sewage pump station

The excavation depth of sewerage system must not exceed 5m to avoid:
1- The excess cost of excavation.
2- Difficult maintenance at deep depth.
3- Difficult installation in the presence of ground water.

Purpose:

1- To rise the sewage from the level of last manhole to the level of the first tank in the wastewater treatment plant (deceleration tank).

2- If the excavation depth exceeds 5m – 7m (depends on the type of soil) sewage pump station is needed to rise the sewage to a manhole of level 1.2m)

Types of sewage pump station:

Rectangular and circular depends on type of soil and the available area.

Types of pumps:

1- Dry pump.
- Horizontal pump.
- Vertical pump.

2- Submerged pump.
3- Screw pump.

The sewage pump station consists of:

Pumps, wet sump, pumps chamber, and rising main.

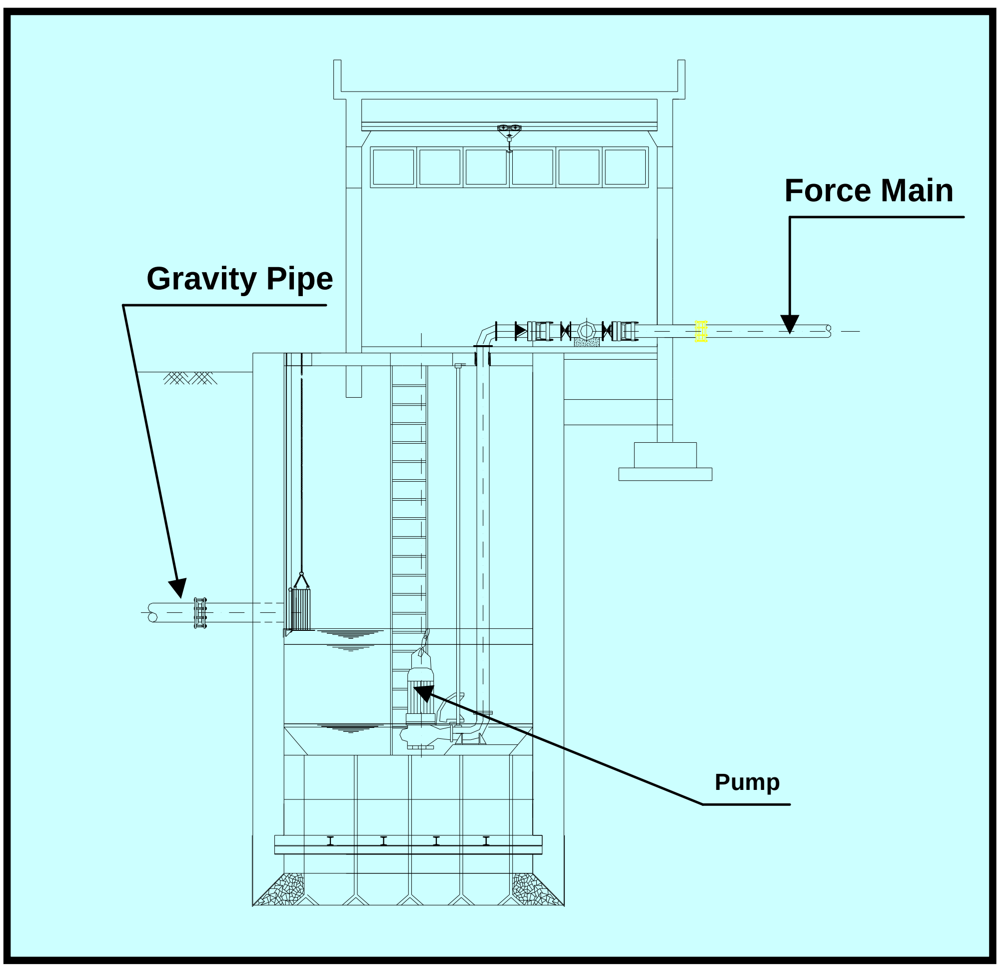
1- pumps:

- The discharge of the pump doesn't exceed 300 l/s and the head of the pump doesn't exceed 90 m.
- The total number of pumps must not be less than 3 pumps (one pump is working and one pump is standing by and the other one is in maintenance).

Types of pumps

Centrifugal pumps

Submersible wastewater pumps



Total head of pump:

HT=H static+h friction+h minor Losses +h Losses in P.S

Hstatic = H.W.L – L.W.L

= water level in the decceleration tank – L.W.L in the wet sump

Friction losses hf

$$h_f = \frac{4flv^2}{2gd}$$

Minor Losses = 10 % of hf

Losses in P.S = 2 – 5 m.

Qd = Qmax (the bigger of Q max summer and Q max winter)

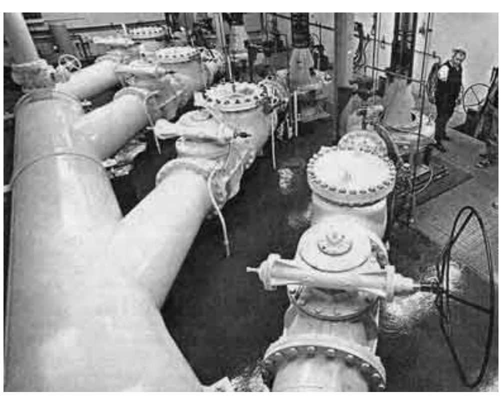
2- Wet sump:

Purpose:

Collects and distributes the wastewater uniformly on the total number of pumps.

Suction well

Suction pipes and the main header



Design criteria:

1- T at Q max = 5 – 10 minutes

T at Q min ≤ 30 minutes

2- vs ≤ 1.5 m/s (velocity in suction pipe)

vd ≤ 2 m/s (velocity in delivery pipe)

3- d = 2 m

4- B = 1 – 3 m

5- The distance between pumps = 1.5 – 2.5 m

6- V = Qd x T

3- Rising main:

Purpose:

Transmit the wastewater from P.S to the deceleration tank.

Design criteria:

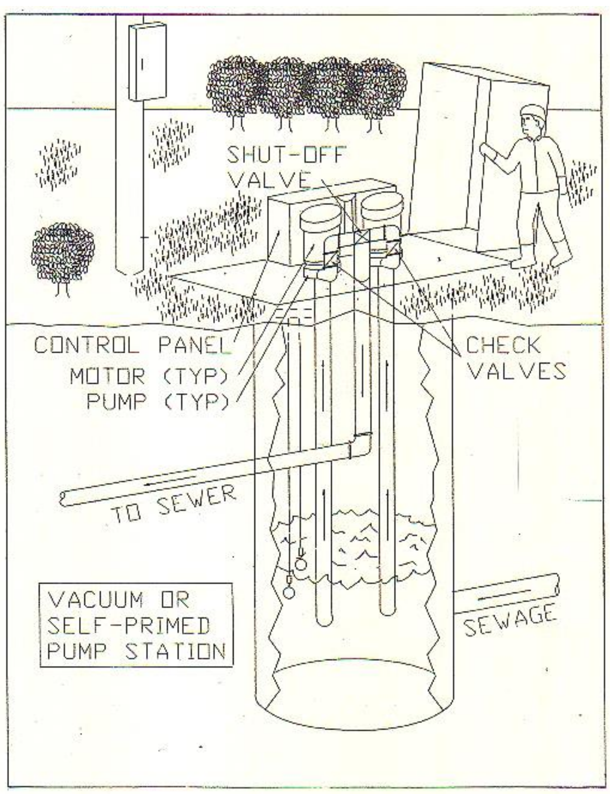
1- Qd = A x v

2- v = 1 - 1.5 m/s v ≥ 1 m/s

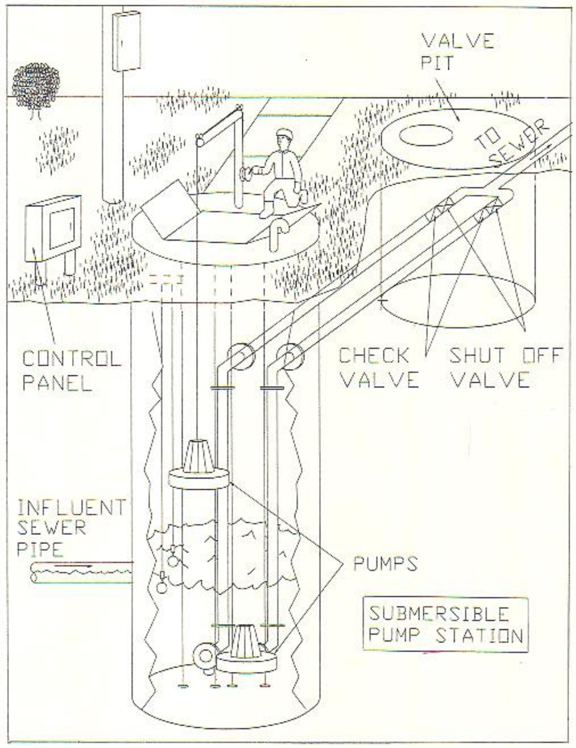
3- minimum Φ = 100 mm (ductile iron)

4- n ≥ 2

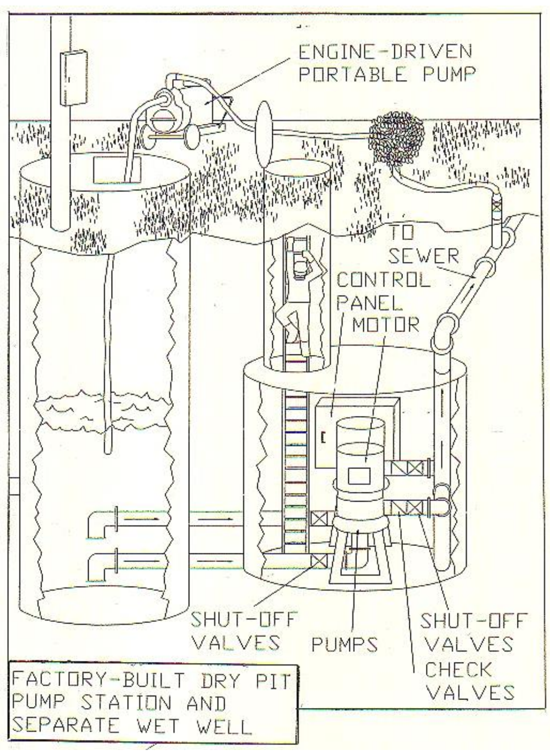
Dry pump

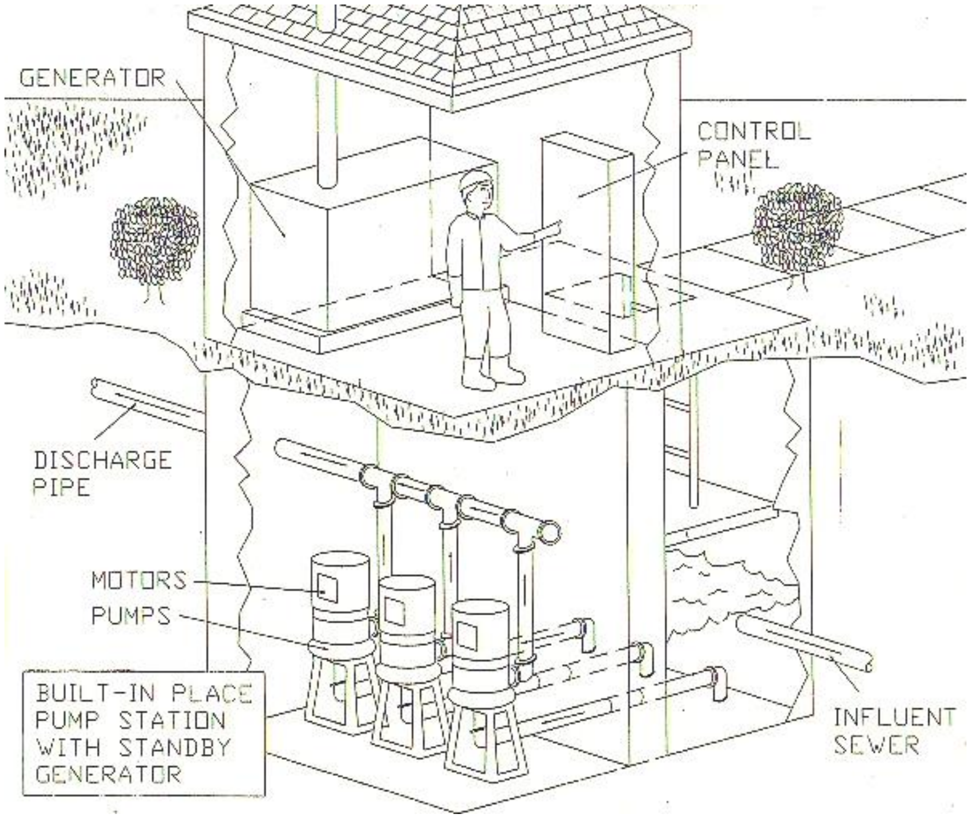


Submerged pumps



Dry pumps





Example:

For a city of present population 10.000 capita has average water consumption 180 l/c/d, and planned to be saturated at year 2050 with population 75.000 capita and average w.c. 280 l/c/d. it is required to design the following parts of its sewerage system as:

- Main collector of this district with invert level (-3.00) from the ground level.
- Pump station wet well & dry well type
- Force main with length 8.0 km up to WWTP where its ground level is (+12.00) & the water level in the first tank is above ground by 4.00m.

For the main collector

$$Q_{ave} = 0.8 \times \frac{pop \times w.c}{24 \times 60 \times 60}$$

$$= 0.8 \times \frac{75000 \times 280}{24 \times 60 \times 60} = 194.44 \text{ l/s}$$

$$P.F.F. = 1 + \frac{14}{4 + \sqrt{\frac{pop}{1000}}}$$

$$P.F.F. = 1 + \frac{14}{4 + \sqrt{\frac{75000}{1000}}} = 2.11$$

$$M.F.F. = 0.2 \left(\frac{pop}{1000} \right)^{0.167}$$

$$M.F.F. = 0.2 \left(\frac{75000}{1000} \right)^{0.167} = 0.52$$

Qave. Summer =1.2 x Qave
= 1.2 x 194.44 = 233.33 l/s
Qmax summer = P.F.F x Qave summer +Qinf
= 2.11 x 233.33 + (10% x 194.44) = 511.77 l/s
Qave winter = 0.7 x Qave
= 0.7 x 194.44 =136.11 l/s
Qmin winter = M.F.F x Qmin winter + Qinf
= 0.52 x 136.11 + 19.44 = 90.22 l/s
Assume d / Ø =0.75 from chart (2) Q max./Qfull.=0.86

Q full.= Q max./0.86 = 511.77 / 0.86 = 595.08 l/s

Assume V min. =0.6 m/s → self. Cleaning velocity
Q min. / Q full= 90.22 / 595.08 = 0.15
from chart (2) V min/ V full =0.73
V full. =0.6/0.73= 0.82 m/s
If we use PVC pipe n= 0.019 & n of chart = 0.015
Q full of chart x n of chart = Q full act x n act
Q full of chart = 595.08 ×0.019/0.015= 753.76 l/s
V full of chart = V full act ×0.019/0.015= 1.04 m/s
From chart (1) with Q full chart & V full chart

Ø- 36" , S = 2.2 %

Q max / Q full act=0.86 & from chart V max./ V full.=1.07

V max.= 1.07 × 0.82 = 0.88 m/s <1.5 o.k.

ii. Pump station

Design of Wet sump:

Q design → Q max & Q min

Q max = 511.77 l/s x 60/1000 = 30.7 m^3/min

Qmin = 90.22 l/s x 60/1000 = 5.41 m^3/min

T = 5 - 10 minutes (at Qmax)

V = Qmax x T

= 30.7 x 5 = 153.5 m^3

d = 2 m

Awet = V/d

= 153.5 / 2 = 76.75 m^2

Take pump of wet & dry well type vertical centrifugal pump with Ratio 1/3 wet & 2/3 dry.

Total area of sump = 3 x 76.75 = 230.25 m2

A = π Φ2 /4

230.25 = π Φ2 /4 ∴Φ = 17.12 m

Check at Qmin:

V = Qmin x T

T = 153.5 / 5.41 = 28.37 minutes < 30 minutes safe

Design of force main

Q= A×v

Take v = 1 m/s v = 1 – 1.5 m/s

A = Q / v

= 511.77/1000 / 1 = 0.51 m2

A = π Φ2 /4

0.51 = π Φ2 /4 ∴Φ = 0.81 ~ 0.8 m

V act = 1.02 m/s <2 o.k.

Pump head

HT=Hstatic+Hfriction+Hminor Losses +HLosses in P.S

Static head (Hs) = 12.00+4+3+0.5+1.75= 21.25m

Dynamic head = friction head loss +secondary loss

$$hf = \frac{4flv^2}{2gd}$$

$$hf = \frac{4 \times 0.008 \times 8000 \times 1.02^2}{2 \times 9.82 \times 0.8} = 16.95m$$

Total head = 21.25 +16.95 + 1.695 + 5 = 44.9 m