Located approximately 25 mi west of the Kansas City metropolitan area, Lawrence has a population of approximately 97,000, including the students at the University of Kansas. The city currently treats and delivers water to customers within the city and provides treated water wholesale to five rural water districts, as well as to the University of Kansas and Baldwin City. Two of the wholesale water customers have a long-term interest in receiving additional water, and one of them provides water to two other municipalities. Both of the connections with these wholesale customers are located in the southeastern part of Lawrence.

The city understood that, in addition to supplying potable water to an increasing customer base, having a redundant means of delivering water to North Lawrence would make water supply more reliable. (North Lawrence is the name given to Lawrence’s northeastern section, which is separated from the rest of the city by the Kansas River.) Prior to the installation of the new, 36 in. diameter pipeline, the city supplied potable water to North Lawrence through a single transmission main 16 in. in diameter crossing the Kansas River. An aerial crossing, this section of the pipeline is connected to the bridge that carries Route 59 over the river. In recent years sections of the aerial crossing had developed pinhole leaks, creating maintenance issues and concerns about the reliability of the supply to North Lawrence. Although repairs were made to the deteriorated sections, the problems convinced the city’s water supply planners of the need to add redundancy to the water delivery system.

In March 2007 an engineering consulting team led by Burns & McDonnell, of Kansas City, Missouri, completed a preliminary hydraulic analysis and transmission main routing study for the city. On the basis of its recommendations, the city decided to phase the construction of a new water transmission main, the first phase to include the Kansas River crossing. Subsequent phases would extend the transmission main to the southeastern part of Lawrence. When complete, the nearly 6 mi long water transmission main would connect to the Kaw River crossing. Subsequent phases would extend the transmission main to the southeastern part of Lawrence. When complete, the nearly 6 mi long water transmission main would connect to the Kaw River Water Treatment Plant, supply water to North Lawrence, and increase service to the southeastern part of the city to meet projected water demands beyond 2020.

In late 2007 the city selected Burns & McDonnell to design the initial, 1.25 mi long transmission main that would connect the Kaw River plant to North Lawrence. Using a slightly modified version of the preliminary hydraulic analysis,
the design team determined the size that would be required for the transmission main. In addition to accounting for the significant development expected to occur in southwestern Lawrence, the model considered the water demands beyond 2030 expected to come from the city’s wholesale customers. The hydraulic analysis indicated that, from the connection at the Kaw River plant to the final connection in southwestern Lawrence, the transmission main should have a diameter of 36 in.

With the size determined for the entire transmission main route, an analysis was carried out to determine the necessary pressure rating for the final phase of project. The main factors considered here were the performance curves of the high-service pumps at the Kaw River plant, surges that might be generated within the system, and possible elevation changes in the initial, 1.25 mi segment of the transmission main.

Based on the results of the analysis, Burns & McDonnell recommended a pressure rating of at least 200 psi.

The design of the transmission main also had to account for the possible presence of highly corrosive soils in the area. The city’s water mains have experienced the deleterious effects of highly corrosive soils in the past. Therefore, preliminary design work included a geotechnical investigation of the area. The investigation indicated that corrosive soil would be encountered in at least one area. It also noted that groundwater was present at the proposed trench depths at various locations. On the basis of these findings and from a realization that there would be limited access to the installation methods for installing were not yet available from the manufacturer. However, in 2008, when the initial pipeline material evaluation was performed, FPVCP and HDPE having a 200 psi pressure rating were not yet available from the manufacturer. However, 36 in. diameter FPVCP and HDPE with this pressure rating became available after the pipe material evaluation and preliminary design phase but before the final design was completed in 2015.

The four grading factors in the pipe material evaluation were the corrosion resistance of the material and the feasibility of construction. The four pipe materials evaluated can be ranked in the following order:

1) Steel pipe;
2) Ductile iron pipe;
3) High-density polyethylene (HDPE);
4) Fusible polyvinyl chloride pipe (FPVCP).

Four pipe materials were evaluated:

In evaluating the various pipe materials with respect to their installation feasibility, the design team considered that the river crossing would most likely be made by horizontal directional drilling (HDD). Because the pipe would be below the river, future maintenance of the pipeline was a concern as well. Both these considerations led to the conclusion that a jointless system should be used for this crossing to facilitate HDD installation and minimize maintenance needs. Depending on the required pipe thickness, the bore hole for jointless pipes is typically smaller than for a ball-and-socket or a restrained joint system of the ball-and-socket type. A jointless piping system will not fail as a result of deteriorated gaskets or loose joints. For these reasons, the installation feasibility assessment eliminated ductile iron pipe from further consideration.

The installation feasibility analysis also evaluated the suitability of HDD methods for installing HDPE pipe for the river crossing portion of the alignment. To this end, the design team evaluated the suitability of HDPE using the design guidelines found in the ASTM International standard ASTM F1962-05 (Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles, Including River Crossings). The analysis of critical buckling pressure during pullback revealed that HDPE had a factor of safety that was below the standard minimum recommended value. The results thus eliminated HDPE pipe from consideration at the river crossing.

Finally, the installation feasibility analysis evaluated the suitability of HDD methods for installing FPVCP for the river crossing. The design guidelines found in the standard ASTM F1962-05 were used in conjunction with the guidelines set forth in the ASCE visual design for Installation by Horizontal Directional Drilling (Reston, Virginia: ASCE Press, 2005) to evaluate the suitability of 200 psi FPVCP. Installation forces and long-term operational loads were considered, and pipe deflection, critical buckling pressure, and anticipated and allowable tensile stress were evaluated. The analysis results indicated that FPVCP would be an acceptable pipe material for the river crossing.

At this stage of the pipe material evaluation, the city expressed a preference for using one type of pipe material throughout the project. FPVCP and steel pipe were still candidates at this point. Corrosion concerns and the resulting corrosion protection systems that would need to be installed and maintained with steel pipe were considered. Because much of the HDD to be conducted for the river crossing would pass through solid rock, a major concern with steel pipe centered on whether the coating system on the outside would hold up during the installation process. This would rule out steel pipe. Because it met all the necessary requirements for the project, FPVCP was selected and included in the bid for the transmission main installation project.

The design team evaluated several installation methods for this project, including opencut, jacking and boring with a casing pipe, and HDD. The method selected would depend on the requirements for each of the particular project areas along the alignment. Opencut installation methods were originally proposed wherever they would be feasible. Installing a pipeline across a Corps of Engineers levee typically involves opencut methods across the top of the levee and repair of the levee after installation. Because railroads typically require jacking and boring in order to install steel casings beneath the rail lines, this method was originally planned for the sections of the alignment that passed beneath the BNSF and Union Pacific lines. HDD would then be used for installation under the highways. Once design progressed, these initial selections were revised.

Installing the steel casing pipe for the transmission main within the railroad right-of-way by jacking and boring required excavating a bore pit and receiving a pit on the two sides of the rail line. As part of this process, the boring machine and the casing pipe would be placed within the boring pit, and the casing pipe would be “jacked” into place by hydraulic jacks. A cutting head on a rotating helical auger would be used to remove the spoil from within the casing pipe. Once the casing pipe was in place, the carrier pipe would be installed. As noted previously, railroads typically require that the steel casing pipe be installed across the
entire width of the railroad right-of-way. Although this installation method worked for the BNSF crossing, near the Kaw River plant, lack of space precluded its use at the Union Pacific crossing. The 1.25 mi long pipeline will connect the Kaw River Water Treatment Plant, in Lawrence, Kansas, to an existing 12 in. diameter water main in the part of the city known as North Lawrence.

During construction a farm field located north of Burcham Park was and the Kansas River was crossed, two subsequent HDD sections through Burcham Park, one 1,400 linear ft and the other 600 linear ft, were installed without issue. Approximately a third of the pipeline for the project was installed by means of open-cut construction in the farm field. Essentially, this portion of the project linked the HDD sections beneath the river and Burcham Park. Construction work for the entire bore required that access to the park and the boathouse be maintained at all times and that tree removal be minimized. The other concern with the crossing in the park involved the number of utilities in the area. The city has raw water wells and a river intake in the area, along with water distribution lines and other utility lines. Existing utility crossings required that the transmission main have a depth of at least 12 ft in this area. However, an open excavation of this depth near the park entrance was not feasible. To address this problem and minimize tree removal within the park, HDD installation was designed for this area. Using HDD in the park also eliminated an open-cut pipe installation through a stream that runs east to west along the north side of the park.

The Kansas River crossing presented higher risks than did other sections of the project. Approximately 2,400 linear ft, the river crossing was the first bore to be completed. The pipe-reaming process for this HDD bore took nearly 56 days. The pilot hole exited the ground approximately 10 ft east and 3 ft north of the design point.

Garney Construction, of Kansas City, Missouri, served as the general contractor for the project. A subcontractor to Garney Construction—Environmental Crossings, Inc.—served as the drilling contractor. Environmental Crossings began the HDD process with a 10 in. diameter pilot hole. Once the pilot hole was through, a 26 in. diameter backream was used. Next, the drilling contractor used a 38 in. diameter backream. However, because of low productivity with this ream, the contractor switched to a 32 in. diameter backream. Therefore, the contractor used a 38 in. diameter ream. Subsequently, the contractor used a 42 in. diameter backream, followed by a final ream of 48 in.

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