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## THE LARGEST CIPP SEWER REHABILITATION PROJECT IN THE COUNTRY

Nancy McWilliams<sup>1</sup>, and Amber Parmer<sup>2</sup>

<sup>1</sup> West Yost Associates, Davis, CA

<sup>2</sup> Sacramento Area Sewer District, Sacramento, CA

**ABSTRACT:** The Sacramento Area Sewer District is undertaking the single largest Cured-In-Place-Pipe (CIPP) rehabilitation project in the United States. The Central Trunk Sewer Rehabilitation project consists of rehabilitating eight miles of trunk sewer ranging from 33 to 60 inches in diameter. The existing reinforced concrete pipe is severely corroded and is located under local residential and busy arterial streets, Highway 99, environmentally sensitive habitat, and residential backyards.

This presentation will be delivered jointly by the owner, Sacramento Area Sewer District, and the designer, West Yost Associates, and will discuss the challenges and successes in bringing this large diameter rehabilitation project to construction. The design elements included bypass pumping up to 34 mgd in busy streets, including crossing Highway 99; liner design calculation considerations; traffic control; weight limitations for transporting liners; installation options and requirements; pipe cleaning requirements, which considered potential for pipeline collapse; and permitting. Environmental constraints included biologically sensitive areas, noise, air quality, access, odors, and emergency response. Public outreach program included communication with all affected residents, schools, public transportation, neighborhood facilities, business organizations, and multiple jurisdictional stakeholders from early in design throughout construction. Contract issues included bidding, prequalification, and award.

### 1. INTRODUCTION

The Central Trunk is a severely corroded sewer trunk line approximately eight miles long serving Sacramento California. The trunk line was constructed in 1961 of unlined reinforced concrete pipe. The trunk line is 42-inches to 60-inches in diameter and runs under major streets, residential backyards, creeks, a freeway, through protected wetlands, and near many homes, schools, and businesses. Approximately 3,000 feet of the Franklin Trunk is also included in the project. The portion of the Franklin Trunk to be rehabilitated is 33-inch diameter sewer reinforced concrete pipe. Figure 1 shows the project location and scope. Restoring the structural stability of the Central Trunk and Franklin Trunk with minimal decrease in capacity is the project's primary goal. The Sacramento Area Sewer District (District) aimed to meet this goal in a cost effective manner with as little disruption to the community as possible, and therefore chose cured-in-place pipe (CIPP) as the single method of rehabilitation.



All bids were rejected by the Board of Directors and the project team was asked to prequalify all applicants. The criteria for prequalification included a combination of personnel and company experience, proper licensing, insurance and bonding ability.

Due to the large size of the project and in combination with the down economy, a very competitive bidding environment was produced. Ultimately, the District awarded the contract to Insituform Technologies Inc. for approximately \$3.4 million less than the engineer's estimate of \$21.6 million.

Although there is no guarantee that protests will be eliminated, given the opportunity to do this again, for a project of this size, we would recommend prequalification so that the contractor requirements can be ironed out prior to all of the work preparing for the bid.

### **3. PUBLIC OUTREACH**

One of the challenges of the Central Trunk Project is keeping the public informed during the project to minimize complaints and project delay. The District developed a multi-faceted public outreach plan. This program included notifying stakeholders by mail, email, public information meetings, a project website and most recently daily updates on Facebook and Twitter.

During construction, a seasoned construction inspector from the County Construction Management Division, has been assigned as Project Liaison. The Project Liaison makes personal contact with impacted residents and businesses approximately one week in advance of construction activity in their neighborhood. The District has implemented a hotel voucher system for residents who request relocation due to adverse construction impacts. A security service is also on retention to watch homes that are unoccupied, due to relocation, for the evening. The public outreach program has been a great success because there have been only a few complaints during construction and one satisfied individual was pleased to be provided alternate accommodations.

### **4. ENVIRONMENTAL REGULATIONS**

The Sacramento County Department of Environmental Review and Assessment prepared an environmental impact report for the Central Trunk Project. Some of the requirements of the Mitigation Monitoring and Reporting Program (MMRP) included coordination with emergency response, regional transit, and schools; light, noise, and air quality regulations; and protection of biological and cultural resources. The three most critical regulations for construction have so far been air quality regulation, noise mitigation, and protection of biological resources. Each of the environmental constraints represented a unique challenge to the project, and were successfully handled as follows:

**Air quality.** Sacramento Valley air quality regulations are stringent. At the onset of construction, the contractor was surprised to learn that their diesel boilers were not in compliance for movable equipment. This required finding alternative fuel boilers or applying for an Alternative Compliance Permit. The contractor was able to rent certified propane boilers while they retrofit, and got their own boilers certified. An Alternative Compliance Permit was obtained cooperatively by the District and the contractor for the southern half of the project because the propane boilers are not powerful enough to heat water.

**Noise Mitigation.** The District retained an acoustic engineer to 1) record ambient noise along the project alignment, 2) measure noise created by contractor equipment and 3) prepare a noise mitigation plan. The noise mitigation plan was based on sleep disturbance criteria common to the industry. The plan included a table showing minimum distances between occupied buildings and specific contractor equipment as well as sound mitigating devices that would be required if the minimum distances could not be met. As shown in Table 1, the report provides clear guidelines for the contractor and inspectors.

Table 1. Excerpt from Noise Reduction Plan

Equipment Noise Levels after Noise Attenuation Central Trunk Rehabilitation Project - Sacramento, California					
Test #	Source(s)	Average Hourly Noise Levels (dBA), $L_{eq}/L_{50}$	Approximate Distance to 63 dB <sup>1</sup> $L_{eq}/L_{50}$ Hourly Noise Contour, unmitigated	Distance to 63 dB <sup>1</sup> $L_{50}$ Hourly Noise Contour : 5 dB attenuation	Distance to 63 dB <sup>1</sup> $L_{50}$ Hourly Noise Contour: 8 dB attenuation
1	Air Compressor: Atlas Copco 850	81 dB @ 23' 74.5 dB @ 50' (approx)	185'	104'	74'
2	Vacuum Truck: Vactor 2100 Series	79 dB @ 100' 85 dB @ 50 feet (approx)	647'	364'	257'
3	Boiler Truck	55 dB @ 50'	19'	11'	8'
4	Video Truck	69 dB @ 50'	97'	55'	39'
5	Water Pump: Godwin Pumps CD 150	66 dB @ 50'	69'	39'	27'
6	Boiler Truck Natural Gas, Southern Ca. Boiler & 70kW diesel genset	60 dB @ 50'	35'	20'	14'
7	Air Compressor: Ingersoll Rand HP1600	67 dB @ 23'	36'	20'	14'

<sup>1</sup> The 63 dB  $L_{50}$  hourly noise contour represents the potential sleep disturbance impact zone.  
Source – j.c. brennan & associates, Inc. 2009.

**Biological Resources.** The Central Trunk runs through an area that provides a buffer between residential development and the Sacramento Regional Wastewater Treatment Plant. The land, known as the Bufferlands, is home to the Giant Garter Snake, Swainson’s Hawk, and Burrowing Owl, and is dotted with seasonal wetlands. The environmentally sensitive area has a construction season limited to dry summer months with additional survey and mitigation requirements for snakes and raptors. The contractor, District, and Bufferlands personnel are holding formal meetings early and regularly so that time sensitive events are not overlooked.

**5. BYPASSING SEWER FLOWS**

CIPP rehabilitation requires sewer flows to be bypassed around the construction zone. Flow in the Central Trunk ranges from approximately 500 gallons per day to 24 million gallons per day.

A pump station was constructed during the design of the Central Trunk that would reroute all upstream sewer flow away from the Central Trunk at the north end of the project. The contractor developed a strategy to plug portions the Central Trunk to divert the flow through this pump station to another trunk sewer instead of bypassing the flows for the upstream third of the project. This strategy was confirmed by

District staff with flow modeling (see Figure 2 and Figure 3) and was supported by calculations provided by the contractor.

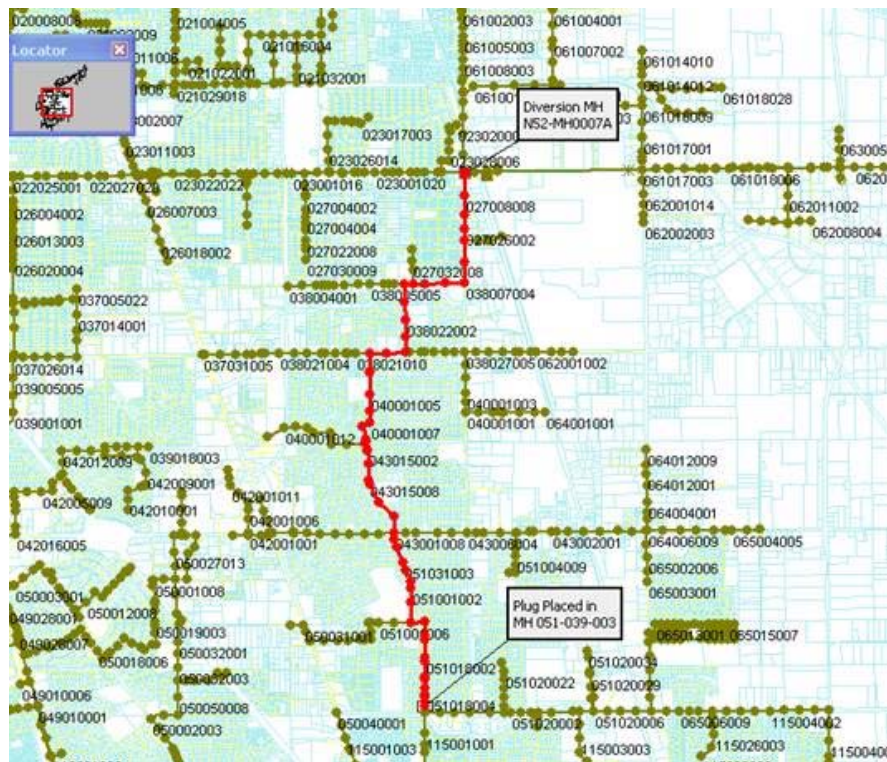


Figure 2: Plan View Map with highlighted section profiled below.

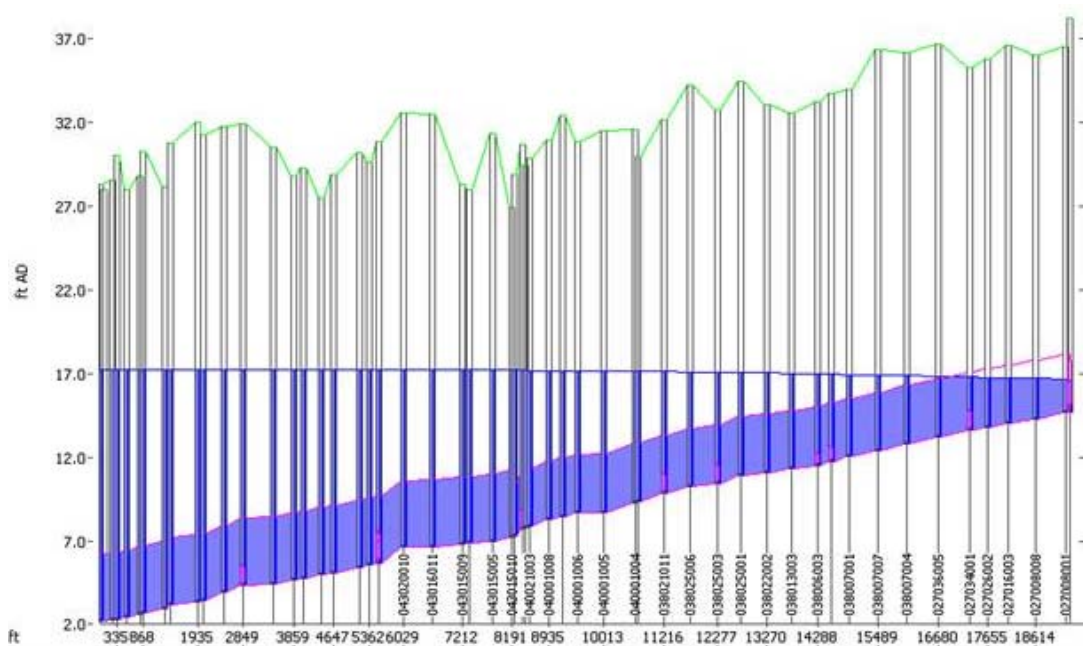


Figure 3: Max DWF HGL EI = 17'. Plug placed in outfall pipe MH 051-039-003. Low upstream manhole 053-031-006 Ground EI=23.0'.

In addition to the modeling effort, there was quite a bit of discussion regarding the ramifications of the diversion including those shown in Table 2. After consideration and testing, the diversion has been used successfully for lining more than 19,000 linear feet of sewer trunk line.

Table 2. Benefits and potential drawbacks of the diversion.

<b>Benefits</b>	<b>Potential Drawbacks</b>
Minimal community impact	Sediment precipitation with each plugging event
No trenching	Challenges associated with the installation and removal of the Plugs
No equipment exposure or maintenance	Plug damage
No bypass pipeline monitoring	Coordination with other project activities
No leaks	Reliance on operation of pump station handling diverted flow

The first full bypass was installed in January and is designed to accommodate up to 5.4 million gallons per day. The next bypass will carry approximately 11 million gallons per day and will require the installation of hydro-pit. The hydro-pit will consist of a 12 foot deep excavation for placement of five 6,000 gallon per minute submersible pumps powered by 275 hp diesel generators. The pipe will run about 6,000 feet to another trunk sewer.

## 6. INSTALLATION CONSIDERATIONS

The design team spent a considerable amount of effort to ensure that the project was constructible within the parameters of the plans and specifications. Some of these considerations included trucking limitations, and the footprint of over-the-hole wet out operations.

**Trucking Limitations.** One of the key components of rehabilitating the Central Trunk was minimizing the public impact. One restriction emanating from this goal was minimizing over-the-hole installations. The depth and condition of the Central Trunk would require fairly thick and therefore heavy liners. California Department of Transportation (Caltrans) has very strict load limits that had to be considered if over-the-hole wetout was limited. The design team, with the help of a CIPP contractor, estimated the maximum truckable length for a variety of diameters and liner thicknesses. Specifics to consider include weight restrictions of access road, vehicle weight, weight of liner with resin, and weight of ice (approximately equal to the weight of the liner with resin). The result of this consideration was the installation of a new manhole in a cross-street which also allowed for the abandonment of two backyard manholes on the north end of the project.

**Over-the-Hole Footprint.** Although every contractor has different equipment and commonly used layouts for over-the-hole CIPP installations, the design team estimated the required footprint and plotted the information on aerial maps to provide the District a realistic estimation of the impact. This effort provided a level of confidence for constructability and allowed the District to contact potentially impacted residents to offer alternative accommodations. Figure 4 shows how the footprint evaluation also pointed to the need for an additional manhole at the south end of the project, allowing installation from an undeveloped right-of-way corridor rather than through backyard manholes.



Figure 4: Installation of new manhole for installation of CIPP

## 7. LINER DESIGN

Although there was some discussion of new fiber reinforced CIPP liner, the design team assumed that the project would be installed with traditional felt liner. The specifications were constructed around standard felt liner to limit the use of single source proprietary material, and increase competition. All the calculations used in the trucking limitations were based on traditional liners. If requested, alternate materials would be considered during the submittal process.

The contract was ultimately awarded to Insituform Technologies, and they submitted a request to use glass reinforced liner material for the entire project. The primary benefit would be a thinner liner that would require less resin, allow for longer truckable lengths, and require shorter cure times. Figure 5 shows the effect of flexural modulus values (the primary calculable improvement seen in fiber reinforced liners) on liner thickness. Some of the additional information the District and design team required for evaluation of the alternate material included project references, explanation of long term retention values based on 10,000 hour test results, special handling requirements, and noted specifically that all test results meet or exceed the values used in design calculations rather than the minimum values specified. After receiving and reviewing all the documentation, the glass reinforced liner was approved for use on the project.

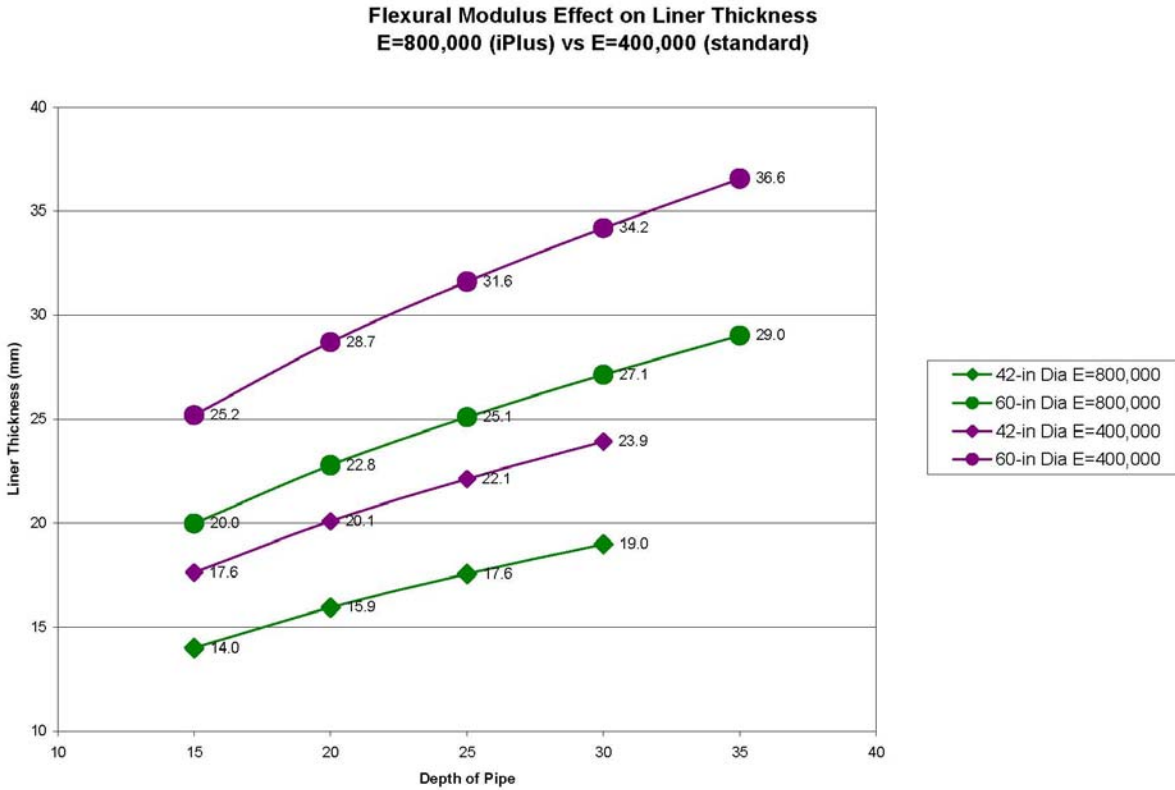


Figure 5: CIPP liner thickness with different flexural modulus values

## 8. QUALITY CONTROL AND QUALITY ASSURANCE

Quality assurance for CIPP is generally established by video inspection and third party testing of prepared liner samples. The use of fiber reinforced liner and steam curing instead of water curing had unanticipated impacts on the quality assurance of the installed liner. Some of the issues that came up early in construction included discoloration of the cured liner, excessively thick liner samples, and a couple of low flexural modulus values. To address the quality control and quality assurance issues, the District and design team met with the Contractor's engineers and agreed to a series of changes and additional testing:

**Discoloration:** Insituform's engineers submitted an explanation regarding the discoloration, and asserted that it was caused by a temperature surge caused by the exotherm of the resin during the curing process. Insituform's engineers claimed that the temperature surge caused the interior polyethylene coating on the liner to blister. County inspectors confirmed a temperature surge during the curing process. The District also contacted a third party engineer, with many years of CIPP experience, for a possible explanation of the discoloration. Not knowing the details, the engineer explained that a temperature surge can cause discoloration. He further explained that temperature surges are common with steam curing during the exotherm of the resin.

County inspectors were present during the wet-out and inversion and did not report any discoloration on the liner. Further, the District and designers collected samples of the discolored liner and found that the discoloration was only located on the interior surface and did not extend through the felt layers of the liner. The District and designers were confident that the discoloration was cosmetic and did not compromise the structural integrity of the liner. To reduce future temperature surges, Insituform's

engineers modified the resin mixture and implemented additional temperature control mechanisms. The discoloration has since subsided.

**Thickness & Flexural Modulus:** By comparing the thickness with the flexural modulus of the prepared samples, it became clear that liner samples that were too thick had lower flexural modulus values. Samples from adjacent shots with the same design thickness, same felt batch, and same resin batch, with correct thickness measurements, had substantially higher flexural modulus values. By collecting incorrectly spaced samples, it was determined that when the spacing between plates, used to prepare liner samples, was too far apart the liner samples began to delaminate, which reduced the strength. Insituform provided additional training to their quality control and sample preparation personnel at the wet-out facility to ensure proper sample material handling and plate spacing. In addition, the contractor checks the sample spacing in the field and keeps a full set of spacers at the job site in case a sample is spaced incorrectly.

**Additional Testing:** To be confident the installed liner did not delaminate and was the correct thickness, the District decided to obtain core samples to measure the actual thickness of the installed liner, and compare it to the results obtained for other shots installed using the same liner and resin batches. The core samples did not show any delaminating and were consistent with the submitted install thickness.

Figure 6 shows the relationship between the tested sample thickness and flexural modulus values. The project team has been successful in resolving the quality assurance issues through open communication between the District, designer, contractor and contractor's engineers. With new procedures in place, all of the subsequent test results have all been satisfactory.

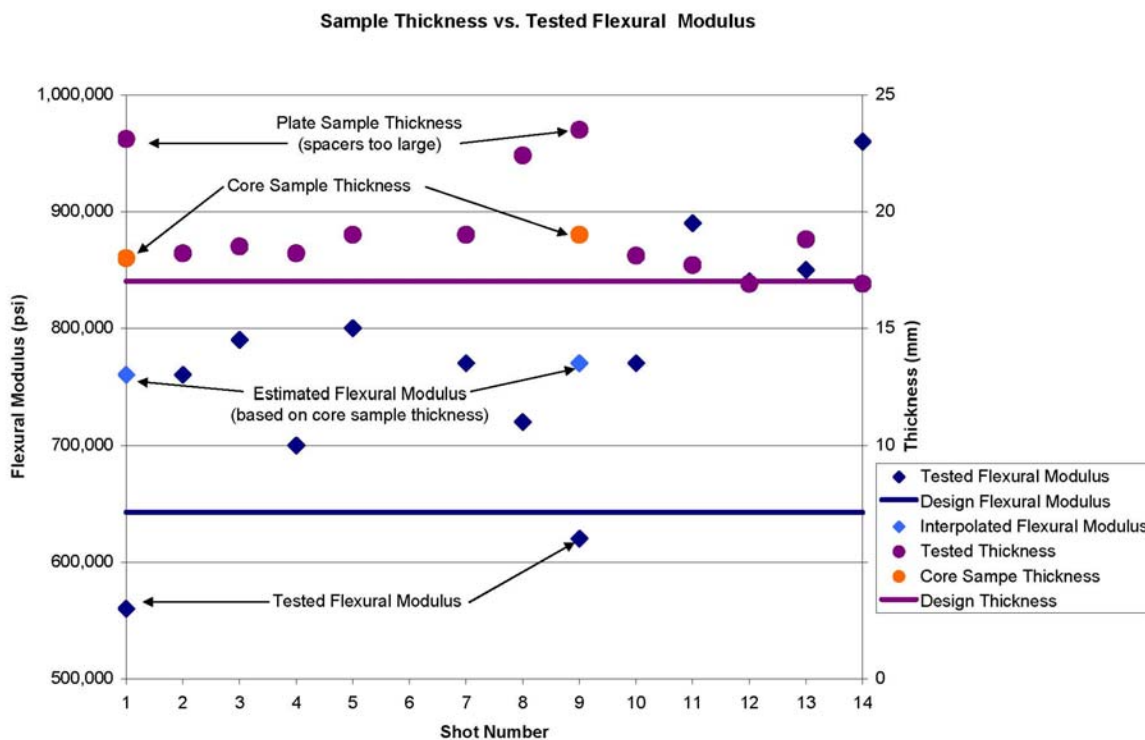


Figure 6: CIPP Sample Thickness vs. Tested Flexural Modulus

## 9. HAZARDOUS DEBRIS DISPOSAL

During the design phase, several samples of debris were collected at various manholes along the project alignment. Although the quantity was small, preliminary tests indicated that the material would be classified as designated or hazardous due to the presence of heavy metals such as lead. Based on previous cleaning records and review of post cleaning sonar, the contract included a line item for disposal of an estimated 700 tons of hazardous material that would need to be removed from the sewer, tested, and properly disposed of. It is critical that the owner know the ramifications of handling this debris. The material that is removed from the trunk sewer belongs to the generator and must be documented by obtaining an EPA ID number. Typically the generator is the owner of the sewer system. Storage and transportation of the material is the responsibility of the Contractor. Some of the items that must be addressed for hazardous material include testing, storage, hauling and disposal.

**Testing:** There is a two tier testing process for potentially hazardous material outlined in California Code Title 22. Total Threshold Limit Concentration (TTLC) is the initial test. If all results fall within TTLC, generally the material is not hazardous and does not require further testing. If TTLC is exceeded, the material is considered hazardous, if TTLC is exceeded by 10 times or more then testing for Soluble Threshold Limit Concentration (STLC) will be required. Initial testing takes time and subsequent testing adds time, these time frames must be considered when storing the material. Once the testing is completed on the first batch and the material is classified and accepted by a disposal facility, no more testing is necessary to take additional loads to the same disposal facility.

**Storage, Hauling and Disposal:** A critical element in handling hazardous material is a work plan. Sacramento County requires that a hazardous material work plan be on file with the Environmental Management Department. The work plan should address liability, containment, secondary containment, bin markings, emergency clean up, hauling, and storage time limits. A transfer facility is a location where material may be stored temporarily prior to proper disposal. If the transfer facility is on the generators property then the time limit is 90 days, otherwise the time limit is 10 days. The hauler must also have an EPA ID number to haul hazardous material and the material must be disposed of in an appropriate facility.

The District did not fully investigate the hazardous material handling requirements prior to awarding the contract. The contractor assumed that the material would not end up being classified as hazardous. Therefore all of the work required for the testing, storage, hauling and disposal of the debris removed from the Central Trunk took longer than anticipated. The transfer facility was initially set up incorrectly and had to be moved quickly to bring it into compliance. The lesson learned is for the District to fully understand the permitting requirements prior to beginning construction.

## 10. CONCLUSION

The Central Trunk project is unique in its large diameters and long runs. The lining is approximately 30 percent complete with the largest diameters, largest bypass installations, and longest shots still to come. The proactive team oriented approach to solving problems has allowed challenges to become successes. The owner and contractor have worked together to keep the project on schedule and within budget.