CURED-IN-PLACE PIPE LINING

PROJECT DESCRIPTION

(I) Scope of Work

Sewer Repairs Contract for Inspection and In-Place Sewer System Rehabilitation consisting of Cured-in-Place Pipe Lining. General Requirements include furnishing of all labor materials and equipment to perform the work of television inspection and rehabilitation/lining of this circular sewer by using the relining method known as of cured in-place pipe (CIPP),

Services to be provided include: field investigation, coordination, procurement, construction (rehabilitation/lining), quality control, start-up, testing, documentation pipe preparation, construction close-out, record documents (reports, photographs, videos and as-built drawings), and other activities necessary to complete the Work.

Other related tasks may include collection and review of available drawings, data ad relevant reports to the project, site specific survey, field investigations, environmental sampling and testing, providing by-pass overflow, temporary closure system (bulkheads/cofferdams) for dewatering, access for cleaning, repairs and inspection (access-shafts/cofferdams), disposal of sewer wash material, closed circuit TV inspection, design of lining system for Owner approval, third party testing, clean-up, restoration of existing connections, and prepare final inspection video.

Field Investigation: Lanzo will perform a preliminary site reconnaissance taking photographs and video recording of existing conditions. All applicable regulations, specifications, available documents and drawings will be collected and reviewed. A base survey and utility search will be conducted to verify existing conditions and allow comprehensive planning to avoid last minute surprises. Possible locations of access, staging areas and other logistics planning will be determined.

Normal Cleaning of Sewer: Lanzo will oversee cleaning the pipeline prior to CCTV inspection. Debris, sludge, roots, bricks, and protrusions will be removed from the pipeline. The interior surface of the existing gravity pipelines will be cleaned with hydraulically powered equipment, high velocity and high pressure water jet cleaners, in accordance with "NASSCO Recommended Specifications for Sewer Collection System Rehabilitation".

Inspection of Sewer: After initial cleaning is completed, pipe inspection will be performed by experienced personnel trained in locating breaks, obstacles and service connections. The inspection will be conducted using closed circuit television (CCTV) or man-entry. An inspection report detailing our findings will be prepared and submitted for record.

Design Professional and Related Services: Design considerations stated in Appendices of ASTM F1216-03 will be followed for the design of Gravity Pipes and Pressure Pipes. Minimum wall thickness requirements shall be as follows:

- Design Safety Factor (N) = 2 (for Gravity Pipe)
- Retention Factor for Flexural Mod.(E) = 50% for Polyester resin materials.
- Enhance Factor (K) = 7; Soil Modulus = 1000 psi; Soil Density = 120-pcf.
- Ground Depth = as shown on drawings 34 feet.
- Ground Water Depth = per drawings, to grade
- Live Load = per AASHTO & H-20 when existing sewer is in the roadway.

Third party test results to confirm the physical properties of materials to be used in the design will be submitted for approval and record.

Lining/Rehabilitation Operation: As part of the lining operation, the following services will be provided, BY OTHERS:

- Traffic control signs and barricades
- Bypass pumping

The following lining method will be utilized:

Cured-in-place pipe (CIPP) using direct inversion and curing of a resin-impregnated tube, conforming to the current standard specification for Rehabilitation of Existing Pipeline and Conduits - ASTM Designation F12l6-03 shall be utilized.

Post Completion Tasks: After the lining operation is completed, the following services will be provided as part of the lining operation:

- Repair any dry spots, lifts and de-laminations
- Seal any space between the existing pipe and installed lining at the terminal point.
- Re-establish all active connections to the sewers.
- Clean up and restore the site as soon as possible. In restricted areas, vacuum cleaning will be performed promptly.
- All lining materials left inside the sewer and/or manholes will be removed.
- Provide Final TV-Inspection Video and As-Built Drawings.
- Provide end treatments by sealing and protecting the ends of the lining with Hydraulic Cement.

All operations will be completed in strict accordance with local, state and federal regulations. Special attention will be given to scaffolding and entering confined spaces.

Lanzo will provide a five (5) year warranty period for all materials and workmanship, starting on the date accepted, work performed under each task order issued under this contract.

(II) Quality of Offering

LANZO TRENCHLESS TECHNOLOGIES (LTT) was formed in 1993 to provide a more cost-effective alternative to replacing failing pipelines. This new CIPP technology gives project owners the option to use one of the most advanced trenchless technologies to successfully rehabilitate pipelines.

Our goal at Lanzo is to provide quality, cost-effective and on-time construction. Lanzo is an equal opportunity employer and meets all Federal, state and municipal health & safety regulations. We hold the highest level of ethics and are committed to ensuring the safety of our employees and the convenience and safety of the people within the communities we service.

Lanzo Lining Services doing business as Lanzo Trenchless Technologies is among a handful of companies qualified to use a cured-in-place pipelining technology to rehabilitate deteriorated pipelines. This technology consists of felt tubing, which is impregnated with special resin. When installed a hydrostatic pressure inverts the resin filled tube, which conforms to the walls of the existing pipe to create a structurally sound, joint-less pipe. The water is then heated and circulated throughout the installed length until the tube is cured in place. Once cured, the pipeline is reinstated and ready for use.

Digital Television Inspection -using the latest CCTV equipment and reporting methods, we can provide unmatched quality, and reliability in sewer inspection. Trouble spots, such as cracked or broken tiles, offset joints, and blockages are quickly and precisely located without excavation. Our software produces the most sophisticated data collection, analysis, reporting and archiving.

Sewer Cleaning -clogged sewer lines can quickly turn from a nuisance into a nightmare of municipal health hazards and irate phone calls. Our trucks have a combination of high vacuum and high CFM that has the versatility to handle most materials and jobs, which allows a faster loading time under the most difficult conditions. This in return causes a much quicker turn around time and will ensure the job is done in a timely manner so that your company can experience a minimal amount of down time.

(III) Narrative

The following narrative explains the scope of offering and describes the proposed rehabilitation procedure.

Cured-in-Place Pipe (CIPP) Lining Method - Our Team will provide the rehabilitation of trunk sewer by using cured-in-place pipe (CIPP) method following the procedure outlined in ASTM F1216-03 "Rehabilitation of existing pipeline and conduits by the inversion and curing of a resin-impregnated tube" as required in the RFP. CIPP (Cured-In-Place Pipe) is defined as a hollow cylinder comprising a non-woven or woven material, or a combination of both material surrounded by a cured thermosetting resin. Plastic coatings may be included. This pipe is formed within an existing pipe; therefore it takes the shape of and tightly fits to the existing pipe.

ASTM F1216-03 describes the procedure for the reconstruction of pipe line and conduits (4 to more than 100 inches diameter) by the inversion of a resin impregnated, flexible fabric tube into an existing conduit by the use of a hydrostatic head, steam or air pressure.

The resin is cured by circulating hot water or steam throughout the tube. When cured, the finished cured-in-place pipe will be continuous and tight fitting. This reconstruction process may be used in this gravity application; sanitary sewers.

The following is a description of materials to be used, their final composite, and information about CIPP methods:

Description of CIPP Lining Materials:
Fabric Tube - The fabric tube selected by the Team will consist of one or more layers of flexible needled felt, or equivalent, woven or non-woven material(s), or both capable of carrying resin, withstanding installation pressures, and curing temperatures. The tube will be compatible with the resin system used. The material will be able to stretch to fit irregular pipe sections and negotiate bends. The outside layer of the tube should be plastic coated with the material that is compatible with the resin system used. The tube will be fabricated to a size that, when installed, will tightly fit the internal circumference and length of the original conduit. Allowance will be made for circumferential stretching during inversion.

Resin - A general purpose, unsaturated, styrene based thermoset polyester or epoxy resin and catalyst system that is compatible with the inversion process will be used. The resin must be able to cure in the presence of water and the initiation temperature for cure will be less than 140°F (60 °C).

Description of CIPP Installation Procedure: (In accordance with ASTM F1216-03)

Pre-installation Safety Measures - Prior to entering access areas, such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen must be undertaken in accordance with local, state, or federal safety regulations. All construction safety and confined space entry safety procedures must be enforced during the cleaning, inspection and installation phases.

Use of Bypass to Minimize Outage - By-pass BY OTHERS shall be set up to cause minimum disruption to residents, commercial establishments and traffic. Pumps shall be of sufficient capacity to accommodate daily peak flows and wet weather flows. Where pipes to be rehabilitated are determined by engineer to be of a critical nature and can not be bypassed during normal work hours, lining may have to be scheduled at low flow during night time hours. If combined sewer overflow is minimal and lining can be installed in a timely manner, by-pass may not be required. The Team shall make every effort possible to notify each customer whose service is affected by lining operation and shall be responsible for any back up or any damage caused by the lining process.

Closed Circuit Television & Video Recording - Experienced Team personnel, PACP trained in locating sewer line defects will perform the inspections of the sewers via closed circuit television (CCTV) by robotic or man-entry methods. The sewers will be carefully inspected to determine such defects as: collapsed or crushed pipe, reductions in the cross-sectional area of more than 40%, protruding taps, mineral/cementitious deposits, changes in vertical/horizontal alignment, failing joints, or infiltration. The existing conditions, including service locations and obstructions, will be noted on the inspection report and recorded for future reference. The results of the inspection will provide a tool in determining

rehabilitation methods and location of any conditions that may prevent proper installation of CIPP.

Preparatory Cleaning & Inspection - The Team shall clean the sewers, prior to rehabilitation. All internal debris, sludge, roots, protrusions, breakages, etc will be removed from the original pipeline. The interior surface of the existing gravity pipes will be cleaned with hydraulically powered equipment, high velocity and high pressure water jet cleaners, or mechanically powered equipment following "NASSCO Recommended Specifications for Sewer Collection System Rehabilitation". The inside of the sewers shall be thoroughly cleaned to perform the inspections and to receive the new liner, if required.

Protruding Service Connections - We do expect protruding connection in sewers. Any such conditions observed during inspection, shall be removed to within ¼-inch of the main pipe by the means of robotic equipment. The protrusions shall be ground by grinding tools, which are specifically designed for that purpose.
The finished product shall be uniform and smooth to accept main line lining product and provide a proper seal. Any damage done to any existing sewer pipe or structure will be immediately repaired to a condition equal to or better than original condition.

Resin Impregnation (Wet-Out) - The fabric tube will be vacuum-impregnated totally with resin (wet-out) under controlled conditions. The volume of resin used should be sufficient to fill all voids in the tube material at nominal thickness and diameter. The volume will be adjusted by adding 5 to 10% excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe. The tube will be run through a set of rollers separated by a space, on-site or at a the Team's facility. The process will be calibrated under controlled conditions to ensure proper distribution of resin.

Liner Tube Installation - The Team shall obtain all field measurements required to properly size the liner for installation. The proposed liner shall be sized to provide for a tight fit to host pipe and extent sufficiently from manhole to manhole. Liners manufactured to ISO 9001 shall be installed in strict accordance with ASTM methods. Liner shall be free of irregularities pinholes,

tears, cracks, excessive wrinkling, and sealed at the ends so as to eliminate any possibility of infiltration at the manhole wall. If the CIPP does not fit tightly against the original pipe at its termination point(s), the annular space between the pipe and liner will be sealed by filling with a resin mixture compatible with the CIPP. Chemical sealant, compatible with liner material, may also be injected by the use of standard packer device and equipment, if a tight seal is not obtained. In this situation we shall be responsible for taking steps necessary to reconnect services or provide a by-pass operation, satisfactory for the affected areas.

Inversion Using Hydrostatic Head - The wet-out tube will be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The tube will be inserted into the vertical inversion standpipe with the impermeable plastic membrane side out. At the lower end or the inversion standpipe, the tube should be turned inside out and attached to the standpipe so that a leak-proof seal is created. The inversion head will be adjusted to be of sufficient height to cause the impregnated tube to invert from point of inversion to point of termination and hold the tube tight to the pipe wall, producing dimples at side connections. Care should be taken during the inversion so as not to over-stress the felt tube.

Required Pressures During Inversion - Before the inversion begins, the tube manufacturer shall provide the minimum pressure required to hold the tube tight against the existing conduit, and the maximum allowable pressure so as not to damage the tube. Once the inversion has started, the pressure shall be maintained between the minimum and maximum pressure until the inversion has been completed. Should the pressure deviate from within the range of the minimum and maximum pressures, the installed tube shall be removed from the existing conduit.

Use of Lubricant - The use of a lubricant during inversion may be utilized to reduce friction during inversion. This lubricant may be applied directly to the tube instead of being poured into the inversion water in the down-tube. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube or boiler and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported.

Curing-In-Place - Curing-In-Place will be performed by using "Circulating Hot Water" After the installation is completed, heated water/steam is circulated throughout the liner. Initial cure will occur during temperature heat-up and is completed when exposed portion of the CIPP appears ton be hard and sound. Temperature will be raised for post cure.

Cool-Down - After heated water cure, the new pipe will be cooled to a temperature below 100°F (38°C) before relieving the static head in the inversion standpipe, Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the down-stream end. Care should be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

Using Cool Water after Cure - The new pipe should be cooled to a temperature below 100°F (38°C) before relieving the internal pressure within the section. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole made in the downstream end. Care should be taken in the release of the air pressure so that a vacuum will not be developed that could damage the newly installed liner.

Service Reconnection- Service reconnection shall be completed as soon as possible upon substantial completion of each sewer main rehabilitation Reconnection shall be accomplished without excavation using robotic cutter. Cuts shall be neat and smooth with the service line opened to 95% of the inside diameter in order to prevent blockages. All cuttings shall be recovered prior to putting the pipe back in service. The Team shall stop all visible service line leaks and seals, each service lateral connection to the new liner. In the event that reconnection within the pipe cannot be accomplished or failure occurs during the reconnection process, we may be permitted to at our expense reconnect to the existing pipe using a Romac Industries, Inc. or a Geneco Sealite sewer saddle. If the service reconnection is of critical nature, we shall backup robotic equipment on site to eliminate any delay to the reactivation of the service to customers. This specification shall also apply to pay item to grind and seal existing service opening on previously lined pipe.

Applicable Laws, Regulations & Codes - The Team shall abide by all applicable city, state, federal and other applicable laws, regulations and codes, pertaining to maintenance of traffic on public streets, detour of traffic, traffic control and other provisions as may be required for the project such as use of electricity & lighting, telephone services, water, sanitary facilities. Our Team will be very careful about existing site features, utilities, stored material, temporary construction, etc. The Team will follow all regulations outlined in the specifications as well as in-house safety procedures for safe and healthy working condition.

Site Cleanup - Keeping the site generally cleans, and providing a final site cleanup is an essential part of the work. As the work progresses and is completed, the Team shall clean the various site areas of all external materials and debris. The Team will completely restore all work areas to the satisfaction of the Client. This cleanup shall be done promptly as practicable and shall not be left until the end of the construction period.

Post-Installation Submittals - Lanzo shall submit (as per specification):

- Pre-installation videotapes of the sewers/water mains being rehabilitated.
- Post-installation tapes of the completed CIPP and reinstated laterals.
- Completed pre & post sewer rehabilitation site logs with comments and observations.
- Flexural property test data for each liner installed, from an independent third party testing laboratory.
- Installed CIPP thickness measurements for each liner installed, from an independent third party testing laboratory.

Rehabilitation of Sewers with Minimal Disruption of Services - Following is a summary of our proposed rehabilitation procedures showing how the rehabilitation of the sewers will be accomplished, while maintaining the connections to the existing Culvert:

- Our plan is to clean and inspect the sewers without closing the barrels.
- We may also arrange for bypassing the flow as needed around the culvert designated for rehabilitation by plugging with expandable balloon and pumping at adequate capacity.
- Our plan is to install continuous CIPP lining in the pipes one at a time so that the other barrels in a multi-barrels outfall will be open.
- After the satisfactory installation of the CIPP lining in one barrel, the system will be removed before another barrel is then available for rehabilitation.

Effect of Lining Method on the Finished Diameter of the Pipe - Our conceptual design calculations presented show that using CIPP method of rehabilitation, the diameter of the pipe will decrease minimally due to the required design thickness of the liner. But at the same time, due to rehabilitation of the fully deteriorated sewer, the discharge flow will be more than 100% of the existing flow. The discharge flow increased in all cases, the ratio ranging from 110% and 135% of the original flow respectively.

Satisfying Objectives & Meeting the Project Requirements:
Our entire proposal is made on the basis of satisfying objectives and meeting the intent of the requirements documents, as required in the RFP. The aspects of the proposed CIPP method, which are especially suited to satisfy the planned objective and meet the intent of the requirements documents, are mentioned below:

Cured-in-place pipe (CIPP) liner is appropriate for this project are summarized as follows:

- CIPP is able to span a diameter range of 30-inches and 36-inches.
- CIPP can be used to rehabilitate sections of pipe over 2000-feet in length.
- CIPP can rehabilitate ovals, bends and transitional diameter without digging.
- CIPP is used to rehabilitate partially as well as fully deteriorated pipes.
- CIPP is used for gravity, internal pressure and vacuum applications.
- CIPP is used in extremes of temperature and pH.

- CIPP eliminates inflow and infiltration, as well as outflow and ex-filtration.
- CIPP increases flow capacity of existing pipe by providing smooth inner surface.
- CIPP is endorsed by ASTM, giving two specifications, ASTM F12l6 and ASTM F1743.
- CIPP tube/resin materials are also specified by ASTM D 5813.

Effects of Means & Methods of CIPP Lining on the Site & Environment - Following is a description of the effects of our proposed rehabilitation procedures showing the minimal disturbances of the site, minimized staging area dimensions, minimal environmental remediation effort, and shortest construction time:

- The Team will collect and review all available project and site related data, drawings, reports and documents. The available information will be used to prepare the work plan, installation procedures and site operation activities. Appropriate measures will be taken to minimize site and outfall disturbances, staging areas, and environmental impact. The construction schedule will be as short as possible.

- After receiving the notice to start work Lanzo will immediately proceed to mobilize equipment and personnel and set up field office. We will also set up traffic & parking , control system, site operation facility, water, power and lighting supply, storage of equipment & materials, containerize and disposal of all debris, soil, water and sludge from cleaning operation.

- Lanzo will conduct a field investigation to identify the existing site surface and subsurface features, underground utilities, access to the sewers, ground water conditions, presence of contaminated soil, and presence of toxic/flammable gases/vapors and lack of oxygen in the confined access areas. Very little site disturbance is expected during these investigations.

- Any damage to the ground resulting from this activity will be repaired and will be restored to the original condition at no additional cost to Lanzo.

- Lanzo will clean the sewers, remove and dispose all internal sludge deposition, debris, and root intrusion, protrusions, from the outfall. All debris, soil, sludge, water and other materials, taken out during cleaning will be containerized and disposed of in accordance with EPA and EQ regulations under the direction of the inspector while no environmental impact is expected.

- We will install continuous lining one at a time. The installation process will include perforation of the resin impregnated tube, placing of tube into position, hydrostatic head calibration hose inversion, curing using circulated heated water or steam under required pressure and cool-down using cool water. The trenchless installation system will have minimal disturbance of the site and no environmental impact.

- Pre-construction and post- construction video recordings will be maintained to restore the site to original condition.

(IV) Materials & Equipment

For successful lining rehabilitation to Owner's specification materials used are listed below:

Material Property Requirements:

Fabric Tube Strength-When tested in accordance with Test Method D1628 shall have a minimum tensile strength of750 psi (5Mpa) in both the longitudinal and transverse directions.

Chemical Resistance-The cured resin/fabric tube matrix, with or without calibration hose in accordance with specification D 5813 shall be capable of exposure to the solution as in table at a temperature of 73.40 F ± 3.60 F (230 C ± 20 C), with a percentage relation of flexural modulus of elasticity of at least 80% after one year exposure.

Minimum Chemical Resistance Requirements
(*for Domestic Sanitary Sewer Application*)

Chemical Solution	***Concentration***
Nitric acid	1
Sulfuric acid	5
ASTM fuel (in accordance with D 4814)	100
Vegetable oil (cottonseed, C0111 or mineral)	100
Detergent (in accordance with test method D 543)	0.1
Soap (in accordance with test method D 543)	0.1

Cured-in-Place-Pipe Lining -The liner material shall be polyester fiber felt resin-impregnated tubing sized to tightly fit the internal circumference and length of the designated gravity sewer. It having no structural strength is to be rehabilitated with H-20 traffic loading, the water table at the ground surface and will have minimum expected life time of 50 years. Liner shall be sized to provide a tight fit to the host pipe and shall be continuous from manhole to manhole.

Chemical Joint, Crack and Annular Space Sealing Materials for Active Leaks and Service Lateral Connections - Materials used shall have properties that react quickly to form a permanent watertight seal; resultant seal shall be flexible and immune to the effects of wet/dry cycles, non-biodegradable and immune to the effects acids, alkalis and organics.

Fabric Tube Materials- The flexible fabric tube is one of several key elements of the CIPP process. The materials used to construct tubes must possess chemical resistance, flexibility, an ability to stretch and conform to irregular piping, and be durable to withstand the rigors of under- ground construction. Currently, the most commonly used fabric tube material in North America is composed of thermoplastic polyester fibers needled into a dense felt.

All fabric tubes are built up to design thickness with the fabric(s) of construction and also have one or two plastic coatings on the outer and inner surfaces (depending on the technology). The most commonly specified product consists of a flexible polyester felt tube having a plastic coating on the outer layer of felt. This

outer coating serves three functions: (1) during resin saturation the membrane allows a vacuum to be placed on the tube, (2) it neatly contains the resin inside the tube, and (3) it acts as a protective barrier between water in the host pipe and the uncured liquid resin during installation (pull-in or direct inversion).

Needled polyester felt tubes are strong and resilient, but only provide a function of resin carrier. Felt does not provide added strength or stiffness to the resin, but keeps it in place during preparation, transportation, and installation of the tube. Fiberglass has extremely high tensile properties, and tubes containing fiberglass can produce significantly elevated physical properties. Elevated internal pressure is an area of technology where glass reinforced technology is applicable. Internal pressure applications requiring elevated tensile strength include force mains, natural gas, industrial applications, raw and potable water piping. Many of these applications have been extensively used over- seas, but are still cautiously being specified in North America. At this time several projects are under way to develop ASTM specification for fiberglass reinforced CIPP, but none as yet have been published.

Minimum ASTM specifications for flexible fabric tubes are specified in ASTM D58l3 and F1743 and require a minimum of 750psi (5MPa) as measured by ASTM D1682 "Test Method for Breaking Load and Elongation of Textile Fabrics". At the time this criterion was placed in these ASTM specifications, the targeted material(s) was needled polyester felt and coated polyester felt. Many coatings can actually enhance the properties of a tube, and Table includes typical values for plain polyester felt and coated polyester felt. Depending on fiber orientation, fiberglass tubes could easily exceed the current ASTM values by several orders of magnitude.

Typical properties for polyester felt & plastic coated felt

Material	% Elongation at Failure	Ultimate Tensile Strength
Felt	85 - 95	800 -1000 psi
Plastic Coated Felt	70 - 75	1200 – 1500 psi

Thermo-set Resins Overview and Properties - The thermosetting resins used for CIPP are the most important component to the short and long term performance of the product. First, there is a distinction between initial or short-term properties and the long-term performance that dictates the life span of a product. Short-term properties include parameters such as flexural, tensile, and compressive properties. Long-term properties include parameters such as chemical resistance, creep, and strain corrosion. Most all these parameters are important for the qualification, design, and performance of CIPP.

Typical Thermo-set Resin Physical Properties

Test Property	Epoxy Resin	Epoxy Vinyl Ester	Isophthalic Polyester
Flexural modulus (psi)	500,000-550,000	500,000-570,000	500,000-570,000
Flexural strength (psi)	15,000-25,000	15,000-25,000	10,000-18,000
Maximum Strain (%)	4-7%	4-7 %	3-5 %
Tensile Modulus (psi)	490,000-540,000	490,000-560,000	490,000-560,000
Tensile Strength (psi)	8,000-10,000	8,000-10,000	5,000-8,000

Minimum Recommended Design Properties

Typical properties of neat and resin/felt composites produced in the laboratory are not typical of the product produced in the field. When all the parameters of the preparation, installation, curing, and sampling are carefully monitored and controlled, the properties of installed CIPP fall within the median range of data provided in the following Table. However, there are many uncontrollable variables of an underground construction project that can negatively affect the end product. The net overall result is that variability is increased and the fluctuation in test data also increases. Therefore, minimum property values have been established within the industry to provide a conservative minimum value for flexural and tensile properties of installed ClPP. Table provides recommended

minimum design values for standard ClPP. The values in Table are relatively low but the median value of installed ClPP is typically 15-25% higher than minimums. In effect, the majority of all ClPP installed essentially has an additional factor of safety due to the conservative design practices that have been adopted. Minimum properties are given for both flexural and tensile properties, but it should be pointed out that tensile properties are only used in the design of stand-alone pressure pipe.

Minimum recommended design properties

Test Property	Epoxy Resin	Epoxy Vinyl Ester	Isophthalic Polyester	Filled Polyester Isophthalic
Flexural Modulus, psi	250,000-300,000	350,000-450,000	350,000-500,000	400,000
Flexural Strength, psi	5,500	5,500	5,500	5,500
Tensile Strength, psi	3,000 - 5,000	3,000 - 5,000	3,000 - 5,000	3,000 - 5,000

Specifications & Definitions:

The following standard specifications for material properties are also used for the preparation of the reference specifications:

- **ASTM D 5813** for thermosetting resin sewer pipes.
- **ASTM D 638** for Tensile Strength of Cured Pipe - Min 3,000-psi
- **ASTM D 790** (modified) for Flexural Strength - Min 4,500-psi
- **ASTM D 790** (modified) for Flexural Modulus of Elasticity - Min. 300,000-psi
- **ASTM D 790** for Long Term (50 yrs.) Modulus of Elasticity - Min. 125,000-psi

Additional reference documents to be followed for this project, as mentioned in the RFP, are listed below:

AASHTO- American Association of State Highway and Transportation Officials
ASTM - American Society for Testing and Materials
ASTM C581 - standard practice for determining chemical resistance of thermosetting resins used in glass fiber reinforced structures, intended for liquid service.
ASTM D543 -Test method of resistance of plastic to chemical reagents.
ASTM D638 -Test method for tensile properties of plastics

ASTM D790 -Test methods for flexural properties of unreinforced and reinforced plastic and electrical insulating material
ASTM D903 -Test method for peel or shipping strength of adhesive bonds.
ASTM D1600 -Terminology for abbreviated terms relating to plastics.
ASTM D1682 -Test method for breaking load and elongation of textile fabrics.
ASTM D3039 -Test method for tensile properties of polymer matrix composite materials.
ASTM D3567 -Practice for determining dimensions of reinforced thermosetting resin pipe (RTRP) and fittings.
ASTM D4814 - Specification for automotive spark-ignition engine fuel.
ASTM D5813 - Standard specification for cured-in-place thermosetting resin sewer pipe.
F 412 -Terminology relating to plastic piping systems.
ASTM F1216 - Standard practice for rehabilitation of existing pipelines and conduits by the inversion and curing of a resin-impregnated tube
ASTM F1743 - Standard practice for the rehabilitation of existing pipelines and conduits by the pulled-in-place installation of cured-in-place thermosetting resin pipe (CIPP)
ASTM D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D3350 - Specification for Polyethylene Plastics Pipe and fitting Materials
ASTM D3262 - Standard Specification for Fiberglass (Glass Fiber Reinforced Thermosetting resin) Sewer Pipe
ASTM D4161 - Standard Specification for Fiberglass (Glass-Fiber Reinforced Thermosetting Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2583 - Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impresser.
ASTM D 2584 - Standard Test Method for Ignition Loss of Cured Reinforced Resin **ASTM D3567** - Standard Practice for Determining Dimensions of Fiberglass (Glass-Fiber Reinforced Thermosetting Resin) Pipe and fittings
ASTM D3681 - Standard Test Method for Chemical Resistance of Fiberglass Pipe in a Deflected Condition.
AWWA Standard - (M28 manual on cleaning and lining water mains.) American Water Works Association
NASSCO Standard - (recommended specification for sewer collection system rehabilitation.) National Association of Sewer Service Companies
API - American Petroleum Institute.
ANSI - American National Standard Institute.
ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME - American Society of Mechanical Engineers
CSDS - DSWD Control System Design Standard
EJCDC -Engineers' Joint Contract Document Committee
FM -Factory Mutual System

FS -Federal Specification
IEEE - Institute of Electrical and Electronics Engineer
ISA -Instrument Society of America
MIL -Military Specification
NEMA -National Electrical Manufacturers' Association
NFPA -National Fire Protection Association
TAS -Technical Aid Series
UL - Underwriters' Laboratories, Inc.

(V) Design Criteria

Structural Elements - Structural elements to be considered are the shape, size and materials of the liner pipe, ovality and other structural defects of the host pipe, external loading, internal resistance to pressure, and design safety factor.

Geo-technical Elements - Ground water depth shall be as shown in the contract documents but less than ½-soil depth. The soil depth shall be as shown in the contract document and ranges between 10-feet and 20-feet.

Soil density shall be 120 pounds per cubic foot (pcf) and live load shall be as per AASHTO or H-20 when existing sewer is in the roadway. The modulus of soil reaction values used represents stable undisturbed soils having elastic support values in the range of 700-psi.

Pipe Condition	Psi value
Unrestrained soil condition	700
Pipe buried deep with stable soil	1000 - 1500

Environmental Elements - The soil, sludge and water should be tested for contaminations above acceptable limits.

Lining Material - Long-term flexural modulus (E) shall be 50% of the short term modulus regardless of the type of resin material used. Enhance factor (K) shall be 7.

We have also considered resin/felt composite properties, creep properties, thermal properties & chemical resistance properties of thermosetting resins. For details please refer to CIPP material properties in the Design Manual included in Appendix M.

Fabric tube material should design to have tensile properties as shown in the following table:

Typical tensile properties for polyester felt and plastic coated felt (fabric tube material)

Material	% Elongation at failure	Ultimate Tensile strength
Felt	85-95	800-1000 psi
Plastic Coated Felt	70-75	1200-1500 psi

Thermo-set resin should be design to meet physical properties as shown in following Table:

Typical Physical Properties of Thermoset resin

TEST PROPERTY	EPOXY RESIN	EPOXY VINYL ESTER	ISOPHTHALIC POLYESTER
Flexural modulus, psi	500,000 - 550,000	500,000 -570,000	500,000 -570,000
Flexural strength, psi	15,000 - 25,000	15,000 - 25,000	10,000 -18,000
Maximum strain, %	4-7 %	4-7%	3-5 %
Tensile modulus, psi	490,000 -540,000	490,000 -560,000	490,000 -560,000
Tensile strength, psi	8,000-10,000	8,000-10,000	5,000-8,000
Tensile elongation, %	4-7 %	4-7%	2-5 %

(VI) Protection of Existing Facilities

Lanzo will make precautions to research existing drawings and documentation, and field investigate the location of existing utilities. We will provide a plan for protection of existing surface and underground facilities and utilities. This plan will include procedures to monitor soil movements, monitor structural movements, monitor water level changes and monitor vibrations of any conditions which could potentially endanger existing facilities.

(XI) Testing & Start-up

After the completion of lining work, the Team proposes to open the outlet end and close the sewer end prior to running a demonstration test for flow capacity for each sewer. A large tanker will be used to feed the water into the outfall for measuring outflow capacity.

No special start-up procedures are anticipated or included.

(X) Field Inspection

We will perform a preliminary site reconnaissance taking photographs and video recording of existing conditions. All applicable regulations, specifications, available documents and drawings will be collected and reviewed. A base survey and utility search will be conducted to verify existing conditions, and allow comprehensive planning to avoid last minute surprises. Possible locations of access shafts, staging area and other logistic planning will be determined. Traffic control requirements and plan will be established.