Conflict Resolution: Unique Design Solves a Complex Sewer Issue in Phoenix

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1. Introduction:

A private development firm contracted with Kimley-Horn and Associates, Inc (KHA) to design the on-site and off-site infrastructure associated with a 270 acre mixed use development in north Phoenix. The site was located north of the 101 Freeway between 56th and 64th streets. Stipulations related to the land purchase demanded the private developer install a portion of a regional sewer line along the southern boundary of the property and connect to an existing 36" line downstream to the west of the project. The existing 36" line was located within 56th street right-of-way, passing though both City of Phoenix and Arizona Department of Transportation right-of-way, along the whole alignment.

As as-built and preliminary field inspections were completed, complex existing utility conflicts became evident. The most significant, a 42" high pressure water line that made a conventional connection to the existing 36" stub impossible. Through close collaboration with the City of Phoenix Water Services Department, Arizona Department of Transportation (ADOT) and Specialized Services Company (SSC), hired to pothole and consult on conflict resolutions, KHA designed an atypical but highly effective solution that split the 36" sewer line into three 18" lines at the point of conflict to allow for the transfer of flow below the 42" & 24" waterlines (with only 4-inches of separation). Two custom junction structures were also designed complete with internal diversion benches and air jumper.

In addition to potholing services SSC provided during the design phase, they were also awarded the sub-contract to install the 78" casing for the diverted sewer lines and the 36" steel casing for the 12" air jumper. During construction additional conflicts were encountered, making this one of the most unusual and technically challenging projects the engineer and sub-contractor had ever encountered.

2. Predesign Challenges:

Existing Utility Conflicts: During initial data collection for the crossing within 56th street as-built for the area revealed an existing 16" Ductile Iron Pipe (DIP) sewer line, an Arizona Public Service (APS) electrical duct bank and two waterlines, a 42" concrete cylinder pipe (CCP) and 24" DIP within 56th street along a north-south alignment. The 16" sewer line connected to an existing manhole on the west side of 56th Street providing a 36" sewer stub designed to be the connection of the proposed sewer line. The APS duct bank consisted of 2-12" conduits encased in concrete for an overall thickness of 3'. Since as-built for the bank were not created, it was estimated to be approximately 4' below grade based on standard design depth provided by APS.

The 42 and 24-inch posed the greatest design challenges since their invert elevation indicated they may have a direct impact on the proposed sewer line alignment and invert elevation. SSC was initially brought on board to vacuum excavate and pothole the 24 and 42" water lines. It was initially believed that a vertical realignment of the 24" waterline, as the as-built indicated, would move the 24" line from impacting the proposed sewer line. Pothole information revealed the as-built information to be incorrect and the 24" water line was less than 4" above the proposed sewer line and would need to be accommodated, but it was not until construction that greater detail in the 24" impact would be revealed. As-built information provided by Ameron, the pipe manufacturer, left no question the 42" line was in the way and pothole information provided by SSC confirmed the design plans indicating the bottom of the 42" waterline was in direct conflict with the top 6" of the proposed sewer line.

Water Services Dept. Stipulations: Armed with this information, KHA performed preliminary designs to realign both the 42 and 24" water lines including appropriate air release and tangential outlets. These solutions were presented to the City of Phoenix Water Services Department (WSD) for review. After a short review WSD indicated that neither of the water lines could be taken out of service and an alternative would need to be found. The 24" water line provided the main feed to the Mayo Hospital located to the south and the 42" waterline provided high pressure water between multiple pressure zones and taking the line out of service was not feasible. In the northern parts of phoenix, sufficient development had not taken place to provide enough redundancy to the system to allow for these lines to be isolated and realigned.

3. Proposed Design Solutions:

Divert North or South: The slope and cover of the 42" waterline appeared to remain fairly constant for several hundred feet in either direction and did not contain any relief where the sewer line could be realigned. ROW and sewer slope challenges also made this option difficult to attain.

Lift Station: The City was not interested in the maintenance and odor potential resulting from this option. It should also be noted that the 36" sewer line was designed to hold the ultimate flow from the upstream basin. The build-out time period for the upstream land is unknown and with market conditions getting more challenging it would be difficult to outline the interim pumping capacities and expansion schedule for the station.

Siphon: This option was also disliked by the City due to maintenance and sizing issues. With an ultimate peak capacity of 11.6 million gallons per day and a preliminary flow of only a few homes for several years the City was looking for a different solution.

Smaller Diameter Pipe: Although this was the ultimate solution several alternatives where looked at:

A. Elliptical Pipes-Conversation with many pipe manufacturers (i.e. Ameron, Hanson, and Rinker) indicated that RGRCP was available but lining was not available for sewer use. The City also has had trouble with unlined sewer pipe and was not open to this option.

B. Diversion into 2 – 24" sewer lines-Closer inspection of the clearances ruled out this option and twin 21" pipes did not have the necessary capacity

C. Diversion into 3 - 18" sewer lines (ultimate selection)

   a. Installed within a 78" casing

4. Final Design

After several meetings and discussions with the city the ultimate solution was to design two diversion structures each approximately 10'x9' to pass the flow through 3-18" pipes under the waterlines and converge the flow downstream back into the existing 36" line. The initial design, based on the best available data, had the 18" lines clearing the 42" water line by 4". The 18" lines were to be installed at grade within a 78" casing. The location of the waterlines provided a fortunate relief. They were located within the existing median of 56th street allowing for a central receiving pit to be excavated exposing the waterlines. The casing was installed from both the east and west side of the road in separate boring events and would meet in the middle under the 24" and 48" waterlines within the central receiving pit. The casing would be notched to accommodate the waterlines as the casing progressed and then steel plating was to be welded to the casing under the waterlines to provide the necessary isolation of the sewer lines.

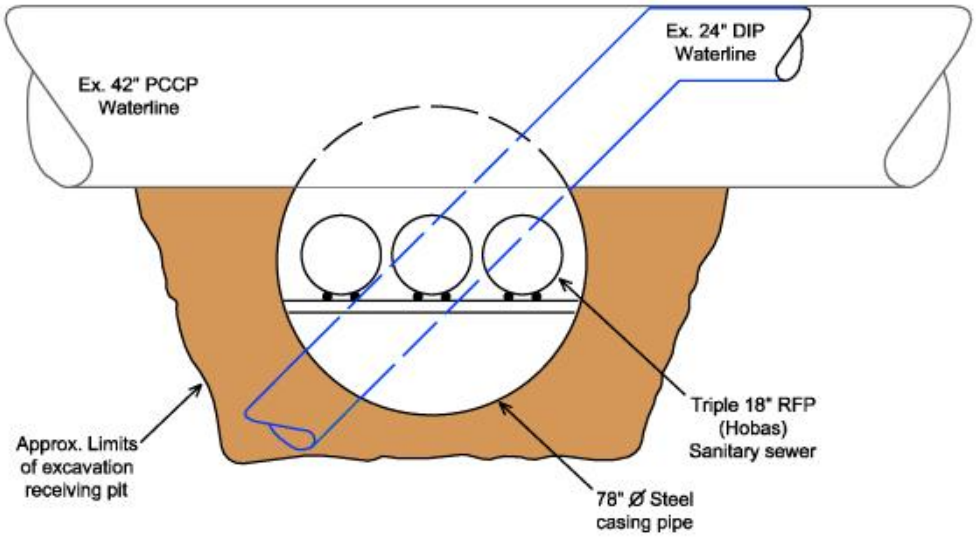
The annular space within the casing was originally designed to be filled with grout but was later changed to sand gravel at the recommendation of SSC, in order to reduce float and maintain grade.

With the understanding that the sewer line would hold very little flow for some period of time, an internal diversion bench was incorporated into both structures. The benches would facilitate flow to one of the 18" pipes and minimize odors cause by deposition of material within the structure cause by periodic peak flow conditions. When upstream development warrants additional flow through the structures, the benches will be removed through manholes provided in the roof deck.

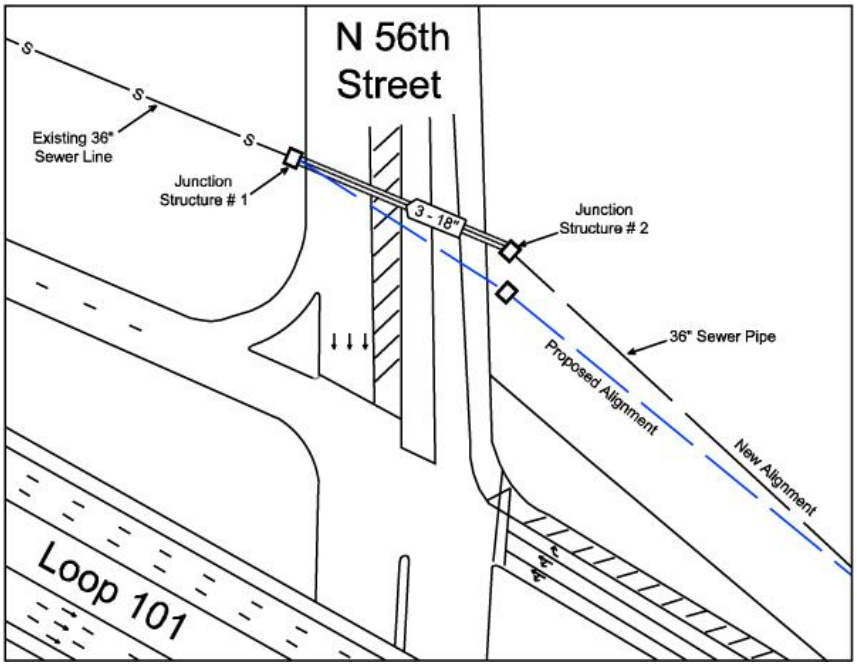
Flush bell HOBAS pipe was selected as the 18" carrier pipes allowing the pipes to be installed at grade and pushed along guiderails welded to the casing pipe.

5. Construction Challenges

A. Proposed Sewer line Realignment: During excavation of the central receiving pit (12' x 10' x 18'), in the center of the median, to connect the 78" casing from the east and west, the depths of the existing 24" and 42" were verified and another unexpected challenge was revealed. A dip existed in the 24" line, which directly impacted the proposed alignment of the sewer line.

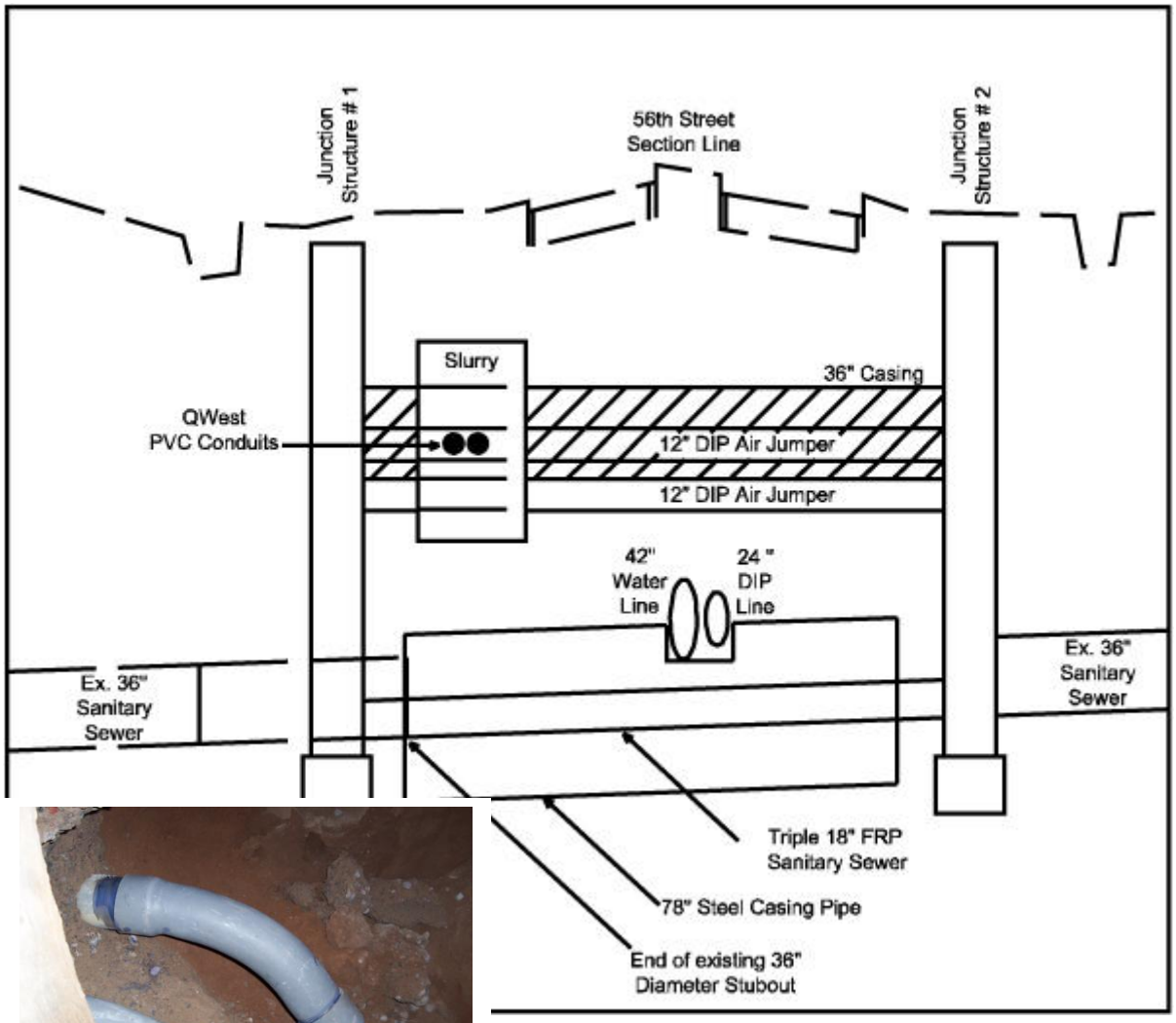


Solution: Realignment of the proposed sewer line 15' to the north.

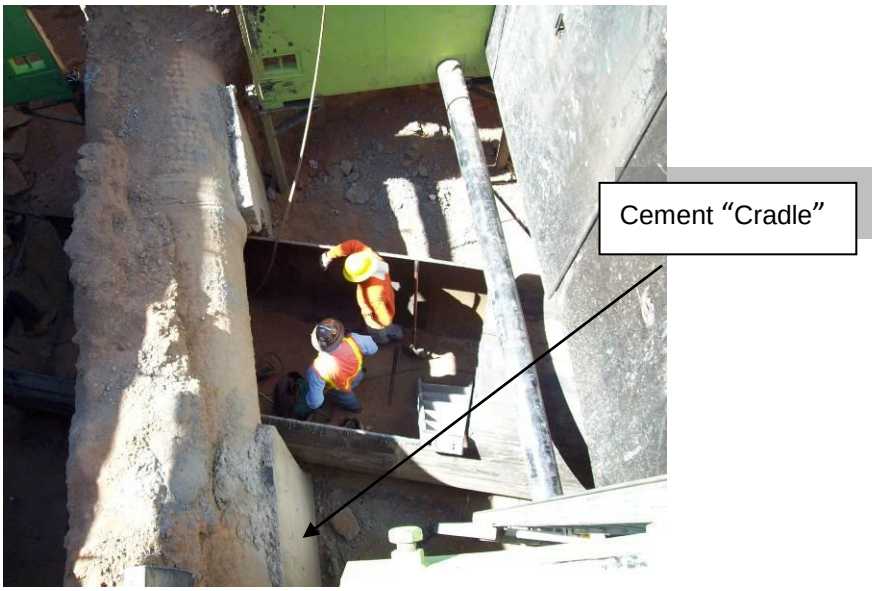


B. APS Electric Duct Bank: As-built records indicated the existence of an electrical duct bank in possible conflict with the proposed air jumper. Using keyhole technology, and vacuum potholing, excavation revealed the existence of 2 - 12" PVC conduits (empty) located in the slurry just above the electric duct bank. This discovery was contrary to as-built information. It was later discovered that the owner was Qwest telecommunications and the PVC was intended for future installations.

Solution: 1) Raised the elevation of the 36" bore for the jumper to 18" below surface.
2) Installed sweeps to existing PVC pipes and realigned below the 36"



C. **42" RGRCP Support:** Due to the vast size of the central receiving pit, and the integrity of the existing casing, the live 42" RGRCP water main was in need of some type of support to avoid cracking during the final stages of the 78" bore.



Solution: Cement "cradle" was constructed to support the 42" RGRCP above the newly installed 78" casing.

6. **Conclusion:** In this case study, the value of subsurface utility engineering, including potholing was definitely demonstrated. However, even with this case the amount of S.U. E. dollars allotted could have been expanded to include slot trenching along the 24" and 42" conflicts to confirm alignment and depth early in the design phase. Early information would not have eliminated the conflicts but would have eliminated the time and expense associated with delays and change orders.

   According to the Federal Highway Administration every dollar spent on subsurface utility engineering, over $4.00 is saved during the construction process.

   This project is a prime example of why it is so important for engineers and other construction professionals to familiarize themselves with and implement S.U.E. practices on every underground installation project, especially large diameter installations in which undocumented conflicts are a routine occurrence.