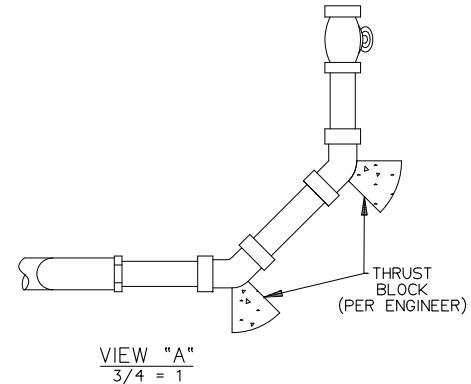
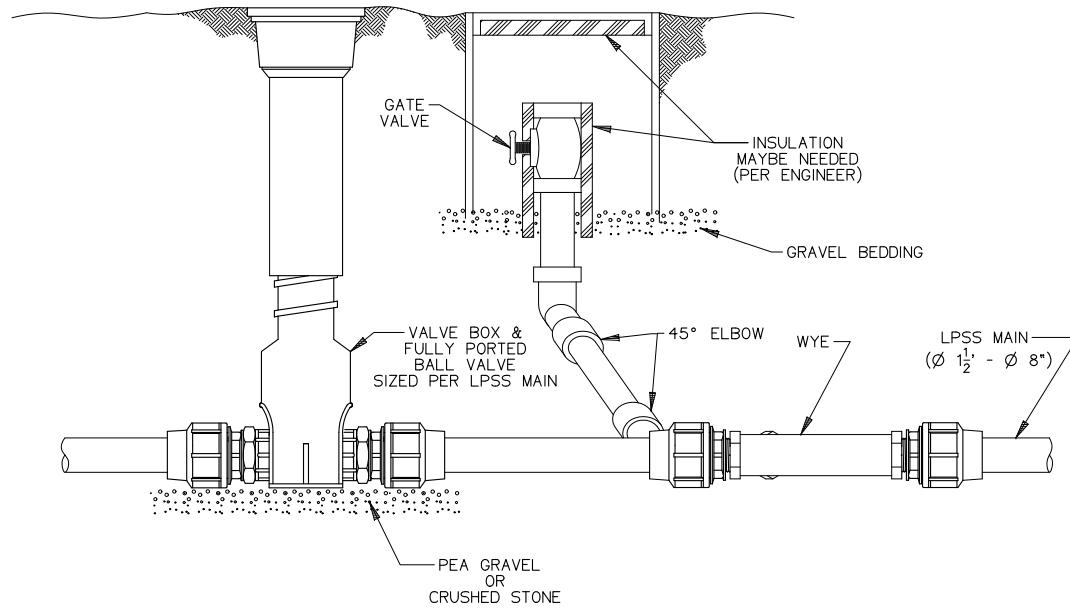


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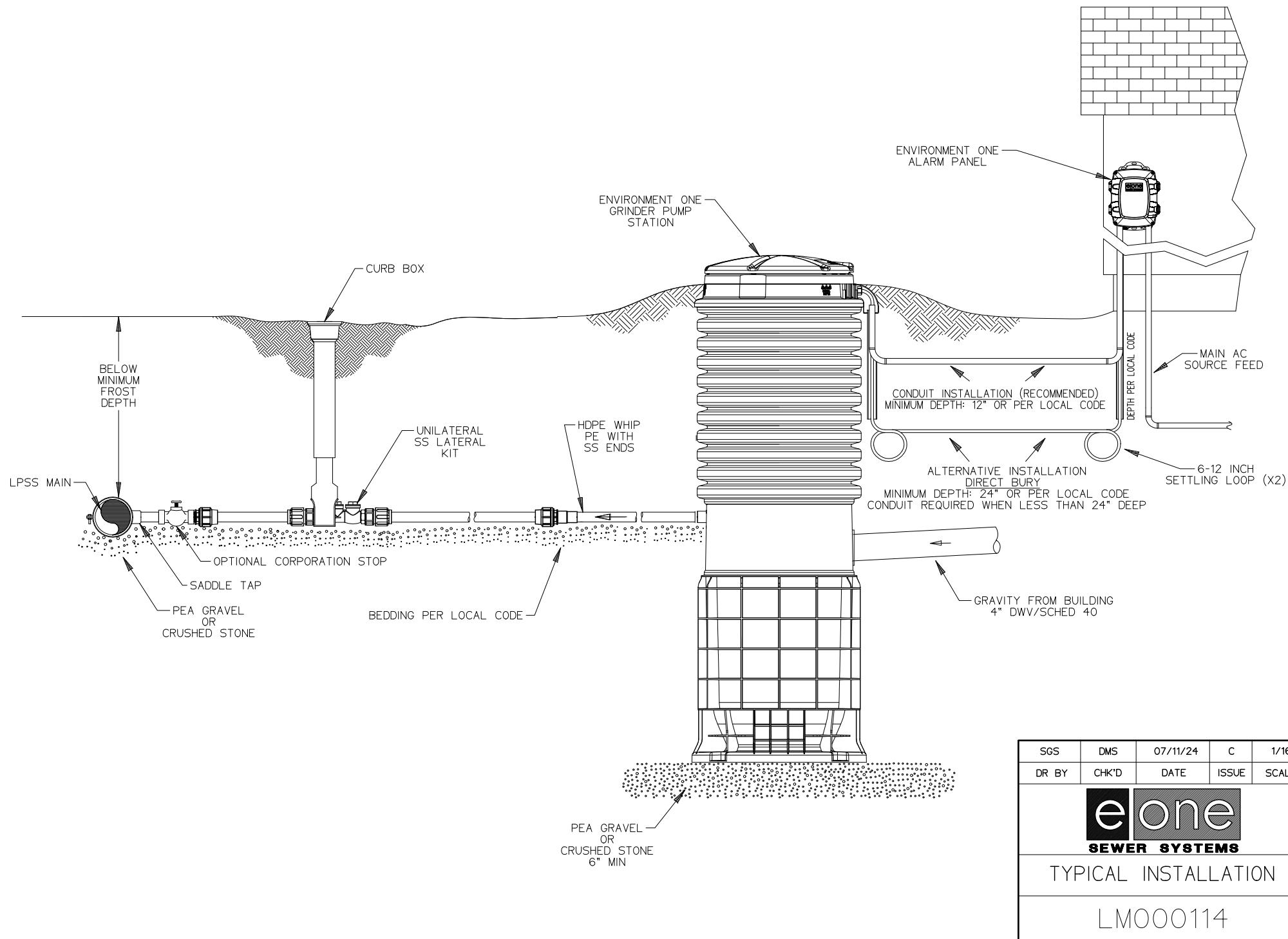




PLAN VIEW



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DR BY	CHK'D	DATE	ISSUE	SCALE
eOne SEWER SYSTEMS				
TYPICAL INSTALLATION				
LM000114				

TYPICAL DROP CONNECTION
LPSS IN EXISTING MANHOLE

