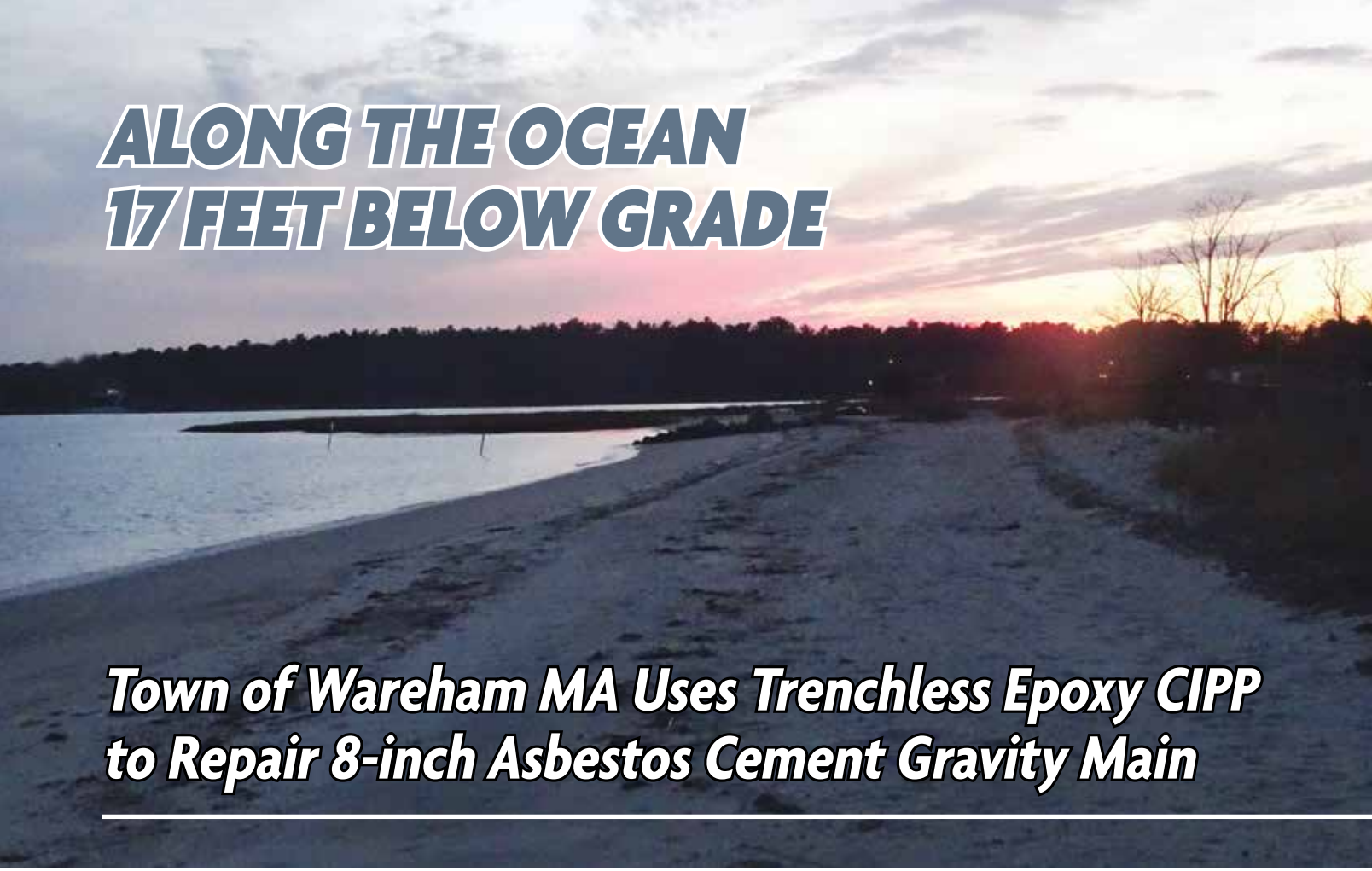


ALONG THE OCEAN 17 FEET BELOW GRADE

Town of Wareham MA Uses Trenchless Epoxy CIPP to Repair 8-inch Asbestos Cement Gravity Main

By: Guy Campinha, Town of Wareham;
Garrett Keegan, P.E., Green Seal Environmental Inc.;
Danny Warren, A&W Maintenance Inc.

INTRODUCTION

With an approved contract in place between the Town of Wareham and Warren Environmental to begin CIPP rehabilitation of a challenging 1600 foot length of severely deteriorated 8-inch Asbestos Cement (AC) gravity main, there was a sudden unexpected complication. A displacement of over 18 inches was discovered at a break in the pipe that was previously repaired by excavation and replacement in 2013.

Already a challenging job, the difficulty factor was raised to a whole new level with this find. The 8-inch AC gravity main was at 17 feet below grade under Wankinco Avenue along the ocean in Swifts Beach. The water table was only at 6 feet, so even with the strong tidal flux this section of main was permanently below the water table. The original project goal had been to stop the major infiltration entering into the main while re-establishing the pipe's structural integrity. Now, in addition to the wet pipe and inclination issues, we had to wrestle with a tough choice between digging up and replacing the deflected section, or attempting an in situ CIPP repair to bridge and reduce the pipe separation.

After all available options were researched, weighed and discussed, our group (Danny Warren - Warren Environmental, Guy Campinha - Director Wareham WPCF, and Garrett Keegan - Green Seal Environmental), decided to present to the Board of Sewer Commissioners for approval of a change order, the idea to use CIPP as a repair for the more than 18-inch separation in pipe.

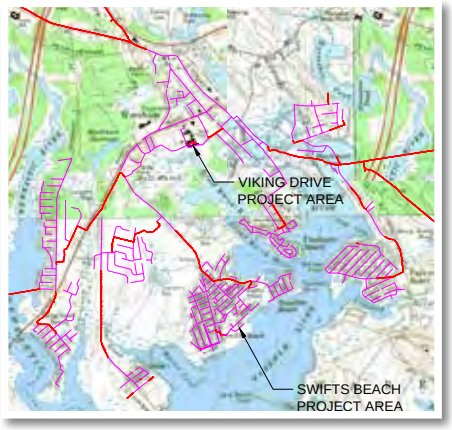
At the same time, there was another unexpected event on the other side of town. A 21-inch reinforced concrete pipe (RCP) interceptor sewer running under newly constructed tennis courts at Wareham Middle School was found to be in need of immediate repair following a CCTV inspection. Again trenchless Epoxy CIPP repair was selected as the best option, the project was put to bid, and Warren Environmental was awarded the contract.

This article details the considerations and collaborative efforts which led to the selection and use of epoxy cured in place (CIPP) liners in these projects: the rehabilitation and repair of the deteriorating 8-inch AC gravity main at Swifts Beach, and the repair of the 21-inch RCP interceptor sewer along Viking Drive near Wareham Middle School.

Both projects give ample and convincing demonstration of the efficacy and cost benefits of utilizing Epoxy CIPP for rehabilitation and repair of AC, and also RCP sewer pipe. They provide great encouragement for the Town of Wareham to use trenchless technology as the go-to approach for pipe repairs.

THERE IS AN ESTIMATED 630,000 MILES OF AC PIPE IN THE UNITED STATES AND CANADA. MOST OF THESE PIPELINES ARE NEARING THE END OF THEIR DESIGN LIFE.

8-inch AC Pipe at Swifts Beach is permanently under water table at 17 feet depth



Epoxy CIPP repair was selected for both locations

TOWN OF WAREHAM

A beautiful community in Plymouth County, with 54 miles of sandy beach coastline, the Town of Wareham has 22,000 year- round residents, and doubles to 44,000 residents in the summer months. Every day, approximately 1 million gallons per day (MGD) is directed to the Water Pollution Control Facility (WPCF) through a network of 70 miles of gravity pipe and 45 pump stations, where it is subjected to biological nutrient removal extended aeration process, and eventual water body discharge.

Significantly 15 miles of the Town's gravity sewer network is AC pipe running along the coast mostly under the tidally influenced water table. Because of aging and corrosion many sections of this AC pipe are beginning to deteriorate and experience infiltration issues.

HISTORY OF AC WATER AND SEWER PIPE

Asbestos cement (AC) pipe has been used world-wide for water supply and sewer piping since its invention in Genoa, Italy in 1906. In the United States AC pipe was installed primarily from the mid-1930s to early 1980s , when the potential health risks were discovered for both the manufacturers and installers of asbestos materials, as well as the public at large. Airborne asbestos fibers were discovered in the manufacturing and installation processes of asbestos materials, and it was found that as AC pipe deteriorated and corroded it released asbestos fibers into the water supply.

Asbestos cement pipes remain in use in many locations today; in fact there is an estimated 630,000 miles of AC pipe in the United States and Canada. Most of these pipelines are nearing the end of their typical design life of 50 years. AC pipe gradually superseded cast or ductile iron and vitrified clay pipe in a large number of applications because asbestos cement is relatively resistant to corrosion, resistant to electrolytic action when buried, light weight, strong, economical to install, and unaffected by temperature changes.

However, asbestos was later found to have significant adverse risk of health effects when fibers are released to the air or water, and as the pipes age they are more prone to failure or fiber release due to corrosion and physical wear. Asbestos cement water mains are not believed to represent a significant hazard to public health in normal use or even if broken

Lining & curing pipe into the night. The neighbors could not have been more hospitable

into pieces during replacement. However, repair, rehabilitation and removal of AC pipes which involves cutting, polishing, and demolition can release asbestos fibers into the air, posing risks to public health. (see facing page: **Regulatory Overview: AC Pipe**)

HISTORY OF AC PIPE RENEWAL ALTERNATIVES

As with the 2013 repair to the 8-inch AC pipe at Swifts Beach, open excavation dig and replacement is often used, particularly for point repairs for breakages. A trench is dug to expose the existing pipe, which is then cut into manageable-sized pieces, placed into containers or wrapped in plastic and disposed at a landfill that accepts asbestos waste. The process is regulated under NESHAP so precautions to prevent fiber release during cutting operations are required. In the case of sewer replacement the process is complicated by the need to reestablish connections with the manholes and service laterals. Since gravity sewers are typically deeper than water lines there is often a need to dewater the trenches and manage the pumped groundwater.

Cured-In-Place Pipe (CIPP) has been widely used for wastewater sewers in the US since the 1980s and has been demonstrated to be safe and effective. However some types of CIPP may release chemical agents such as styrene utilized in the reaction process resulting in water contamination downstream of rehabilitated pipes or an off-gas emission to the air that is can be a significant air pollution problem for workers and local residents. Due to the low toxicity zero VOC epoxy CIPP products used at both the Swifts Beach and Viking Drive worksites there was no residual odor present at either site.

Polymeric Spray-In-Place Pipe (SIPP) is widely used for water main rehabilitation, manhole rehabilitation and person-entry tunnels. It is also used for some small-diameter gravity sewer main applications, however special provisions for adequately preparing the surface in a non-person-entry sewer environment have to be made in order to obtain a dependable bond.

BENEFITS OF CIPP TRENCHLESS SOLUTIONS

CIPP trenchless solutions reduce cost and time risks because they are relatively unaffected by the materials they are rehabilitating or the polluted soils and ground water they contact via relining. Specifically, AC pipe can be relined without removal or remediation.

The engineering, lead time, construction time and disruption of normal traffic and street use required for trenchless solutions is much less than excavation and replacement projects. The engineering is simplified and generally

Tee Liner with inflatable packer assembled and ready for insertion

Regulatory Overview: AC Pipe

The USEPA regulates asbestos under the NESHAP section of the Clean Air Act that governs hazardous air pollutants. NESHAP recognizes two types of asbestos-containing material, friable and non-friable. Friable, or Regulated Asbestos Containing Materials (RACM) is defined as any material containing more than 1 percent asbestos that, when dry, can be crumbled, pulverized or reduced to powder by hand pressure.

EPA has determined that backfilling and burial of crushed asbestos cement pipe would cause these locations to be considered active disposal sites and therefore subject to the "Standard for Active Waste Disposal Sites" (40 CFR 61.154).

Non-friable ACM is any material containing more than 1 percent asbestos that, when dry, cannot be crumbled, pulverized or reduced to powder by hand pressure. Although there is some controversy and disagreement about whether AC pipe fragments are friable RACM, many jurisdictions have declared that disturbance by excavation and replacement or by pipe bursting is likely to create pipe fragments that are Regulated ACM. This includes Massachusetts which explicitly bans pipe reaming or pipe bursting or crushing AC pipe in place when replacing with new pipe. Massachusetts allows undisturbed and unexcavated AC pipe to be left in place during a replacement.

A recent study sponsored by the Water Research Foundation, USEPA and the Water Environment Research Foundation investigated the performance, environmental impact, and cost of both cured-in-place pipe (CIPP) and pipe bursting on AC water mains. The results showed that neither pipe bursting nor CIPP lining of AC pipe was found to have a negative impact on the surrounding air environment or the heath of the workers. Overall, soil samples collected at each site indicated only trace amounts of asbestos in the soil surrounding the pipe. No increase in asbestos was found following the completion of the renewal activities (especially in the case of pipe bursting) it was determined that neither renewal method adversely impacted the soil environment. The water samples collected from each site showed that the renewal technologies had no negative impact on the water quality.

Although the USEPA sponsored the Environmental Impact study, to date it has not decided modify or rescind the NESHAP rules or issue an EPA Administrator Approved Alternative (AAA) for pipe bursting that would allow the use of pipe bursting on AC pipe when proper procedures are followed.

only requires project scope and location, preparing and reviewing sewer video files and/or other techniques such as pipe penetrating radar, surveying and documenting on plans and profiles the manholes/access points with invert elevations, any required/known point repairs, pipe lengths & diameters and lateral connections to reinstate. There are no bedding details, tap connections or specification of alternative systems required.

SELECTION OF CIPP TECHNOLOGY

In addition to these known benefits, local factors ultimately determined the choice to select CIPP as the best pipe renewal technology for the rehabilitation/repair work at Swifts Beach and the reline job at Viking Drive. Reviewing these physical and regulatory aspects, the Town of Wareham selected a low toxicity epoxy CIPP technology for both locations.

Inflow and Infiltration flow studies and video inspection on the 8-inch AC gravity sewer had demonstrated significant problems with inflow due to defects at the laterals and residential sump pump discharge. There was also substantial infiltration occurring in the gravity sewer due to cracks, defective joints, and breakage in the sections below the water table elevation.

Regulations in Massachusetts prohibit use of pipe bursting technology for AC pipe rehabilitation. In addition, necessary

Liner inversion and curing worked very well at pipe deflection

Re-lined Manhole on Wankinco Avenue

Tee Liner Installation

Rock in pipe near area of deflection. A very challenging job

surface preparation for polymeric spray-in-place pipe (SIPP) would be difficult in the relatively small diameter AC sewer several feet below the water table. Much of the sewer is 15-16 feet deep with a tidally influenced groundwater level of 6 to 8 feet deep and sandy soil with a high hydraulic conductivity, which would make dewatering for open excavation replacement difficult and cost prohibitive.

It was also essential that there was minimal impact on the residents and disruption to their daily lives. Swifts Beach is a very densely populated beachfront community with narrow streets, and the compact site footprint required for CIPP resulted in minimal impact upon the neighborhood. Similarly, the section of the 21-inch Viking Drive gravity sewer needing immediate repair was at 15-18 feet depth with shallow tidally influenced groundwater running directly underneath the new tennis courts built at Wareham Middle School. With minimal impact on the site, CIPP again proved to be the best option.

CIPP CONSTRUCTION: 8-INCH AC PIPE SWIFTS BEACH

Repair and lining of the 8-inch AC gravity main along the coastline at Swifts Beach by far presented the greatest set of challenges. The Bayview Street and Wankinco Avenue sewers at Swifts Beach consist of 8-inch AC pipe 742 feet in length on Wankinco, the deeper sewer at 9 to 16 feet depth, and 826 feet along Bayview, 7 to 9 feet deep. Both streets have a relatively shallow tidally influenced water table, with the Bayview sewer often below the water table at high tide and the Wankinco sewer usually 5-10 feet below the water table at all times. The tidal influence and high water table presented enormous challenges during construction. While curing the liner, it was sometimes difficult to maintain consistent temperature and pressure, especially during high tides. The Contractor was able to improvise solutions to remedy these issues on site.

The Wankinco Ave. sewer previously had a break that was repaired in 2013 by excavation and replacement. Before the CIPP lining commenced, this was found to have a significant deflection at the upstream end and high flow infiltration which had to be repaired prior to the CIPP lining process.

An 8-inch bladder was put inside the pipe and air pressure was added to gently align the pipe as close as possible without destroying the already fragile asbestos pipe. Once the maximum possible alignment was achieved grout was then inserted on both sides of the pipe deflection and infiltration point, using pressure injection through six ½-inch steel pipes driven down to the pipe depth

DEMONSTRATED THE EFFICACY AND COST SAVINGS OF USING AN EPOXY IMPREGNATED FIBERGLASS OR POLYESTER FELT LINER FOR INSTALLING A STRUCTURAL REHABILITATION OF AC AND RCP GRAVITY SEWER PIPES AT A SIGNIFICANT DEPTH AND BELOW A TIDALLY FLUCTUATING WATER TABLE.

by jet washing and hammering. Once the grout had set, the infiltration from the pipe deflection point was reduced to a very small amount. After epoxy CIPP lining was completed the separation was reduced to 6 inches and the pipe was structurally sound.

The CIPP system used was epoxy resin, Warren Environmental Cured in Place Liner, a 125 mil vinyl clad braided E Glass structural tube insert impregnated with a zero VOC 100 percent solids, non-toxic, solvent free, epoxy resin laminar system certified to NSF Standard 61 and passing aquatic organisms toxicity testing. The liner was inverted using air pressure and cured by injecting live steam for several hours.

The liner inversion and curing process worked very well at the pipe deflection location. Although it was not possible to pass the sewer camera though the 2-3 inch deflection it was possible to visualize the transition from both sides. Based on visual and flow observation we determined that the sewer hydraulic condition was adequate for the projected flows and that the sewer could be cleaned in the future by approaching the deflection from upstream and downstream ends.

After the laterals were reinstated, the lateral/main connections located below the water table were repaired by installing a tee liner connection using an inflatable packer. Any concerns the neighborhood residents had regarding disruption, inability to get around, and prevention of access of emergency vehicles did not materialize. In 2013, the 20 feet of 8-inch AC gravity main that was dug up and replaced disrupted the neighborhood for 3 weeks. The CIPP project lining

Liner Installation 21-inch RCP at Viking Drive near Wareham Middle School

1,600 feet of the same pipe took a week, including the critical repair to the pipe separation. **Eighty times the length in linear feet, in one third of the time, at a fraction of the cost, compared to dig and replace.**

Viking Drive 21-inch RCP: Wareham Middle School

The reline work on the 315 foot segment of the Viking Drive sewer between 2 manholes under the tennis courts at Wareham Middle School was a great learning opportunity for students in the engineering program, who were invited along with their instructor, to take part in this trenchless technology project. Learning how to repair a pipe without digging up the new tennis court amazed the students, and was a godsend for the school.

CONCLUSIONS

Both projects demonstrated the efficacy and cost savings of using an epoxy impregnated fiberglass or polyester felt liner for installing a structural rehabilitation of AC and RCP gravity sewer pipes at a significant depth and below a tidally fluctuating water table. The epoxies used are 100 percent solids,

ENGINEERING, LEAD TIME, CONSTRUCTION TIME AND DISRUPTION OF NORMAL TRAFFIC AND STREET USE REQUIRED FOR TRENCHLESS SOLUTIONS IS MUCH LESS THAN EXCAVATION AND REPLACEMENT PROJECTS.

Tight working conditions, narrow streets, minimal site impact

Grout was inserted on both sides of the pipe deflection

non-toxic and moisture insensitive with superior strength and chemical resistance properties.

Wareham has a total of five miles of AC gravity main pipe remaining along Swifts Beach to be rehabilitated. If the Town of Wareham were to complete this project removing pipe with traditional dig and replace methods, the cost would be astronomical, estimated at over $100M, and taking more than 70 years to complete! Dig and replace methods for rehabilitation, based on time and cost parameters established for the Town of Wareham are simply not realistic, as summarized in Table 1.

Working in close collaboration with Green Seal Environmental and the Town of Wareham, the Epoxy CIPP trenchless technology application used by Warren Environmental at Swifts Beach and Viking Drive has already saved millions in rehabilitation costs for this coastal community, and is bound to save even more in the future. Along with saving money for the community, using the Epoxy CIPP trenchless approach to repair and rehabilitate pipe in the Town greatly minimized potentially harmful social impacts, and provided a great educational

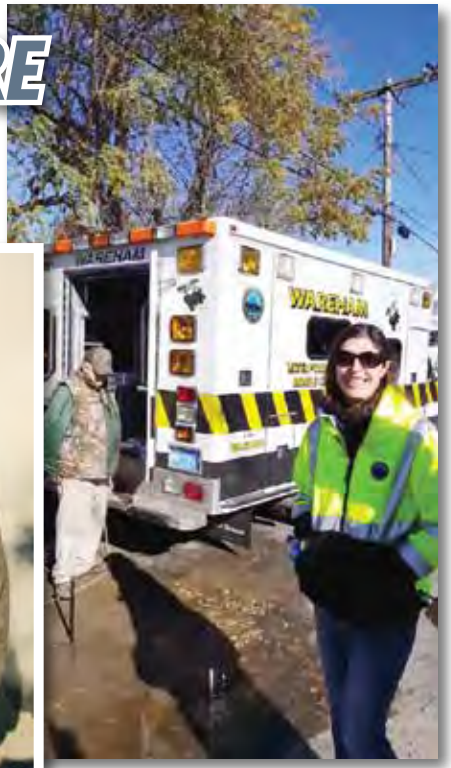
Table 1. Wareham Construction Experience

Technology	Length/ Duration	Cost/Foot	Feet/Day	Length & Duration Remaining	Remaining Cost	Social & Economic Impact
Dig & Replace	20 ft/21 days	$7,000/ft	1ft/day	26,400 ft (5 miles) **70+ Years**	**$100,000,000+**	Street closures, emergency vehicle restrictions, public safety & public health concerns due to open exposed trench. **Not economically feasible. Unrealistic given high cost/ time factor.**
Trenchless CIPP Technology	1,600 ft/ 7 days	$155/ft	228ft/day	26,400 ft (5 miles) **4 months**	**$6,000,000**	Cost & time savings unsurpassed. Minimal social impacts & health/ safety concerns. **Economically feasible for coastal community of Wareham**

THE PEOPLE WERE INCREDIBLE

Danny Warren getting "steamed". Some people have all the fun

Danny Warren (left) brings his long-time friend and mentor Mr. Waldo Roby (right) to the Swifts Beach job site. Mr. Roby had originally questioned the use of AC pipe in underground installations



Alanna Sparagna, Pretreatment Coordinator, WPCF, served as on-site chemist during the grouting process

opportunity for tomorrow's trenchless technology leaders at Wareham Middle School.

At every step in the process, the people were incredible, allowing Warren Environmental, Green Seal Environmental and the Town of Wareham to work together collaboratively finding solutions to unexpected challenges as they arose. Trenchless technology has proved to be very beneficial for the sea side community in Wareham.

ABOUT THE AUTHORS:

Guy Campinha Sr. *is Director of Water Pollution Control for the Town of Wareham. He has spent the past 20 years managing Wastewater facilities and was also Past Chair of the Wareham Board of Health. Guy is a NASSCO: LACP, MACP, PACP certified Member, and is a Certified Grade 7 Wastewater Operator in Massachusetts. He is a currently serving member of the NASTT-NE Board of Directors.*

Garrett Keegan, P.E. *is a project manager with Green Seal Environmental in Sagamore Beach MA with 35 years of experience as an environmental engineer. His work has included industrial and domestic waste water treatment and collection systems, the design and construction management of secure landfills and bulk petroleum and hazardous materials storage facilities. He has conducted groundwater investigations and modeling and performed well pumping tests, water quality evaluations and water treatment designs for public water supplies.*

Danny Warren *has over 30 years of experience in the mediation of corrosion, specializing in specialty 100% solids epoxy coatings and linings. He is the head of field research and development for Warren Environmental Inc., a company that specializes in epoxy restoration products and processes. In 1992, he developed and patented the first successful process for spraying plural component epoxies in their solvent free form, to distances up to 500 feet.*

Since that time, Mr. Warren has been awarded multiple patents in the epoxy application field and has received the prestigious NASTT Innovative Product Award for his Infusion Lining System.