Comparison of Reconstruction Options for Water Supply Network of Small Village

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Abstract. The article is aimed at comparative analysis of options for reconstructing water supply network of small village. To this end, two methods of replacing the pipeline are considered - horizontal directional drilling technology and open method. To achieve the task for each of the options, the scope of work on laying polyethylene pipes was determined, estimated cost of work was calculated, schedule for reconstruction of water supply networks was developed, plans and schedules for funds inflow for reconstruction of water supply network were presented.

1. Introduction
Providing population with clean drinking water is currently the most important area of socio-economic development of any region of Russian Federation. Only 48% of all rural settlements in Russia is covered by centralized water supply, most of which do not meet SanPiN requirements, and over 70% of water pipelines and distribution networks are in disrepair. Deterioration of water supply network in water supply system has always been very acute, the village of Omutinskoye, Tyumen Region, is no exception. In the village of Omutinskoye, 29% of water supply network is made of cast-iron pipe. The cast-iron pipes that are currently still in use were laid in 1975-1980. Over time, being in the ground, cast-iron pipes begin to corrode, it weakens their strength. Decrease in strength leads to pipe breaks. Also, when slag, clay particles, sludge, etc. get into water supply network. all this stuff settle on the walls of cast-iron pipes, which leads to decrease in the diameter of water passage, and interruptions in water supply also worsen the quality of drinking water delivered to consumers. The subject of this study includes options for reconstruction of existing worn-out water supply systems on the example of small settlement in the Tyumen region using comparative analysis of their economic content.

2. The research part
This study compares two pipeline replacement options.

Option 1 - Using horizontal directional drilling technology. This method has several advantages and allows performing work not only under natural landscape barriers: rivers, lakes, forests, but also in densely populated urban areas, including architectural monuments, if there are already existing communications, under railways, etc.. If it is necessary to carry out underground communications under such obstacles, punctures are performed. Based on the analysis of water supply network scheme in the village it was possible to determine the volume of work on laying polyethylene pipes, on this basis the estimated cost of work was calculated, which amounted to 111733105.20 rubles and schedule
was developed for implementation of works on reconstruction of water supply networks, Appendix 1. The duration of works on laying the pipeline using HDD method was 5 months.

**Option 2 -** Open way to replace pipeline. Basically, the open method of laying pipeline is used when there is no necessary equipment for implementation of the closed one. Since this option is a compromise, it has a number of drawbacks: the need for high costs, destruction of landscape with its subsequent restoration, temporary delay of work of enterprises located in the work zone, difficulty of moving, and so on. Open method of pipeline laying includes digging trenches of required depth with their subsequent strengthening and placement of pipes themselves.

According to the data obtained, statement of the scope of work on replacing pipeline with an open method was compiled, estimated cost of work was determined, which amounted to 386788.88 rubles, and schedule was developed for implementation of work to modernize water supply networks, Appendix B.

The duration of open pipeline replacement was 8 months.

Based on the calendar schedules of work, plans were drawn up for receipt of funds for modernization of water supply network by considered methods, table 1 and 2 and schedule for receipt of funds for implementation of the project, figure 1 and 2.

The project is financed from regional budget as part of the Clean Water federal program.

**Table 1.** Funds flow plan for the modernization of water supply network using HDD method, thousand rubles.

| Name of the work area | Financial needs for implementation of the project, thousand rubles |
|-----------------------|---------------------------------------------------------------------|
|                       | May       | June     | July    | August   | September |
| №1, ø160 mm L= 384 m  | 5569,57   |          |         |          |           |
| №2, ø160 mm L= 808 m  | 5603,47   |          |         |          |           |
| №3, ø160 mm L= 813 m  | 6246,25   |          |         |          |           |
| №4, ø160 mm L= 898 m  | 2388,06   |          |         |          |           |
| №5, ø160 mm L=219 m   | 1465,46   |          |         |          |           |
| №6, ø160 mm L= 331 m  |          | 1505,14  |         |          |           |
| №7, ø160 mm L= 921 m  |          | 2719,24  |         |          |           |
| №8, ø160 mm L= 410 m  |          | 6326,11  |         |          |           |
| №9, ø160 mm L= 3475 m |          |          | 24126,62|         |           |
| №10, ø160 mm L= 2793 m|          |          | 19241,58|         |           |
| №11, ø160 mm L= 686 m |          |          | 9516,67 |         |           |
| №12, ø160 mm L= 279 m |          |          | 4835,53 |         |           |
| №13, ø160 mm L= 321 m |          |          | 1911,92 |         |           |
| №14, ø160 mm L= 1370 m|          |          | 2197,44 |         |           |
| №15, ø160 mm L= 233 m |          |          | 2801,6  |         |           |
| №16, ø160 mm L= 209 m |          |          |          | 1453,12  |           |
| №17, ø160 mm L= 2050 m|          |          |          | 14209,16 |           |
| Total monthly         | 21272,8  | 10550,5  | 43368,2 | 21263,2  | 15662,28  |
| Total:                | 111733,1 |          |         |          |           |
Figure 1. Schedule of funds flows for implementation of the HDD project.

Table 2. Funds flow plan for modernization of water supply network using the open method, thousand rubles.

| Name of the work area           | Financial needs for implementation of the project, thousand rubles | 2019 | 2020 |
|---------------------------------|---------------------------------------------------------------|------|------|
| №1, ø160 mm L= 384 m           |                                                               | 898,25 |      |
| №2, ø160 mm L= 808 m           |                                                               | 1836,4 |      |
| №3, ø160 mm L= 813 m           |                                                               | 1883,5 |      |
| №4, ø160 mm L= 898 m           |                                                               | 2143,7 |      |
| №5, ø160 mm L= 219 m           |                                                               | 463,31 |      |
| №6, ø160 mm L= 331 m           |                                                               | 877,35 |      |
| №7, ø160 mm L= 921 m           |                                                               | 2083,5 |      |
| №8, ø160 mm L= 410 m           |                                                               | 862,8  |      |
| №9, ø160 mm L= 3475 m          |                                                               | 8297,86 |     |
| №10, ø160 mm L= 384 m          |                                                               | 6583,2  |     |
| №11, ø160 mm L= 686 m          |                                                               | 2676,8  |     |
| №12, ø160 mm L= 279 m          |                                                               | 588,1   |     |
| №13, ø160 mm L= 321 m          |                                                               | 683,8   |     |
| №14, ø160 mm L= 1370 m         |                                                               | 3273,9  |     |
| №15, ø160 mm L= 233 m          |                                                               | 333,56  |     |
| №16, ø160 mm L= 209 m          |                                                               |        | 479  |
| №17, ø160 mm L= 2050 m         |                                                               | 9,6     | 432, |
| Total monyhly                   |                                                               | 5167,9  | 88   |
| Total: 38678,877                |                                                               |        |      |
Figure 2. Schedule of funds flow for implementation of the project by open method.

Figure 3. Presents comparison of estimated cost of reconstruction of water supply system using the methods used.

Table 3 presents comparative analysis of considered options for reconstruction of water supply network of the village of Omutinskoye, Tyumen Region.

Table 3. Comparative analysis of applied methods.

| Comparison criteria                  | Horizontal directional drilling | Open method   |
|-------------------------------------|--------------------------------|---------------|
| Estimated cost of work, thousand rubles. | 111733,105                   | 38687,877    |
| Duration of work, months            | 5                             | 8             |
| Ability to work in tight spaces     | Yes                           | No            |
| Performance of work at a high groundwater level | Yes                           | No            |
| Costs for improvement, thousand rubles. | 0                             | 5161,839     |
| The probability of damage to existing communications | No                             | Yes           |

3. Conclusion
According to the results of the study, it is proposed to use the method of horizontal directional drilling for reconstruction of water supply network in the village of Omutinskoye, since despite its high cost, its use is preferred due to several reasons:
- in most streets of the village of Omutinskoye there are cramped conditions, so it is impossible to replace water supply network in an open way;
- there are existing gas and engineering networks, with this method there is much less chance of damage;
- high groundwater level in some areas of the village of Omutinskoye;
- duration is three months less than the open method;
- costs are not required for improvement and restoration of roads, territories.

References
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[3] Pereshivkin A K 1978 Installation of external water supply and sewage systems (Moscow: Stroyizdat) p 576
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Appendix A

| №  | Name of works | Scope of work meter | Needed cars | Shift work | Number of workers per shift | Duration days | May | June | July | August | Sept |
|----|---------------|---------------------|-------------|------------|-----------------------------|---------------|-----|------|-------|--------|------|
| 1  | Sector M1    | 384                 | HDD Vermeer | 1          | 1                           | 6             | 2   |      |       |        |      |
| 2  | Sector M2    | 808                 | HDD Vermeer | 1          | 1                           | 5             | 4   |      |       |        |      |
| 3  | Sector M3    | 853                 | HDD Vermeer | 1          | 1                           | 6             | 4   |      |       |        |      |
| 4  | Sector M4    | 898                 | HDD Vermeer | 1          | 1                           | 6             | 5   |      |       |        |      |
| 5  | Sector M5    | 219                 | HDD Vermeer | 1          | 1                           | 6             | 1   |      |       |        |      |
| 6  | Sector M6    | 331                 | HDD Vermeer | 1          | 1                           | 6             | 2   |      |       |        |      |
| 7  | Sector M7    | 921                 | HDD Vermeer | 1          | 1                           | 6             | 5   |      |       |        |      |
| 8  | Sector M8    | 410                 | HDD Vermeer | 1          | 1                           | 6             | 2   |      |       |        |      |
| 9  | Sector M9    | 3475                | HDD Vermeer | 1          | 1                           | 6             | 18  |      |       |        |      |
| 10 | Sector M10   | 2793                | HDD Vermeer | 1          | 1                           | 6             | 14  |      |       |        |      |
| 11 | Sector M11   | 685                 | HDD Vermeer | 1          | 1                           | 6             | 4   |      |       |        |      |
| 12 | Sector M12   | 279                 | HDD Vermeer | 1          | 1                           | 6             | 2   |      |       |        |      |
| 13 | Sector M13   | 321                 | HDD Vermeer | 1          | 1                           | 6             | 2   |      |       |        |      |
| 14 | Sector M14   | 1279                | HDD Vermeer | 1          | 1                           | 6             | 1   |      |       |        |      |
| 15 | Sector M15   | 223                 | HDD Vermeer | 1          | 1                           | 6             | 1   |      |       |        |      |
| 16 | Sector M16   | 2659                | HDD Vermeer | 1          | 1                           | 6             | 1   |      |       |        |      |
| 17 | Sector M17   | 269                 | HDD Vermeer | 1          | 1                           | 6             | 1   |      |       |        |      |

Figure A1. HDD reconstruction schedule.
## Appendix B

| No. | Name of works | Stage of work, meter | Needed cars | Shift work | Number of workers per shift | Duration days |
|-----|---------------|----------------------|-------------|------------|-----------------------------|--------------|
| 1   | Sector V1    | 304                  | Excavator  | 1          | 4                           | 1            |
| 2   | Sector V2    | 320                  | Excavator  | 1          | 2                           | 1            |
| 3   | Sector V3    | 313                  | Excavator  | 1          | 4                           | 1            |
| 4   | Sector V4    | 338                  | Excavator  | 1          | 4                           | 1            |
| 5   | Sector V5    | 219                  | Excavator  | 1          | 4                           | 3            |
| 6   | Sector V6    | 331                  | Excavator  | 1          | 4                           | 1            |
| 7   | Sector V7    | 921                  | Excavator  | 1          | 4                           | 10           |
| 8   | Sector V8    | 410                  | Excavator  | 1          | 4                           | 1            |
| 9   | Sector V9    | 3425                 | Excavator  | 1          | 4                           | 15           |
| 10  | Sector V10   | 2193                 | Excavator  | 1          | 4                           | 28           |
| 11  | Sector V11   | 686                  | Excavator  | 1          | 4                           | 1            |
| 12  | Sector V12   | 259                  | Excavator  | 1          | 4                           | 1            |
| 13  | Sector V13   | 321                  | Excavator  | 1          | 4                           | 3            |
| 14  | Sector V14   | 3278                 | Excavator  | 1          | 4                           | 14           |
| 15  | Sector V15   | 239                  | Excavator  | 1          | 4                           | 3            |
| 16  | Sector V16   | 2150                 | Excavator  | 1          | 4                           | 21           |
| 17  | Sector V17   | 2150                 | Excavator  | 1          | 4                           | 2            |

*Figure B1. Open water pipeline reconstruction schedule.*