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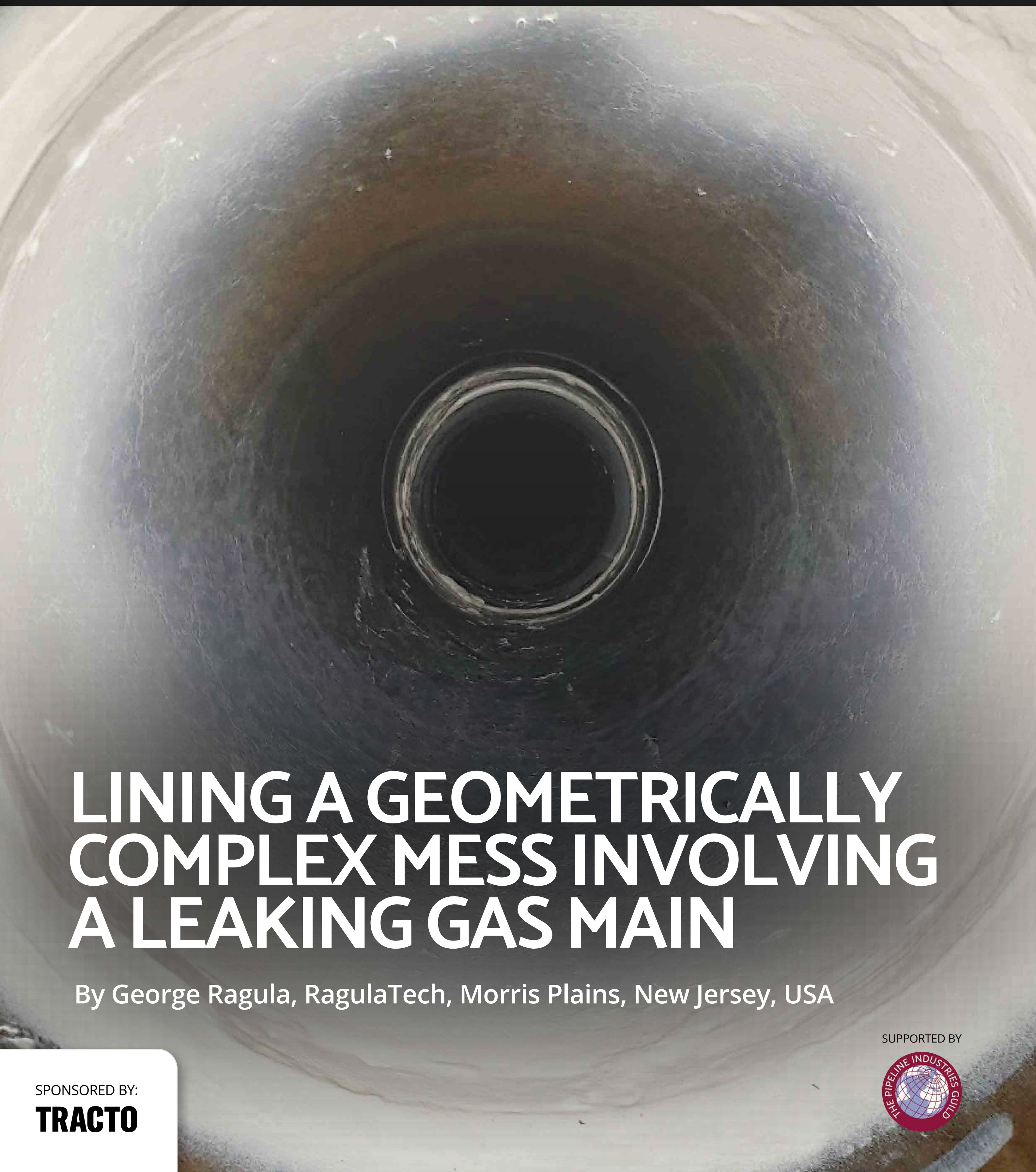

LINING A GEOMETRICALLY COMPLEX MESS INVOLVING A LEAKING GAS MAIN

By George Ragula, RagulaTech, Morris Plains, New Jersey, USA

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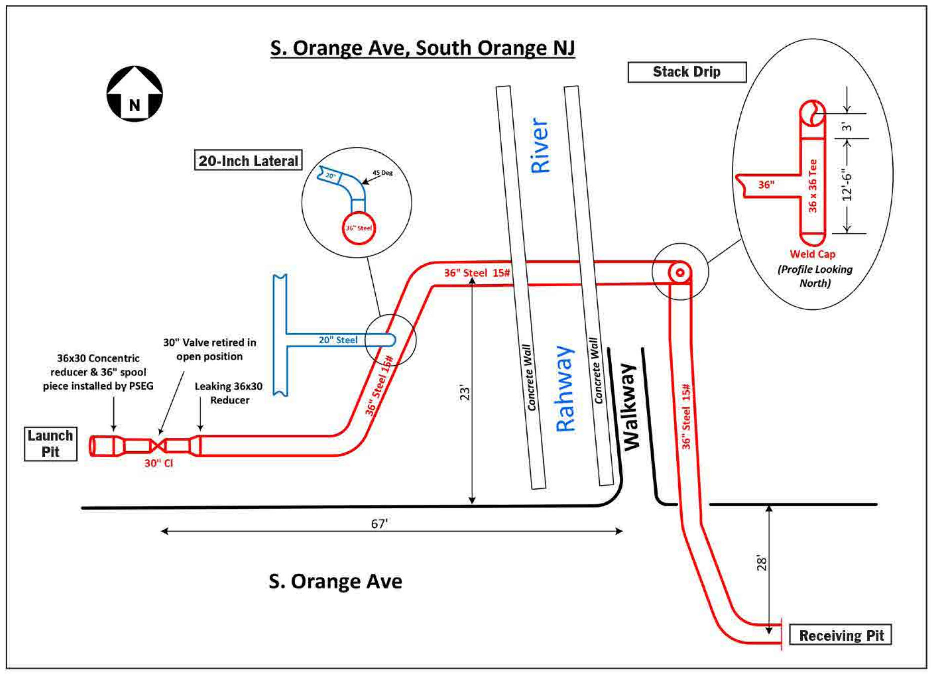

Piping schematic of lining segment referred to as "The Mess".

The NASTT 2022 No-Dig Show in Minneapolis, Minnesota, USA this past April saw the presentation of the Trenchless Technology magazine Project of the Year Award. The following highlights the project concerned and the complexities it encountered.

Large diameter gas pipelines regularly use lining techniques as a 'go to' option for extremely complex and challenging projects.

The renewal of a 30 to 36 in (760 mm to 910 mm) diameter leaking high pressure (HP) gas main, operating at 15 psig, which crosses a river in central New Jersey, USA had significant challenges and required engineering design solutions to be developed for a successful lining operation. Not only did the pipeline run very deep to cross beneath a concrete sluiceway, it also carried six bends including a stack drip, a 36x30 in (910 mmx 760 mm) diameter reducer and a 30 in (760 mm) diameter valve that could not be removed. There was also a deep buried 20 in (500 mm) diameter lateral coming off the larger diameter main. The complexities of the project were further enhanced by the overall depth of the pipeline, high water table, monitoring wells constructed in an old leaking gas station, and the stack drip that could not be removed.

Ultimately, the project involved inversion of a 36 in (910 mm) diameter liner through the 30 in (760 mm) diameter pipe, the 30 in (760 mm) diameter valve, a leaking reducer that opened to the 36 in (910 mm) diameter pipe.

Shop testing prior to commencement of the project.

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To achieve this however a number of first-time engineering solutions needed to be developed, tested, and employed to successfully complete the project. These techniques included curtain grouting, high-strength epoxies, and a lateral restraint plug. The planning, testing and implementation of the solutions employed, building on previous innovations, successes and advancements associated with the challenges of big-inch pipe renewal formed the basis for the project being named Project of the Year.

HISTORY

During the winter of 2020, a major leak was discovered on a critical segment of a high-pressure HP gas main at a steel reducer that transitioned the main from 30 in (760 mm) diameter to 36 in (910 mm) diameter. A vent had to be excavated to safely handle the gas emission in a heavily congested subsurface area containing multiple utilities. That deep excavation revealed a maze of utilities around the gas main that did not allow any access to the pipe for conventional open cut repair. The main continued to get deeper as it continued east to cross the Rahway River in South Orange, New Jersey. On the east side of the river the piping contained a stack drip used for pumping fluids out of the pipe. The stack drip was in an area containing several monitoring wells from an abandoned gas station. The whole arrangement quickly became referred to as 'The Mess'.

This major trunk pipeline was a critical feed to moving gas out to the western end of the territory, so it made complete sense to maximise the length of the shutdown area to take full advantage of renewing a maximum length of pipe. This enabled two additional lining installations one of 825 ft (251 m) to the west of main Launch Pit and 875 ft (267 m) to the east of Receiving Pit to be completed. Because the main was a critical supply source, the permitted downtime for the site was limited to just 1 June to 1 October.

Given these circumstances lining was the obvious solution for renewing this pipeline because of the inaccessibility issues, flow capacity requirements and multiple fittings. However, the unique and challenging layout presented problems never before encountered that required careful thought and consideration from an engineering perspective, requiring creative thinking and breakthrough technical achievements. This also meant that some level of shop-testing with the liner installation contractor, Progressive Pipeline Management, would be needed to prove some of the design concepts and ensure the project's success.

Minimal liner wrinkling confirmed.

Field installation of guide pipe with reducer.

TECHNOLOGY ADVANCES

Many innovations and advancements have been implemented over the years for lining positive pressure gas pipe through successively challenging projects involving large diameter pipe, many of which were used as a steppingstone towards preparing the successful design and plan for this project.

In addition to the extremely challenging layout, there were also five major challenging aspects of the project requiring solutions that had never been attempted before in any positive pressure liner application. The solutions required careful innovative thought and planning, as well as pre-project testing where appropriate to validate the design. The specific challenges included:

1. Liner Installation in a Varying Diameter System – The liner had to be inverted from west to east because of the more complicated layout on the east side of the river. Removing the short section of 30 in (760 mm) diameter pipe approximately 10 ft (3 m) long that contained an inoperable 30 in valve on the west side of the river was impossible due to the extremely heavy subsurface congestion combined with depths ranging from 10 to 16 ft (3 to 5 m). Inverting a 36 in (910 mm) diameter liner directly into a 30 in (760 mm) diameter pipe had the potential to cause several issues including liner entry bubble stability problems, misalignment, and excessive wrinkling/bubbling – all potential liner failure causes.

The solution was to add a short section of 36 in (910 mm) diameter pipe with a second 30x36 in reducer to the end of the 30 in (760 mm) diameter CI pipe to ensure proper alignment of the liner and stability before entering the 30 in (760 mm) diameter pipe. Since this had never been performed before, testing was performed to confirm the anticipated results. The results verified proper liner alignment could be achieved and steady state conditions reached to minimise wrinkling in the installation without negatively impacting the integrity of the liner.

2. Active 20 in (500 mm) Diameter Lateral – The 36x20 in (910x500 mm) tee was deep, and it was not known if it could be cut-off as is normally done because of overall heavy subsurface congestion, an operation that would be time consuming and expensive. Even then, the take-off would have to be temporarily bridged to provide adequate bearing surface for the liner inversion and subsequent pressure test to avoid a blow-out of the liner.

Plug with 2 components assembled.

Plug with final cover plate.

The solution was a specially designed and fabricated restraint plug consisting of three major components for ease of assembly into the 36 in (910 mm) diameter pipe using confined space entry protocols. This plug was designed to act as a bearing surface for the liner inversion and planned 25 psig pressure test. Prior to project start, it was tested to ensure ease of installation and reliability of operation.

3. Stack Drip Transformation – The stack drip consisted of a 36x36 in (910x910 mm) tee at a depth of over 15 ft (4.5 m) with a capped vertical leg looking down. Such fittings were always installed at the lowest point of a segment of pipe and used to periodically pump fluids out of the main that may have collected. The geometry was extremely complex and normally would have been replaced with two 90º bends, but it was in an area containing monitoring wells from an abandoned gas station making it extremely time consuming and costly to replace. From prior experience, the project team knew that a liner could never be successfully inverted through such a complicated geometry.

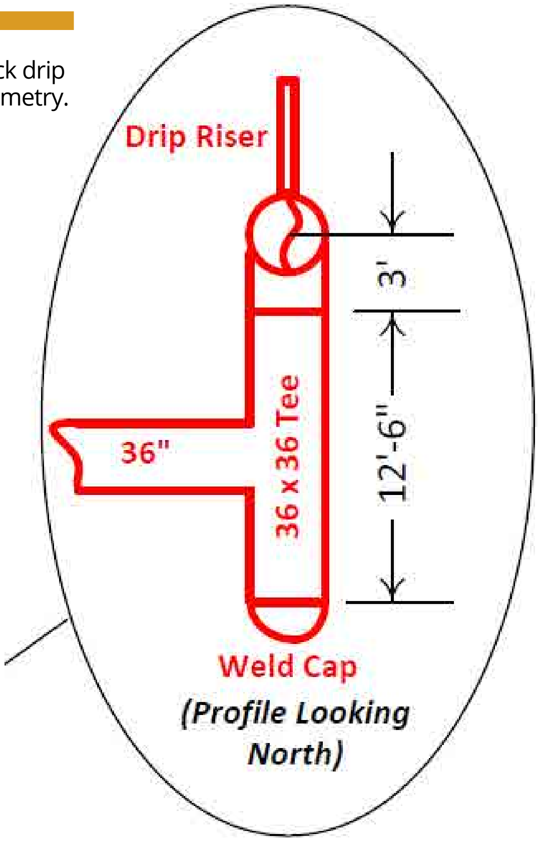
Familiarity with epoxies used in various applications led to a solution whereby the concept of fabricating a 90o bend out of the tee was devised, since the leg looking down was no longer needed. The process envisioned was to leave sandblast grit material after the main cleaning process which is an integral process of lining to properly prepare the pipe for maximum liner adhesion to a 6 in (150 mm) level below the invert of the tee, backfill it with aggregate, and then hand apply high temperature high strength epoxy to smooth out the epoxy to form a 90º bend out of the tee.

4. Leaking 30x36 in (760x910 mm) Reducer – The steel reducer was corroded and there was concern the air pressure from either the liner inversion, pressure test or 15 psig operating pressure over time could lead to failure of the fitting, and potentially leading ultimately to liner failure.

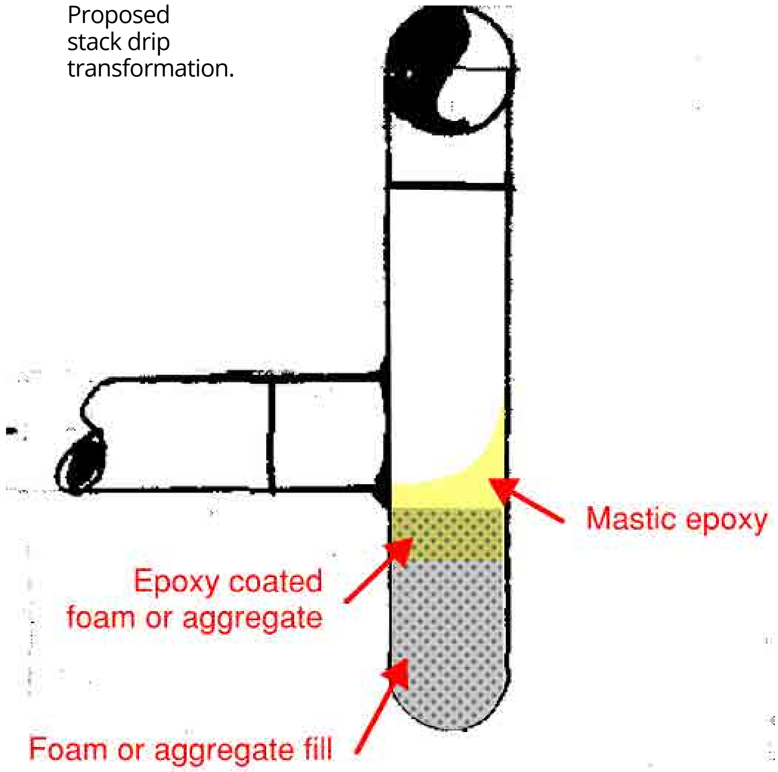
The solution involved spraying an approximate ¼ in (6 mm) layer of high strength epoxy using spin casting techniques to reinforce the leaking fitting, while adding rigidity and strength to the fitting.

5. Inoperable 30 in (760 mm) Valve – Ideally, this gate valve would have been cut-out to accommodate lining operations, but the maze of utilities surrounding it prevented that. Instead, it had to be abandoned in-place. The fitting contained a 6 in (150 mm) wide well for the gate operator to close through, leaving a weak point for liner installation.

Stack drip geometry.



Proposed stack drip transformation.



The solution would normally be to use a carbon fibre structural reinforcement sleeve (SRS) to bridge the well gap to provide adequate bearing surface for the liner, but since the design was employing the use of epoxies for other aspects of the work and their manpower/equipment was in the pipe anyway, bridging the gate well with epoxy was less time consuming and more efficient.

PLANNING AND CONSTRUCTION

Having completed project planning and development testing focus moved to the site itself. The short segment described as 'The Mess' was approximately 175 ft (53 m) long and was the most complex, so the decision was made to schedule that section for construction first. In this way, if there were any delays caused by unforeseen circumstances or difficulties, there was flexibility in moving crews around to the remaining inversions associated with the project to keep the project moving forward within the permitted timeframe. The other inversions were straightforward and expected to be completed without incident.

Subcontractors were employed for some aspects of the preliminary works on 'The Mess', with the full schedule including CCTV survey, curtain grouting, sandblasting, work on the stack drip and leaking reducer, installing the restraint plug at the lateral. Wetting out the liner followed with inversion and ambient curing. Finally post installation CCTV was carried out along with a final pressure test to 25 psig. The lateral was then reconnected to the main line.

In mid-August the lining contractor, Progressive Pipeline Management (PPM), mobilised to site. Fortunately, all the lining work proceeded flawlessly and according to plan. Within a 3 week period, although filled apprehension and anxiety, works on 'The Mess' was successfully completed. This was followed by the remaining two additional straightforward inversions that completed the project ahead of schedule and in time for a 29 September recommissioning date.

Corroded 30x36 in (760x910 mm) diameter steel reducer.

Spin-blast epoxy over reducer.

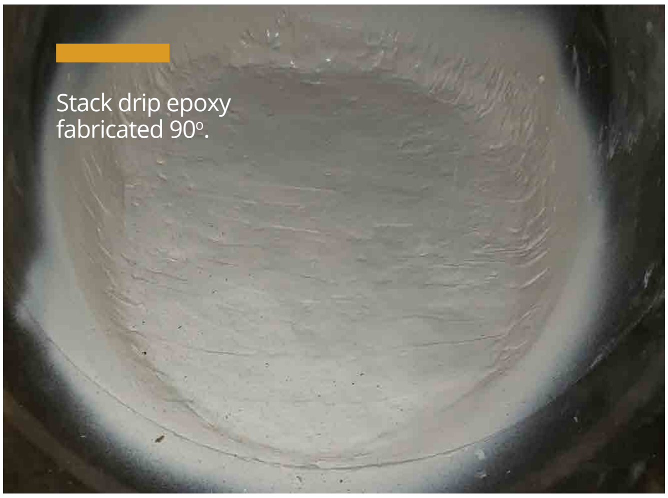
30 in (760 mm) diameter gate valve well.

Since all three segments were renewed with ample time to spare, the decision was made to first tie-in all three lined segments to perform one single pressure test at 25 psig instead of performing three separate pressure tests that required considerable thrust restraint work. By testing it in one segment, PSE&G crews saved additional time and money by avoiding thrust restraint of four of the six end caps.

Whilst the project threw no unforeseen curves at the contractor once the extensive planning was completed, project's ultimate success was due to the level of planning, pre-site testing, expert involvement where necessary and creative and innovative thinking throughout.


Epoxy-filled gate valve well.


Curtain grouting process.


Stack drip epoxy fabricated 90°.


Liner installation through stack drip.

Stack drip aggregate.

Commenting on the project as design lead George Ragula, managing director of RagulaTech said: "This was the most challenging positive pressure lining project ever completed by the project team, led by my design and proper planning, engineering design, shop testing and that teamwork was key to its success from conception to construction. The approach to each challenge presented was built on past successes, innovative design approaches, and consideration of intended success or failure. The break-through innovations and advancements successfully utilised can only contribute to the expanded use of liners on challenging projects in the future."

A full version the paper about this project presented at the NASTT 2022 No-Dig event is available for a fee at: https://member.nastt.org/products/product/2022-MA-T3-01-03