# ಕರ್ನಾಟಕ ವಿಧಾನ ಪರಿಷತ್ತು

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4. ಉತ್ತರಿಸುವ ಸಚಿವರು : ಮಾನ್ಯ ಕಾನೂನು, ಸಂಸದೀಯ ವ್ಯವಹಾರಗಳು ಹಾಗೂ ಶಾಸನ ರಚನೆ ಮತ್ತು ಸಣ್ಣ ನೀರಾವರಿ ಸಚಿವರು.

| ಕ್ರ.ಸಂ | ಪ್ರಶ್ನೆ | ಉತ್ತರ |
|---|---|---|
| ಅ | ಶಿವಮೊಗ್ಗ ಜಿಲ್ಲೆಯ ತುಂಗಾ ನದಿಯಿಂದ ಶಿವಮೊಗ್ಗ ಗ್ರಾಮಾಂತರ ಪ್ರದೇಶದ 29 ಕೆರೆಗಳಿಗೆ ನೀರು ತುಂಬಿಸುವ ಏತ ನೀರಾವರಿ ಯೋಜನೆಯ ಯೋಜನಾ ಅಂದಾಜು ಮೊತ್ತವೆಷ್ಟು: ಇದನ್ನು ಎಷ್ಟು ಬಾರಿ ಪರಿಷ್ಕರಿಸಲಾಗಿದೆ. ಪ್ರಸ್ತುತ ಈ ಯೋಜನೆಯ ಪರಿಷ್ಕøತ ಯೋಜನಾ ಅಂದಾಜು ಮೊತ್ತವೆಷ್ಟು | ಶಿವಮೊಗ್ಗ ಜಿಲ್ಲೆಯ ತುಂಗಾ ನದಿಯಿಂದ ಶಿವಮೊಗ್ಗ ಗ್ರಾಮಾಂತರ ಪ್ರದೇಶದ 22 ಕೆರೆಗಳಿಗೆ ನೀರು ತುಂಬಿಸುವ ಏತ ನೀರಾವರಿ ಯೋಜನೆಯ ಅಂದಾಜು ಮೊತ್ತ: 2900.00 ಲಕ್ಷಗಳಾಗಿರುತ್ತದೆ. ಸದರಿ ಯೋಜನೆಯಲ್ಲಿ 22 ಕೆರೆಗಳಿಗೆ ನೀರು ತುಂಬಿಸಲು ಪರಿಗಣಿಸಿ ಅಂದಾಜು ಪಟ್ಟಿಗೆ ತಾಂತ್ರಿಕ ಮಂಜೂರಾತಿ ನೀಡಲಾಗಿದೆ.<br><br>ಟೆಂಡರ್ ಕರೆಯುವ ಸಮಯದಲ್ಲಿ ಇನ್ನೂ ಹೆಚ್ಚಿನ 7 ಕೆರೆಗಳನ್ನು ತುಂಬಿಸಲು ರೈತರಿಂದ ಬೇಡಿಕೆ ಬಂದಿರುವ ಹಿನ್ನಲೆಯಲ್ಲಿ 29 ಕೆರೆಗಳಿಗೆ ಏತ ನೀರಾವರಿ ಮೂಲಕ ನೀರನ್ನು ತುಂಬಿಸಲು ಟೆಂಡರ್ ಕರೆಯಲಾಗಿದೆ. ಅದರಂತೆ, ಟೆಂಡರ್ ಮೊತ್ತವನ್ನು ಒಂದು ಬಾರಿ ಪರಿಷ್ಕರಿಸಲಾಗಿದೆ. ಪರಿಷ್ಕರಿಸಿದ ಮೊತ್ತ ರೂ.3174.39 ಲಕ್ಷಗಳು |
| ಆ | ಸಮಗ್ರ ಯೋಜನಾ ವರದಿಯಲ್ಲಿರುವ ಮೊತ್ತಕ್ಕೆ ಪ್ರತಿಯಾಗಿ ಯೋಜನಾ ವೆಚ್ಚವನ್ನು ಎಷ್ಟು ಪ್ರಮಾಣದಲ್ಲಿ ಹೆಚ್ಚಿಸಲಾಗಿದೆ: ಯೋಜನಾ ವೆಚ್ಚವನ್ನು ಪರಿಷ್ಕರಿಸಲು ಕಾರಣವೇನು: (ಈ ಬಗ್ಗೆ ಪಡೆದಿರುವ ಪರಿಣತರ ವರದಿಯ ಪ್ರತಿಯ ಜೊತೆಗೆ ಸಂಪೂರ್ಣ ಮಾಹಿತಿ ಒದಗಿಸುವುದು) | ಮೂಲ ಯೋಜನಾ ವರದಿಯ ಮೊತ್ತಕ್ಕೆ ಶೇ 25.07 ರಷ್ಟು ಪ್ರಮಾಣ ಹೆಚ್ಚಾಗಿರುತ್ತದೆ.<br><br>ಮೂಲ ಪ್ರಸ್ತಾವನೆಯಲ್ಲಿ ಸದರಿ ಯೋಜನೆಯಲ್ಲಿ 22 ಕೆರೆಗಳಿಗೆ ನೀರು ತುಂಬಿಸಲು ಯೋಜಿಸಲಾಗಿದ್ದು, 7 ಹೆಚ್ಚುವರಿ ಕೆರೆಗಳನ್ನು ತುಂಬಿಸಲು ಬೇಡಿಕೆ ಬಂದಿದ್ದರಿಂದ ಯೋಜನಾ ವೆಚ್ಚವನ್ನು ಪರಿಷ್ಕರಿಸಲಾಗಿದೆ.<br><br>ಯೋಜನೆಯ ವಿನ್ಯಾಸ ಕುರಿತು ಭಾರತೀಯ ವಿಜ್ಞಾನ ಸಂಸ್ಥೆಯ ನಿವೃತ್ತ ಪ್ರೊಫೇಸರ್ ಮತ್ತು ತಾಂತ್ರಿಕ ಮೌಲ್ಯ ನಿರ್ಣಯ ಸಮಿತಿಯ ಸದಸ್ಯರಿಂದ ಪಡೆದಿರುವ ವರದಿಯ ಪ್ರತಿಯನ್ನು ನೀಡಲಾಗಿದೆ. |
| ಇ | ಈ ಯೋಜನೆಯು ನದಿಯ ನೀರನ್ನು (ಸಂಸ್ಕರಿಸದ) ನೇರವಾಗಿ ಕೆರೆಗಳಿಗೆ ತುಂಬಿಸುವ ಯೋಜನೆಯಾಗಿದ್ದಾಗಲೂ ಯೋಜನೆಗೆ ಪೂರಕವಾದ HDD (high density poly ethylene pipe) ಪೈಪ್‌ಗಳ ಬದಲು, ಆರ್ಥಿಕವಾಗಿ ಹೊರೆಯಾಗಿರುವ Ductile iron ಪೈಪ್‌ಗಳನ್ನು ಬಳಸುತ್ತಿರುವ ಉದ್ದೇಶವೇನು: (ಈ ಬಗ್ಗೆ ಪಡೆದಿರುವ ತಾಂತ್ರಿಕ ಪರಿಣಿತರ ವರದಿಯ ಪ್ರತಿಯನ್ನು ಒದಗಿಸುವುದು) | ಸದರಿ ಯೋಜನೆಯಲ್ಲಿ ರೈಸಿಂಗ್ ಮೇನ್‌ಗಳನ್ನು 2 ಹಂತದಲ್ಲಿ ವಿನ್ಯಾಸಿಸಲಾಗಿದೆ.<br><br>ಮೊದಲನೇ ಹಂತದಲ್ಲಿ ಒಟ್ಟು 95.00 ಮೀ. ಎತ್ತರಕ್ಕೆ (Total Head) 0.2465 ಕ್ಯೂಮೆಕ್ಸ್ ನೀರನ್ನು ಪಂಪ್ ಮಾಡಲು ಉದ್ದೇಶಿಸಿದೆ. ರೈಸಿಂಗ್ ಮೇನ್ ಪೈಪ್‌ಗಳನ್ನು 14.88 ಕಿ.ಮೀ. ಉದ್ದಕ್ಕೆ ರಸ್ತೆಯ ಅಂಚಿನಲ್ಲಿ ಅಳವಡಿಸಬೇಕಾಗಿರುತ್ತದೆ, ಅದರಂತೆ ಎಂ.ಎಸ್. ಪೈಪ್ (4.89 ಕಿ.ಮೀ.) ಮತ್ತು ಡಿ.ಐ. ಪೈಪ್ (9.99 ಕಿ.ಮೀ.) ಅಳವಡಿಸಲು ವಿನ್ಯಾಸಿಸಿದೆ.<br><br>ಎರಡನೇ ಹಂತದಲ್ಲಿ 168 ಮೀ. ಎತ್ತರಕ್ಕೆ (Total Head) 0.2093 ಕ್ಯೂಮೆಕ್ಸ್ ನೀರನ್ನು ಪಂಪ್ ಮಾಡಲು ಉದ್ದೇಶಿಸಿದೆ. ರೈಸಿಂಗ್ ಮೇನ್‌ನ್ನು 27.65 ಕಿ.ಮೀ. ಉದ್ದಕ್ಕೆ ಡಿ.ಐ. ಪೈಪ್ ಗಳನ್ನು ರಸ್ತೆಯ ಅಂಚಿನಲ್ಲಿ ಅಳವಡಿಸಲು ವಿನ್ಯಾಸಿಸಿದೆ.<br><br>ರಸ್ತೆಯಲ್ಲಿ ವಾಹನ ದಟ್ಟಣೆ ಇರುವುದರಿಂದ, ಸದರಿ ರೈಸಿಂಗ್ ಮೇನ್‌ಗಾಗಿ HDPE ಪೈಪ್‌ಗಳನ್ನು ಅಳವಡಿಸಿದಲ್ಲಿ ಟ್ರಾಫಿಕ್ ಒತ್ತಡಕ್ಕೆ ಒಡೆದು ಹೋಗುವ ಸಂಭವವಿರುತ್ತದೆ ಹಾಗೂ HDPE |

| | | |
|---|---|---|
| | | ಪೈಪ್‌ಗಳಿಗೆ Surge Pressure ಅನ್ನು ತಡೆದುಕೊಳ್ಳುವ ಸಾಮರ್ಥ್ಯವಿರುವುದಿಲ್ಲವಾದ್ದರಿಂದ ಡಿ.ಐ. ಪೈಪ್‌ಗಳನ್ನು ಅಳವಡಿಸಲಾಗಿದೆ.<br><br>HDPE ಪೈಪ್‌ಗಳಿಗೆ ಹೋಲಿಸಿದಾಗ ಡಿ.ಐ. ಪೈಪ್‌ಗಳು 24 ರಷ್ಟು ಹೆಚ್ಚಿನ ಸಾಮರ್ಥ್ಯ ಹೊಂದಿರುತ್ತದೆ. ಈ ಅಂಶಗಳನ್ನು ಪರಿಗಣಿಸಿ ಭಾರತೀಯ ವಿಜ್ಞಾನ ಸಂಸ್ಥೆಯ ನುರಿತ ತಜ್ಞರ ವರದಿಯನ್ನಾಧರಿಸಿ ಡಿ.ಐ. ಪೈಪ್ ಅಳವಡಿಸಲಾಗಿದೆ.<br><br>ಬ್ಲೀಡರ್ ಪೈಪ್‌ಗಳು 100 ಎಂ.ಎಂ. ವ್ಯಾಸಕ್ಕಿಂತ ಕಡಿಮೆ ಇದ್ದಲ್ಲಿ HDPE ಪೈಪ್‌ಗಳನ್ನುಅಳವಡಿಸಿ ಮಿತವ್ಯಯ ಸಾಧಿಸಿದೆ. |
| ಈ | ಈ ಯೋಜನೆಯನ್ನು ಗುತ್ತಿಗೆ ಪಡೆದಿರುವ ಸಂಸ್ಥೆ ಯಾವುದು: ಗುತ್ತಿಗೆ ಸಂಸ್ಥೆಗೆ ಈವರೆಗೆ ಪಾವತಿಸಲಾದ ಮೊತ್ತವೆಷ್ಟು: ಪಾವತಿಸಲು ಬಾಕಿಯಿರುವ ಮೊತ್ತವೆಷ್ಟು? (ಹಂತವಾರು ಮಾಹಿತಿ ನೀಡುವುದು) | ಸದರಿ ಯೋಜನೆಯನ್ನು ಶ್ರೀ ಪಿ. ಸುಧೀರ್‌ನಾಯ್ಡು, 1ನೇ ದರ್ಜೆ ಗುತ್ತಿಗೆದಾರರು, ಹಾವೇರಿ ಜಿಲ್ಲೆ ಇವರಿಗೆ ಗುತ್ತಿಗೆ ಆಧಾರದ ಮೇಲೆ ಪರಿಷ್ಕೃತ ಟೆಂಡರ್‌ಗಿಟ್ಟ ಮೊತ್ತದ ಮೇಲೆ ಶೇ 9.98 ರಷ್ಟು ಹೆಚ್ಚಿನ ಮೊತ್ತಕ್ಕೆ ವಹಿಸಲಾಗಿದೆ.<br>ಈವರೆಗೆ ಪಾವತಿಸಲಾದ ಮೊತ್ತ ರೂ.24,35,40,974/- ಗಳಾಗಿರುತ್ತದೆ.<br><br>ಪಾವತಿಸಲು ಬಾಕಿ ಇರುವ ಮೊತ್ತ ರೂ.10,55,78,960/- |

ಕಡತ ಸಂಖ್ಯೆ:MID 03 LCQ 2023

(ಜೆ.ಸಿ.ಮಾಧುಸ್ವಾಮಿ)
ಕಾನೂನು, ಸಂಸದೀಯ ವ್ಯವಹಾರಗಳು ಹಾಗೂ
ಶಾಸನ ರಚನೆ ಮತ್ತು ಸಣ್ಣ ನೀರಾವರಿ ಸಚಿವರು.

GOVERNMENT OF KARNATAKA

MINOR IRRIGATION & GWD (S)

# HOLE HANASAVADI LIFT IRRIGATION SCHEME

## PROOF CHECKING OF HYDRAULIC DESIGNS AND SURGE ANALYSIS OF STAGES 1 AND 2


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# PROOF CHECKING OF HOLE HANASAVADI LIS PUMP AND PIPE DESIGNS AND SURGE ANALYSIS

## 1. INTRODUCTION

The Hole Hanasavadi LIS is planned by the Minor Irrigation Department, Government of Karnataka, to fill 29 tanks in Shivamogga taluk by pumping 0.493 cumec of water from Tunga river. The pumping is proposed to be done in two stages. In the first stage, 12 tanks will be filled, and the remaining 17 in the second stage. The project contractors have submitted a design report to the Department.

The Engineer-in-Chief, MI (South), has assigned the task of proof checking the designs of pumping machinery and rising main *vide* Letter ಸಂಖ್ಯೆ: ಪ್ರ.ಇಂ.ಸ.ದ/ತಾಂ.-4/ಸ.ಇಂ.1/ ಹೊಳೆಹನಸವಾಡಿ/2021/2509 ದಿನಾಂಕ 30.10.2021. Accordingly, the proof checking report is presented here in three parts, the first part dealing with the first stage, the second part with the second stage, and the third part containing the conclusions and recommendations.

## PART-1: FIRST STAGE DESIGNS AND SURGE ANALYSIS

## 2. DISCHARGE REQUIRED FOR FIRST STAGE

The discharge required is 0.493 cumec.

It is proposed to use 2 working and 1 standby VT pumps to lift this quantity.

Discharge per pump will therefore be 0.493/2 = 0.2465 cumec.

## 3. PIPE NETWORK

The system consists of a pump house, rising main, and bleeders from the rising main to different tanks. The first stage terminates at Abbalagere Sarakari Hosa Kere. A second pump house is located at this tank for the second stage.

## 4. PUMP DISCHARGE AND SUCTION PIPES

Velocity in the pump discharge pipe is normally around 2.5 m/s.

Two working and one standby pumps (2W + 1S) are proposed to be installed.

Pump discharge pipe of 350 mm diameter is adopted.

Pump discharge = 0.493/2 = 0.2465 cumec

Area of cross section = $\pi \times 0.35^2/4 = 0.0962$ m$^2$

Velocity = 0.2465 /0.0962 = 2.56 m/s, which is acceptable.

Suction pipe of 350 mm diameter and 5 mm thickness is proposed, which is acceptable.

*Diameter of 350 mm and thickness of 5 mm may be approved for the MS suction and discharge pipes.*

## 5. PUMP RATING

### 5.1. Head Losses in the System

The pumping system hydraulic path for VT pumps generally consists of the sump, draft tube/strainer and bell mouth, pump, discharge column/pipe, discharge elbow, expander, discharge pipe, distance pieces, dismantling joint, butterfly valve, nonreturn valve, bends where necessary, manifold, rising main and delivery chamber. All of them except the last two are in the pump house, and head losses in them are collectively called pump house losses.

### 5.2. Pump House Losses

Head losses occur at the entrance to the strainer/bell mouth and in whatever other components mentioned above installed in the pump house. There will also be losses at entrance to and exit from the manifold. There are formulae to calculate these losses, but they are valid only when there is sufficient straight length of pipe upstream and downstream of the components. In a pump house, there is no such sufficient straight length, different components are spaced a short distance apart, and losses will always be higher than those given by the formulae. A good practice is to take the pump house losses equal to $4v^2/(2g)$ where each pump has its own rising main, and $6v^2/(2g)$ where pumps are connected to rising main through a manifold, where $v$ is the velocity in the discharge pipe. The latter is adopted in the present case since delivery pipes of three pumps are connected to a manifold. The pump house losses work out to $6 \times 2.56^2/2g = 2.007$ m.

### 5.3. Rising Main Losses

Hazen-Williams formula is extensively used to calculate friction loss in water supply and irrigation pipelines:

$$h_f = \frac{10.65 L Q^{1.852}}{C^{1.852} D^{4.87}}$$

where $h_f$ is head loss due to friction (m), $L$ is pipe length (m), $Q$ is discharge (cumecs), $C$ is a coefficient and $D$ is pipe diameter (m). The value of $C$ depends on the pipe material. For MS pipes the AWWA Manual M11 specifies the formula for $C$ as

$$C = 130 + 0.16d$$

where $d$ is the inner diameter of the pipe in inches. The same is used for DI pipes also. For HDPE pipes $C$ is taken as 140.

In addition to friction loss, minor losses occur in the rising main due to joints, bends and other fittings, air pockets etc. As per standard practice, these are taken as 10% of the friction loss.

### 5.4. Delivery Level

The level at the end of the pipe at which water is delivered determines the static lift. The FTL of the tank is this level. Since FTL varies from tank to tank, static lift also varies. The FTL's of the 12 tanks in the first stage are as follows:

| Tank | FTL, m |
|---|---|
| Belalakatte kere-3 | 576.896 |
| Melina Hanasavadi kere | 571.845 |
| Girishettikere | 591.467 |
| Belalakatte kere-1 | 589.513 |
| Belalakatte kere-2 | 587.874 |
| Muthodu Balasokere | 581.613 |
| Muthodu Hosahulikere | 581.912 |
| Channamumbapura sarkarikatte | 595.331 |
| Basavanagangooru sarkarikere | 597.881 |
| Basavanagangooru siddanakatte | 591.881 |
| Mathodu vaddinakatte | 587.602 |
| Abbalagere Sarakari hosakere | 586.247 |

The pump head should be high enough to ensure that the HGL is positive at all these delivery points.

### 5.5. Pump Head Required

The pathway through which water passes to each tank from the pump house can be easily traced from Fig. 1. The pathway consists of different reaches whose lengths, diameters and discharges are different. Friction loss (plus minor losses) through each of these reaches has to be calculated and summed to get the total loss through the pathway, which is then added to the static lift for that particular tank to get the pump head required for that tank. Since friction loss depends on the pipe diameter, trial values for the diameter have to be assumed initially and then optimized. Thus the calculations have to be carried out simultaneously for the complete network. When calculating HGL's, it was found that the path from the pump house to Basavanagangooru sarkari kere requires the largest head (static lift + head loss). Accordingly, the rising main is considered to be composed of the reaches Jackwell 1 to B-1 to B-2 to B-6 to B-7 to B-10 to Basavanagangooru sarakari kere. The pump head for this path is calculated as follows:

Delivery level at Basavanagangooru sarkari kere = 597.881 m

LWL in sump = 554.750 m

Static lift = 597.881 – 554.750 = 43.131 m

| Reach | Length | Discharge | ID | Friction Loss |
|---|---|---|---|---|
| m | m | cumec | mm | m |
| Jackwell to B-1 | 2460 | 0.493 | 550 | 15.055 |
| B-1 to B-2 | 2439 | 0.393 | 550 | 9.809 |
| B-2 to B-6 | 1384 | 0.285 | 500 | 4.905 |
| B-6 to B-7 | 1063 | 0.071 | 300 | 3.517 |
| B-7 to B-10 | 950 | 0.005 | 100 | 4.951 |
| B-10 to Basavanagangooru sarkarikere | 20 | 0.004 | 80 | 0.180 |
| | | | **Total** | **38.42** |
| | | Minor Losses at 10% | | 3.84 |
| | | Total Head Loss | | 42.26 |
| | | Static Lift | | 43.13 |
| | | Pump House Loss | | 2.01 |
| | | **Pump Head Required** | | **87.4** |

The pump head proposed is 95 m, which gives a residual pressure of 7.6 m, and hence is acceptable.

### 5.6. Motor Rating and Power Requirement

According to the Hydraulic Institute efficiency chart, VT pumps of capacity 0.2465 cumec can attain efficiency of 87%. Hence,

BkW per pump = 9.81QH/h = 9.81×0. 2465 ×95/0.87 = 267 kW

Add 10% for motor rating:

Motor output = 1.1 × 267 = 294 kW

Motor input = 294/0.95 = 310 kW (assuming motor efficiency of 95%)

The proposed pump power is 318.56 kW, which is therefore adequate and is acceptable.

## 6. HGL CALCULATIONS

HGL's calculated as described above for the first stage are shown in Table 1. The starting HGL at the beginning of the rising main was calculated as follows:

LWL in sump = 554.750 m

Pump head = 95 m

Pump house loss = 2.007 m

HGL at Ch 0 m = 554.75 + 95 – 2.007 = 647.743 m

HGL at the end of a reach was calculated by subtracting head loss from HGL at the beginning. It is seen from Table 1 that residual pressures at the tanks are positive.

## 7. PIPE MATERIAL, DIAMETER AND THICKNESS

Table 1 shows the pipe material and diameter. These are as per the L-Sections given in the design report. Thickness of 5 mm for MS pipes is acceptable.

## 8. MS PIPE THICKNESS CHECKS

### 8.1. Check for Deflection

According to Spangler's theory (AWWA Manual M11), the pipe deflection is given by the formula

$$\Delta x = D_i\,[KWr^3/(EI+0.061E'r^3)]$$

where $\Delta x$ = Deflection, $D_i$ = Deflection lag factor (taken as 1.1), $K$ = Bedding constant (taken as 0.1), $W = \gamma_s Dh$, $\gamma_s$ =Specific weight of soil overburden (2100 kg/m$^3$), $D$ = Mean diameter of pipe, $h$ = Height of backfill above pipe top (150 cm), $E$ = Young's Modulus for steel (2100000 kg/cm$^2$), $I$ = Transverse moment of inertia per unit length of pipe wall, $E'$ = Modulus of soil reaction (28 kg/m$^2$), and $r$ = Radius of pipe

Deflection of the 550 mm dia 5 mm thick MS pipe from the above formula is 0.7 cm. The permissible deflection for epoxy-inlined and gunited MS pipes is 3% of the pipe diameter, or 1.65 cm. The deflection is well within the permissible value.

DI and HDPE pipes have ample thickness and deflect much less than MS pipes.

### 8.2. Resistance to Collapse

According to the AWWA Manual M11, the critical collapse pressure for MS pipes is given by Stewart's formula:

$$P_c = 50.2\times10^6\times(t/D_n)^3$$

where $P_c$ = Critical collapse pressure in psi

$t$ = Pipe wall thickness in mm

$D_n$ = Diameter to neutral axis of the pipe in mm (for thin walled pipes, mean diameter can be taken).

Critical collapse pressure for the MS pipes works out to –25 m. Since the actual collapse pressure cannot go beyond –10 m (atmospheric pressure outside and full vacuum inside), the pipes are safe against collapse in any surge event.

## Table 1. HGL Calculations for Hole Hanasavadi LIS – First Stage

| Reach | HGL | L | Q | ID | Material | C | V | Head | HGL end | FTL | Pressure |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | cumecs | mm | | | m/s | m | m | m | m |
| Jackwell to B-1 | 647.743 | 2460 | 0.493 | 550 | MS | 133.46 | 2.075 | 16.561 | 631.182 | | |
| B-1 to Melina hanasavadi kere | 631.182 | 90 | 0.099 | 200 | DI | 131.26 | 3.151 | 4.407 | 626.775 | 571.845 | 54.93 |
| B-1 to B-2 | 631.182 | 2439 | 0.393 | 550 | MS | 133.46 | 1.654 | 10.790 | 620.392 | | |
| B-2 to B-3 | 620.392 | 275 | 0.109 | 300 | DI | 131.89 | 1.542 | 2.214 | 618.178 | | |
| B-3 to Girishettikere | 618.178 | 20 | 0.014 | 80 | HDPE | 140 | 2.785 | 2.012 | 616.165 | 591.467 | 24.70 |
| B-3 to B-4 | 618.178 | 525 | 0.094 | 300 | DI | 131.89 | 1.330 | 3.213 | 614.964 | | |
| B-4 to Belalakatte kere-1 | 614.964 | 20 | 0.037 | 125 | DI | 130.79 | 3.015 | 1.571 | 613.393 | 589.513 | 23.88 |
| B-4 to B-5 | 614.964 | 570 | 0.057 | 300 | DI | 131.89 | 0.806 | 1.381 | 613.583 | | |
| B-5 to Belalakatte kere-2 | 613.583 | 20 | 0.008 | 80 | HDPE | 140 | 1.592 | 0.714 | 612.869 | 587.874 | 25.00 |
| B-5 to Belalakatte kere-3 | 613.583 | 1685 | 0.049 | 300 | DI | 131.89 | 0.693 | 3.086 | 610.497 | 576.896 | 33.60 |
| B-2 to B-6 | 620.392 | 1384 | 0.285 | 500 | DI | 133.15 | 1.451 | 5.395 | 614.997 | | |
| B-6 to Abbalagere Sarakari hosa kere | 614.997 | 140 | 0.213 | 250 | DI | 131.57 | 4.339 | 9.514 | 605.483 | 586.247 | 19.24 |
| B-6 to B-7 | 614.997 | 1063 | 0.071 | 300 | DI | 131.89 | 1.004 | 3.869 | 611.128 | | |
| B-7 to B-8 | 611.128 | 646 | 0.058 | 250 | DI | 131.57 | 1.182 | 3.946 | 607.182 | | |
| B-8 to Mathodu vaddinakatte | 607.182 | 770 | 0.002 | 57 | HDPE | 140 | 0.784 | 10.990 | 596.191 | 587.602 | 8.59 |
| B-8 to B-9 | 607.182 | 865 | 0.056 | 250 | DI | 131.57 | 1.141 | 4.951 | 602.230 | | |
| B-9 to Muthodu Balasokere | 602.230 | 650 | 0.049 | 250 | DI | 131.57 | 0.998 | 2.906 | 599.325 | 581.613 | 17.71 |
| B-9 to Muthodu Hosahulikere | 602.230 | 392 | 0.007 | 100 | DI | 130.63 | 0.891 | 4.190 | 598.040 | 581.912 | 16.13 |
| B-7 to Channamumbapura | 611.128 | 735 | 0.008 | 150 | DI | 130.94 | 0.453 | 1.390 | 609.737 | 595.331 | 14.41 |
| B-7 to B-10 | 611.128 | 950 | 0.005 | 100 | DI | 130.63 | 0.637 | 5.446 | 605.682 | | |
| B-10 to Basavanagangooru | 605.682 | 20 | 0.004 | 80 | HDPE | 140 | 0.796 | 0.198 | 605.484 | 597.881 | 7.60 |
| B-10 to Basavanagangooru | 605.682 | 240 | 0.001 | 46 | HDPE | 140 | 0.602 | 2.696 | 602.986 | 591.881 | 11.11 |

### 8.3. Resistance to Buckling

The rising main is buried in soil, and is therefore subject to the weight of the overburden on it as well as helped by the soil support. When negative pressure occurs inside the pipe, there is a buckling pressure on the pipe composed of the soil overburden and the differential pressure between outside (atmospheric) and inside. The allowable buckling pressure according to AWWA Manual M11 is

$$q_a = \left(\frac{1}{FS}\right)\left(32 R_w B' E' \frac{EI}{D^3}\right)^{1/2}$$

where $q_a$ = allowable buckling pressure (kg/cm$^2$), $FS$ = design factor, $R_w$ = water buoyancy factor = 1 – 0.33($H_w/H$), $H_w$ = height of water surface (if any) above top of pipe (cm), $H$ = height of backfill above top of pipe (cm), $B' = \frac{1}{1+4e^{(-0.065h)}}$ where $h$ is in feet, $E'$ = Modulus of soil reaction (kg/cm$^2$), $E$ = Young's modulus of pipe material (kg/cm$^2$), $I$ = Moment of inertia of pipe wall (cm$^3$) = $t^3/12$, and $D$ = Pipe diameter (cm). The design factor $FS$ is to be taken as 2.

The pipe is safe against buckling if

$$\gamma_w H_w + R_w \frac{W}{D} + P_v \le q_a$$

where $\gamma_w$ = specific weight of water (kg/cm$^3$), $W$ = load per cm length of pipe due to soil overburden (kg/cm) = $\gamma_s DH$, $\gamma_s$ = specific weight of soil (kg/cm$^3$) and $P_v$ = internal vacuum pressure (kg/cm$^2$) in the pipe, *i.e.*, atmospheric pressure minus absolute pressure in the pipe.

In the present case, the allowable buckling pressure works out to –20 m. Since the actual buckling pressure cannot go beyond –10 m, the pipes are safe against buckling.

### 8.4. Normal and Allowable Working Pressure

The normal working pressure at any point in the rising main is the difference between the elevations of HGL and rising main at that point.

The allowable working pressure for MS pipes according to IS 5822 is given by the equation

$$p = \frac{2tafe}{D-t}$$

where $a$ = design factor (to be taken as 0.6 for working pressure and 0.9 for test pressure inclusive of surge pressure), $f$ = specified minimum yield stress and $e$ = weld efficiency of the joint (to be taken as 0.9 for shop welding and 0.8 for field welding). $D$ is the outside diameter and $t$ the thickness of the pipe. Any set of consistent units can be used in the above equation.

For normal working pressure, $a$ is taken as 0.9. Value of $f$ is 235 MPa for Fe410 grade steel (IS 3589). Since welding takes place in the field, $e$ is taken as 0.8. The allowable working pressure calculated with these values is 206 m. Taking $a$ as 0.6, allowable upsurge pressure is 310 m.

Since the pump head is only 95 m, the actual working pressure is well within the allowable working pressure.

Hence the diameter and thickness are satisfactory.

## 9. SURGE ANALYSIS

Following a power failure, vacuum pressures and upsurge pressures will develop in the rising main. For large pipes, surge protection is necessary, but smaller pipes usually have adequate thickness to withstand these pressures without surge protection. These points are analysed in the following sections.

As shown in the previous section, the MS pipe is capable of withstanding collapse and buckling pressures even with full vacuum inside. Surge protection is thus not needed to prevent pipe collapse or buckling. However, the rising main has to be checked for upsurge pressure.

### 9.1. Allowable Upsurge Pressure

The allowable upsurge pressure is 310 m (§7.4). The actual upsurge pressure is calculated in the next Section.

### 9.2. Upsurge Pressure due to Rejoining of Water Columns

Deep vacuum pressures will occur in the pipes following power failure. Water will get vapourised at peak points in the L-Section under these conditions, and the water column in the pipes will break at these points. When a positive pressure wave passes, vapour will condense and the separated water columns rejoin. Velocity of the water columns will be arrested during rejoining and this will give rise to high pressures.

The upsurge pressure generated by rejoining of water columns is given by Joukowsky's equation

$$\Delta h = a\Delta v/g$$

where $\Delta h$ is the head rise, $a$ is the wave celerity, $\Delta v$ is the change in velocity of the water column due to rejoining, and $g$ is the acceleration due to gravity.

Because of energy conservation, the velocity of the rejoining water column can at the most be equal to the velocity in the rising main during steady state operation, which is 2.075 m/s in the present case. The water column can at worst come to rest after rejoining. Thus the maximum value of $\Delta v$ can be 2.075 m/s.

The celerity is given by the equation

$$a = \sqrt{\frac{E_w}{\rho}\left(\frac{1}{1 + E_w D/(Et)}\right)}$$

where $E_w$ is the bulk modulus of elasticity of water (22434 kg/cm$^2$), $\rho$ is its density (0.001 kg/cm$^3$), $E$ is Young's Modulus for the pipe material (2100000 kg/cm$^2$), and $D$ and $t$ are the mean diameter and thickness of the pipe respectively. For the dimensions of the MS pipe ($D$ = 555.812 mm and $t$ = 5 mm), $a$ works out to 1011 m/s. With these values, $\Delta h$ can at most be 206 m. This pressure will propagate throughout the pipe and has to be added to the static head. Static pressure in the rising main is the difference between highest FTL (597.881 m) and lowest elevation of the rising main (557.425 m), which amounts to 40.5 m. Thus the maximum upsurge pressure is 246.5 m (= 206 + 40.5). This is less than the allowable surge pressure of 310 m.

Thus the rising main is strong enough to withstand upsurge as well as downsurge pressures without surge protection. However, the propagating surge pressure waves would cause noise and vibrations after a power failure, and to mitigate this, *it is recommended that air cushion valves be installed on the rising main at the chainages indicated in Table 2, where local peaks in the L-Section are present. This is in addition to the usual kinetic air valves.*

An air cushion valve of PN 20 rating can withstand 200 m working pressure and 300 m surge pressure. Thus PN 20 rating is adequate.

**Table 2. Specifications of Air Cushion Valve to be installed on the Rising Main**

| Chainages at which to be Installed | Air Cushion Valve | |
|---|---|---|
| | Diameter | Rating |
| 30 m, 2190 m, 5100 m, 6493 m, and 7003 m | 100 mm | PN 20 |

*Since the surge pressure wave propagates throughout the pipe, all fittings such as control valves, non-return valves, dismantling joints, kinetic air valves, scour valves etc should also be of PN 20 rating.*

*A pressure relief valve should be installed at the beginning of the rising main to reduce the surge pressure in order to minimize noise and vibration that might occur due to the surge wave following power failure.* Since the pump head is 95 m, the pressure relief valve should be set to open at 10.5 kg/cm$^2$. When pressure exceeds 105 m due to the surge wave, the valve will open and let out water, reducing the pressure. Specifications of the pressure relief valve are given in Table 3.

**Table 3. Pressure Relief Valve Specifications**
**(To be installed at the beginning of Rising Main)**

| Pressure Relief Valve | | |
|---|---|---|
| **Diameter** | **Rating** | **To Open if Pressure Exceeds** |
| 100 mm | PN 20 | 10.5 kg/cm$^2$ |

## PART-2: SECOND STAGE DESIGNS AND SURGE ANALYSIS

### 10. DISCHARGE REQUIRED FOR SECOND STAGE

The discharge required for the second stage is 0.2093 cumec.

It is proposed to use 2 working and 1 standby VT pumps to lift this quantity.

Discharge per pump will therefore be 0.2093/2 = 0.10465 cumec.

### 11. PUMP DISCHARGE PIPE

Velocity in the pump discharge pipe is normally around 2.5 m/s.

Two working and one standby pumps (2W + 1S) may be installed.

Pump discharge pipe of 250 mm diameter is proposed in the design report.

Pump discharge = 0.2093/2 = 0. 10465 cumec

Area of cross section = $\pi \times 0.25^2/4 = 0.0491$ m$^2$

Velocity = 0. 10465 /0.0491 = 2.13 m/s, which is acceptable.

*MS pipe of diameter 250 mm and thickness 5 mm may be adopted for the discharge pipe.*

### 12. DELIVERY LEVELS

The FTL's of the 17 tanks in the second stage are as shown in Table 3.

The pump head should be high enough to ensure that the HGL is positive at all these delivery points.

# Table 3. HGL Calculations for Hole Hanasavadi LIS – Second Stage

| Reach | HGL start | L | Q | ID | Material | C | V | Head | HGL end | FTL | Pressure |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | m | m | cumecs | mm | | | m/s | m | m | m | m |
| Jackwell-2 to B-11 | 752.8601 | 810 | 0.2093 | 450 | DI | 132.8346 | 1.316 | 2.991 | 749.8694 | | |
| B-11 to B-12 | 749.869 | 578 | 0.1088 | 300 | DI | 131.8898 | 1.539 | 4.638 | 745.2318 | | |
| B-12 to Abbalagere Muddana kere | 745.232 | 200 | 0.0022 | 63 | HDPE | 140 | 0.706 | 2.092 | 743.1399 | 606.699 | 136.441 |
| B-12 to B-13 | 745.232 | 695 | 0.1066 | 300 | DI | 131.8898 | 1.508 | 5.369 | 739.8624 | | |
| B-13 to Basavana gangooru Sarakari | 739.862 | 960 | 0.001 | 63 | HDPE | 140 | 0.321 | 2.331 | 737.5311 | 597.881 | 139.650 |
| B-13 to B-14 | 739.862 | 452 | 0.1056 | 300 | DI | 131.8898 | 1.494 | 3.432 | 736.4308 | | |
| B-14 to Hunasodu sarakar kere | 736.431 | 20 | 0.0084 | 100 | DI | 130.6299 | 1.070 | 0.300 | 736.1312 | 620.158 | 115.973 |
| B-14 to B-15 | 736.431 | 823 | 0.0972 | 300 | DI | 131.8898 | 1.375 | 5.359 | 731.0718 | | |
| B-15 to Kallaganuru Hosakere | 731.072 | 560 | 0.0112 | 100 | DI | 130.6299 | 1.426 | 14.295 | 716.7772 | 657.301 | 59.476 |
| B-15 to B-24 | 731.072 | 1435 | 0.0859 | 300 | DI | 131.8898 | 1.215 | 7.433 | 723.6392 | | |
| B-24 to Basavana Gangooru hirekere | 723.639 | 1315 | 0.08 | 250 | DI | 131.5748 | 1.630 | 14.572 | 709.0673 | 603.454 | 105.613 |
| B-24 to B-25 | 723.639 | 8400 | 0.006 | 150 | DI | 130.9449 | 0.340 | 9.327 | 714.3121 | | |
| B-25 to Tyajavalli katte-2 | 714.312 | 1570 | 0.0006 | 63 | HDPE | 140 | 0.192 | 1.480 | 712.8318 | 687.325 | 25.507 |
| B-25 to B-26 | 714.312 | 100 | 0.0054 | 100 | DI | 130.6299 | 0.688 | 0.661 | 713.6511 | | |
| B-26 to Tyajavalli katte-1 | 713.651 | 10 | 0.0006 | 63 | HDPE | 140 | 0.192 | 0.009 | 713.6417 | 663.376 | 50.266 |
| B-26 to Tyajavalli kere | 713.651 | 690 | 0.0048 | 100 | DI | 130.6299 | 0.611 | 3.667 | 709.9839 | 664.392 | 45.592 |
| B-11 to B-16 | 749.869 | 1584 | 0.1005 | 300 | DI | 131.8898 | 1.422 | 10.972 | 738.8971 | | |
| B-16 to Abbalagere Murdayyana kere | 738.897 | 20 | 0.0025 | 63 | HDPE | 140 | 0.802 | 0.265 | 738.632 | 614.622 | 124.010 |
| B-16 to B-17 | 738.897 | 2188 | 0.098 | 300 | DI | 131.8898 | 1.386 | 14.465 | 724.4317 | | |
| B-17 to Kommanalu tank | 724.432 | 150 | 0.0047 | 63 | HDPE | 140 | 1.508 | 6.399 | 718.0323 | 649.338 | 68.694 |
| B-17 to B-18 | 724.432 | 353 | 0.0933 | 300 | DI | 131.8898 | 1.320 | 2.131 | 722.301 | | |
| B-18 to Bikkonahalli hosakere | 722.301 | 970 | 0.0057 | 100 | DI | 130.6299 | 0.726 | 7.087 | 715.2137 | 659.321 | 55.893 |
| B-18 to B-19 | 722.301 | 2767 | 0.0876 | 300 | DI | 131.8898 | 1.239 | 14.861 | 707.4397 | | |
| B-19 to Biranakere ramanagudda | 707.440 | 140 | 0.0004 | 63 | HDPE | 140 | 0.128 | 0.062 | 707.3774 | 681.603 | 25.774 |
| B-19 to B-20 | 707.440 | 385 | 0.0872 | 300 | DI | 131.8898 | 1.234 | 2.050 | 705.3893 | | |
| B-20 to Biranakere Katte | 705.389 | 280 | 0.0004 | 63 | HDPE | 140 | 0.128 | 0.125 | 705.2647 | 673.991 | 31.274 |
| B-20 to B-21 | 705.389 | 2295 | 0.0868 | 300 | DI | 131.8898 | 1.228 | 12.119 | 693.2707 | | |
| B-21 to Kunchanahalli doddakere | 693.271 | 20 | 0.0528 | 250 | DI | 131.5748 | 1.076 | 0.103 | 693.1681 | 678.438 | 14.730 |
| B-21 to B-22 | 693.271 | 398 | 0.034 | 200 | DI | 131.2598 | 1.082 | 2.692 | 690.5784 | | |
| B-22 to Kunchanahalli katte | 690.578 | 320 | 0.0054 | 100 | DI | 130.6299 | 0.688 | 2.115 | 688.4631 | 659.919 | 28.544 |
| B-22 to B-23 | 690.578 | 472 | 0.0286 | 200 | DI | 131.2598 | 0.910 | 2.318 | 688.2606 | | |
| B-23 to Kallapura sarkari kere | 688.261 | 20 | 0.0282 | 150 | DI | 130.9449 | 1.596 | 0.390 | 687.8705 | 654.991 | 32.879 |

## 13. PUMP AND MOTOR RATING

The deciding path for the pump head is Jackwell 2–B11–B16–B17–B18–B19–B20–B21–Kunchanahalli doddakere. The required pump head calculated in the same way as for Stage-1 works out to 153.4 m. The design report proposes pump head as 168 m, which is acceptable.

Pump and motor ratings as per design report are acceptable.

## 14. HGL CALCULATIONS

HGL's calculated as described for Stage-1 are shown in Table 3. It is seen from Table 3 that residual pressures at the tanks are positive.

## 15. PIPE MATERIAL, DIAMETER AND CLASS

Pipe diameters and material shown in Table 3 can be accepted.

## 16. SURGE ANALYSIS

Following a power failure, vacuum pressures and upsurge pressures will develop in the rising main. DI pipes are used for the rising main in Stage-2, and are capable of withstanding collapse and buckling pressures even with full vacuum inside. Surge protection is thus not needed to prevent pipe collapse or buckling. However, the rising main has to be checked for upsurge pressure.

### 16.1. Upsurge Pressure due to Rejoining of Water Columns

As per the discussion in §9.2 for Stage-1, the velocity of the rejoining water column can at the most be 1.539 m/s, which is the maximum velocity in the present case (reach B11 to B12). The water column can at worst come to rest after rejoining. Thus the maximum value of $\Delta v$ can be 1.539 m/s.

The celerity $a$ works out to 1180 m/s considering Young's Modulus for DI as 1650000 kg/cm$^2$. With these values, $\Delta h$ can at most be 185 m. This pressure will propagate throughout the pipe and has to be added to the static head. Static pressure in the rising main is the difference between highest FTL (687.33 m) and lowest elevation of the rising main (583.747 m), which amounts to 103.6 m. Thus the maximum upsurge pressure is 288.6 m (= 185 + 103.6).

The allowable surge pressures for DI pipes according to Annex E of IS 8329 are as follows:

**Allowable Surge Pressures for DI Pipes**

| Diameter, | Allowable Working Pressure | Allowable Surge Pressure |
|---|---|---|
| 80 | 640 | 770 |
| 100 | 640 | 770 |
| 125 | 640 | 770 |
| 150 | 640 | 770 |
| 200 | 620 | 740 |
| 250 | 540 | 650 |
| 300 | 490 | 590 |
| 350 | 450 | 540 |
| 400 | 420 | 510 |
| 450 | 400 | 480 |

The maximum upsurge pressure is less than the allowable surge pressure in every reach. Thus the rising main is strong enough to withstand upsurge as well as downsurge pressures without surge protection. However, the propagating surge pressure waves would cause noise and vibrations after a power failure, and to mitigate this, *it is recommended that air cushion valves and pressure relief valves be installed on the rising main at the chainages indicated in Table 4, where local peaks in the L-Section are present. This is in addition to the usual kinetic air valves.*

An air cushion valve of PN 25 rating can withstand 250 m working pressure and 375 m surge pressure. Thus PN 25 rating is adequate.

**Table 4. Specifications of Air Cushion Valve to be installed on the Rising Main**

| Chainages at which to be Installed | Air Cushion Valve | |
|---|---|---|
| | Diameter | Rating |
| 1980 m, 2970 m, 4470 m, 5010 m, 5910 m, and 9060 m on the Submain from Jackwell to Kallapura katte | 75 mm | PN 25 |
| 2370 m, 3930 m, 4930 m, 6630 m, 10030 m, and 11480 m on the Submain from Jackwell to Tyajavalli katte | 75 mm | PN 25 |

*Since the surge pressure wave propagates throughout the pipe, all fittings such as control valves, non-return valves, dismantling joints, kinetic air valves, scour valves etc should also be of PN 25 rating.*

*A pressure relief valve should be installed at the beginning of the rising main to reduce the surge pressure in order to minimize noise and vibration that might occur due to the surge wave following power failure.* Since the pump head is 168 m, the pressure relief valve should be set to open at 17.5 kg/cm$^2$. When pressure exceeds 175 m due to the surge wave, the valve will open and let out water, reducing the pressure. Specifications of the pressure relief valve are given in Table 5.

**Table 5. Pressure Relief Valve Specifications**
**(To be installed at the beginning of Rising Main)**

| Pressure Relief Valve | | |
|---|---|---|
| Diameter | Rating | To Open if Pressure Exceeds |
| 75 mm | PN 25 | 17.5 kg/cm$^2$ |

## PART-3: CONCLUSIONS AND RECOMMENDATIONS

### STAGE-1

1. Pipe sizes and materials for different reaches as per design report may be approved
2. Pumping machinery design may be approved.
3. MS, DI and HDPE pipe thicknesses are adequate to withstand collapse, buckling or bursting due to surge pressures. Hence surge protection is not necessary, but air cushion valves and pressure relief valve are necessary.
4. To mitigate noise and vibration due to surge waves following power failure, air cushion valves should be installed on the rising main as per the following specification

| Chainages at which to be Installed | Air Cushion Valve | |
|---|---|---|
| | Diameter | Rating |
| 30 m, 2190 m, 5100 m, 6493 m, and 7003 m | 100 mm | PN 20 |

5. A pressure relief valve of the following specification should be installed at the beginning of the rising main

| Pressure Relief Valve | | |
|---|---|---|
| Diameter | Rating | To Open if Pressure Exceeds |
| 100 mm | PN 20 | 10.5 kg/cm$^2$ |

6. All fittings like NRV, discharge control valve, dismantling joint, scour valves etc in pump house as well as rising main should have PN 20 rating.

**STAGE-2**

1. Pipe diameters and materials for different reaches as per Table 3 may be approved
2. Pumping machinery design may be approved.
3. DI and HDPE pipe thicknesses are adequate to withstand collapse, buckling or bursting due to surge pressures. Hence surge protection is not necessary, but air cushion valves and pressure relief valve are necessary.
4. Discharge control valves should be installed at the beginning of all bleeders and adjusted to allow design discharges to flow through each bleeder, if necessary in combination with orifices to dissipate high residual pressures.
5. To mitigate noise and vibration due to surge waves following power failure, air cushion valves should be installed on the rising main as per the following specification

| Chainages at which to be Installed | Air Cushion Valve | |
|---|---|---|
| | Diameter | Rating |
| 1980 m, 2970 m, 4470 m, 5010 m, 5910 m, and 9060 m on the Submain from Jackwell to Kallapura katte | 75 mm | PN 25 |
| 2370 m, 3930 m, 4930 m, 6630 m, 10030 m, and 11480 m on the Submain from Jackwell to Tyajavalli katte | 75 mm | PN 25 |

6. A pressure relief valve of the following specification should be installed at the beginning of the rising main

| Pressure Relief Valve | | |
|---|---|---|
| Diameter | Rating | To Open if Pressure Exceeds |
| 75 mm | PN 25 | 17.5 kg/cm$^2$ |

7. Tamper proof kinetic air valves should be installed on the pipes at spacing not exceeding 700 m, including all peaks. These valves should have PN 25 rating.
8. All fittings like NRV, discharge control valve, dismantling joint, scour valves etc in pump house as well as rising main should have PN 25 rating.