ABSTRACT

The City of Billings has been involved with water and sanitary sewer main replacement since 1980. These replacement projects total $8 million annually. Some of these projects have involved some trenchless technologies, mainly sliplining and CIPP on the sanitary sewer side. A collapsed 24-inch concrete storm drain initialized the City of Billings to utilize a Vermeer/Hammerhead HB12 winch to slipline a 20” HDPE pipe to repair the failure. The success of this project lead the City of Billings to begin exploring the benefits of performing “in-house” pipe bursting projects.

In August of 2005, the City of Billings performed its first pipe burst project. The success of that project sparked a flame. Since that first project, the City of Billings has completed 35 pipe burst projects (see Figure 1 photo). There have been some setbacks that have caused us to change or modify our procedures or materials. This paper will explain/explore the successes/failures of past projects (10 years) to present. We will also discuss how we determine/prioritize projects utilizing various asset management techniques.
Figure 1. South 34th Street Pipe Bursting Project
INTRODUCTION

Today more and more municipalities are being asked to do more with less. By adopting new technologies, this mindset can be accomplished. Trenchless technology is a way to supplement investments in aging/failing infrastructure. “Pay backs” on investments in equipment can be realized rather quickly. This is what prompted the City of Billings to pursue pipe bursting. By beginning with small scale projects, our crews were able to develop skills and confidence to tackle larger projects.

DISCUSSION

The City of Billings Public Works Department began looking at performing trenchless work in the spring of 2005. A 24” storm drain collapsed in the alley adjacent to the Crown Plaza Hotel. Conventional open cut trenching could not be performed due to the proximity of utilities (see Figure 2 photo). Our CCTV crew televised the storm sewer and it was determined that the failing storm sewer could be sliplined with a 20” HDPE pipe. We rented a Vermeer HB12 winch to facilitate the pull. Our crews completed the pull and became heroes. This project sparked confidence in our crews and a desire to perform more of this type of work. Our next opportunity happened that same summer of 2005. An 8” VC sanitary sewer collapsed. We contacted our local supplier (Rocky Mountain Vermeer) to rent the HB12 winch. They suggested that we look into pipe bursting and even made an offer of free equipment rental to perform the job. We jumped on it. Northwest Pipe had inventory of 400 feet of 8” DR 14 HDPE pipe and allowed us to use their McElroy 412 pipe fusion machine. Overall the project was a success. We had a few hiccups – two 185 cfm compressors manifolded together does not equal the 375 cfm required to efficiently run the Hammerhead hammer. Also plan the project so the burst is completed in the first start up. Don’t try to start/stop/start. We did not have the manhole invert cut/broke, so we had to stop the pull. We could not start after stopping and had to dig at the manhole to complete our connection.

Our crew’s confidence level and “can do” attitude increased.

The next pipe burst job we decided to try was 300 feet of a 6” cast iron water main in the spring of 2006. On this project, we used 6” DR14 HDPE based on our previous success using HDPE. Rocky Mountain Vermeer arranged

Figure 2. Alley at Crown Plaza Hotel

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for a contractor to demonstrate their Vermeer HB80 and tooling for this project. Again, another successful project that instilled more confidence.

After these successful projects, we put together a list of men and equipment that would allow us to perform both water and sanitary sewer pipe burst projects. Our Public Works Director presented our plan to the City Administrator and City Council. The plan included the addition of five (5) men and $760,000 of equipment. The equipment included static and pneumatic pipe burst equipment, various trenching and trench safety equipment, pipe fusion machine, and various support vehicles. The upfront cost was expensive, but we were able to demonstrate a short payback period based on previous projects. The men and equipment were phased in over a two-year period – $370,000.00 in FY07 (three men), and $390,000.00 in FY08 (two men). The plan was approved and we began to purchase equipment and increase staff in 2007 and 2008.

During 2008 we began to increase the number of pipe bursting projects. In Montana we have two seasons – construction season and winter. During the winter, we work on designing pipe bursting projects for the next construction season (April – October). When designing projects, we look at several factors. Our GIS enables us to focus our efforts on areas that have had a history of maintenance problems. With sanitary sewer, we look at Sanitary Sewer Overflows (SSO’s), what caused the SSO, depth of sewers, and location of the sewer, adjacent utilities, soil conditions, and street/right-of-way surface. Our current records system is able to track the number of SSO’s our crews respond to. We are able to classify these as the City of Billings’ problems or the owner’s problems. When the SSO’s are the City of Billings’ problems, our crews try to determine what caused the SSO. The CCTV crew will follow up on City of Billings’ SSO’s and televise the City main line to determine if further maintenance is needed. The main line is rated through the PACP system. Annually we have a map produced by our GIS/RPS division that shows these “hot spot” areas (see Figure 3).

![Figure 3. Map of Billings, Montana Sewer Complaint Hot](image)

We are able to further access these areas to see if they qualify for pipe bursting projects.
The water distribution system is handled similarly. Again our GIS tracks the number of water main leaks we have in certain areas. When repairing the leak, our crews will rate the condition of the main line, cause of leak, soil conditions, and depth of bury, and then put that information in the work report. Our GIS staff is able to produce maps showing water leaks. This enables us to focus on these problem areas. Another valuable tool is the water model. Our model showed several areas that were below fire flow standards (see Figure 4). Pipe bursting allowed us to upsize water mains to achieve or exceed fire flow standards. In some projects, we are able to make two increases in size (see Figure 5).

Figure 4.

Figure 5.
In Billings, Montana most infrastructure is buried a minimum of 6 – 6.5’ deep due to frost. As a result, all excavations involved in pipe bursting require sloping/shoring/shielding. We have tried several different pipe systems for both water and sewer pipe bursting. Failures have evolved limiting our uses to FPVC for water pipe bursting and FHDPE for sewer pipe bursting. We are intrigued by the “cartridge” style of pipe systems, but have not found a system that will work in our conditions/applications.

Another lesson we have learned is to plan every detail of a pipe burst project. The old adage applies – failure to plan is planning to fail. We investigate every situation from service connections to utility crossings (see Figure 6). All utility crossings are vacuum excavated to verify alignment and elevation to avoid possible conflict or damage.

The City of Billings has had an active water and sanitary sewer main replacement program since 1980. Approximately 10,000 – 12,000 feet of both water and sanitary sewer main lines are replaced annually. This construction is typically conventional open-cut methods. Costs per feet vary from $200/ft to as high as $800/ft. Our average cost per foot on water pipe burst projects is $114.93/ft and sanitary sewer is $60.82/ft (see Table 1).

Table 1. Final Costs for Pipe Bursting and Sliplining Projects

<table>
<thead>
<tr>
<th>PIPE BURSTING &amp; SLIPLINING PROJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>18,400 Feet - Water</td>
</tr>
<tr>
<td>Average Cost Per Lin. Foot - $114.93</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>25,410 Feet - Sewer</td>
</tr>
<tr>
<td>Average Cost Per Lin. Foot - $60.82</td>
</tr>
</tbody>
</table>

Virginia Lane - 8" Sewer in Alleys Between Avenues D, E & F
PUD 2005-01 - Project # SL0313 - SEWER (HDPE Pipe)

<table>
<thead>
<tr>
<th>Completed</th>
<th>Footage</th>
<th>State Fee</th>
<th>Labor</th>
<th>Equipment</th>
<th>Material</th>
<th>Total Cost</th>
<th>Cost Per Lin. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/05</td>
<td>360</td>
<td>---------</td>
<td>4,476.79</td>
<td>5,820.44</td>
<td>4,219.15</td>
<td>14,516.38</td>
<td>40.32</td>
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Pryor Avenue - 6" Water
PUD 2006-01 - Project # MA5275 - WATER (HDPE Pipe)

<table>
<thead>
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<th>Completed</th>
<th>Footage</th>
<th>State Fee</th>
<th>Labor</th>
<th>Equipment</th>
<th>Material</th>
<th>Total Cost</th>
<th>Cost Per Lin. Ft.</th>
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</thead>
<tbody>
<tr>
<td>10/06</td>
<td>300</td>
<td>---------</td>
<td>5,495.73</td>
<td>319.95</td>
<td>7,858.53</td>
<td>13,674.21</td>
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Daniels Street - 8" Sewer
PUD 2006-02 - Project # SL0315 - SEWER (HDPE Pipe)

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<th>Equipment</th>
<th>Material</th>
<th>Total Cost</th>
<th>Cost Per Lin. Ft.</th>
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<td>6,265.38</td>
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Our projects do not reflect any engineering design costs or site restoration costs. These costs are difficult to track as they are performed “in-house” by other divisions/departments. Even if these costs were reflected in the final $/ft.

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cost, the pipe bursting $/ft cost is more cost effective than conventional open-cut construction. Other costs/factors that are difficult to track are disruptions to businesses and traffic.

Not all projects can be completed by pipe bursting. Once we determine that a line needs to be replaced, we look at several factors that would allow pipe bursting: depth of bury – most of the water and sanitary sewer mains in the City of Billings are buried a minimum of six (6) feet due to frost. We are capable (with our equipment) to safely dig 13-14 feet deep. Anything deeper requires larger excavators and trench protection equipment. Soil conditions are another factor that weigh heavily in the decision process (see Figure 7 – photo of Billings, Montana), particularly if a line is being considered for upsizing. The presence of rock and rock size increase the difficulty for a pipe burst project. Service connection excavations are also considered. If there are a large number of service reconnects, it may be more cost effective to consider open-cut replacement methods. Surface restoration should also weigh into the decision process. Type of street, alley and its restoration can become very expensive (asphalt, concrete), not to mention age of the street or alley. Public Works Departments tend to get a “black eye” if they tear up a street or right-of-way that had been resurfaced recently [less than five (5) years]. Maybe the project can be coordinated with a street reconstruction project. We have a PAVER Program that tracks the Pavement Condition Index (PCI) of various right-of-ways in the city. Annually the PAVER Program resurfaces or rebuilds right-of-ways and streets that have become poor. These projects are coordinated with replacement/pipe burst projects.

Figure 7. Billings, Montana
Some other factors include condition and type of pipe to be replaced. Maybe the sewer main has several grade issues that require repair prior to a pipe burst project. When considered for pipe bursting, vitrified clay sewer pipe (see Figure 8) will pose a different degree of difficulty than a ductile iron sewer pipe. Pipe bursting methods (static/pneumatic), equipment and tooling must also be factored into the decision making process. Sometimes the equipment size (tonnage of pulling force) may limit a project. Different pipe materials also require different types of cutters/splitters (see Figure 9). Replacement pipe materials also have limitations to consider. Some pipe manufacturers may not warranty or recommend their product use with certain methods of pipe bursting (static/pneumatic), or if their product is used, there may be requirements or limitations. Other considerations are length of pull and “foot print”. Typically, the longer a pull is, the more tonnage pull force is required. This tonnage force requirement is also influenced by the soil type, host pipe that is being burst, size of new pipe, and material of new pipe.
Sometimes the only way to estimate the tonnage force is from experience or experimentation. If possible, try a shorter pull on the same project.

We define “foot print” as area of right-of-way, street or easement that your pipe burst operation will use. Again, several factors dictate the size of “foot print”. First being the type of pipe and joining method used for your replacement pipe. Fusible pipe products typically require preassembly and the need to string out the opposite direction of the pull, thus requiring more area (see Figure 10). Mechanical pipe products can usually be assembled as the pull is being performed. These products vary in length from one (1) meter to 20 feet, thus resulting in a smaller work area or “foot print” (see Figure 11). Not all pipe products can be used with both pipe bursting methods. Our experience has been that the more rigid pipe products require static pipe burst methods while more flexible pipe products will allow pneumatic pipe bursting.
As you can see, there are a lot of factors to consider before taking on a pipe bursting project. If you are new to this type of construction, we would suggest to perform a small project first with a lesser degree of difficulty.

**CONCLUSION**

By taking “baby steps” with small projects, we were able to train and build confidence in our people and pipe bursting processes. In-house pipe bursting has allowed us to respond to failing infrastructure quicker. Rather than “band-aid”, we are able to replace infrastructure with our own staff at a cheaper rate $/foot without creating inconvenience to customers/residents. Municipalities should explore the benefits of adopting an “in-house” pipe bursting program. As discussed, the benefits are not only to the community, but also to your work force.