BALTIMORE CITY TRENCHLESS: HOWARD STREET WATER LEAK INVESTIGATION & REPAIR

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ACTIVE WATER LEAK ON HOWARD STREET

Baltimore City Department of Public Works was informed of an active water leak on Howard Street. The location of the leak caused concern and was designated for immediate repair. The immediate concern was due to the fact that the leaks were not surfacing but entering the CSX tunnel running under the Light Rail tracks in Howard Street. This leak caused a sink hole about 16 x 22 feet in area under the Maryland Transportation Authority (MTA) light rail tracks and goes all the way to the CSX tunnel running under the MTA tracks. The repair of water main was carried out over the CSX tunnel and under MTA light rail tracks.

Baltimore City had prepared in advance for emergencies with current on-call Contracts for engineering and repair. EBA led and coordinated the repair activities until complete. EBA provided engineering and inspection support to the City and worked directly with the Contractor for this emergency repair. . The foresight by Baltimore City to have on-call contractor and on-call consultant resulted in the most efficient identification of the leaks, extensive coordination, permit acquisition, urgent and durable design, and repair of the leaks. As you will see in this article there were many entities involved in the project, which required many site visits and numerous approvals to complete the project. Proper coordination and cooperation were essential to complete the project quickly and successfully.

SIGNIFICANT WATER INFILTRATION

EBA received a call from the Baltimore City that water is leaking into the CSX tunnel and a site visit was scheduled to determine the issue. EBA arrived onsite to provide a visual evaluation of a portion of the Howard Street Tunnel where extensive water infiltration was occurring. Arriving onsite at approximately 7 PM at the intersection of Ostend and Warner Streets, EBA Engineers met with the response team. The response team was transported into the tunnel at approximately 7.30 PM by CSX Transportation. The response team arrived at the problem area which was located at Station 4500 in the tunnel. It was understood that this location corresponded to the area on the ground surface along Howard between Lexington and Saratoga Streets.

There was significant water infiltration occurring within the problem area. The water infiltration consisted of extensive dripping, seeping and flowing water across a distance of about 200 feet of tunnel. The water infiltration was relatively equal over the entire tunnel section meaning water infiltration was occurring from the crown down to the base of each side. The areas of flowing water were generally located near the base on each side. The crown was dripping from many locations. The information indicated that water was impounded over the entire tunnel section. The water infiltration appeared to be occurring through cracks and gaps in the brick and mortar tunnel lining. Soil infiltration was limited but occurring

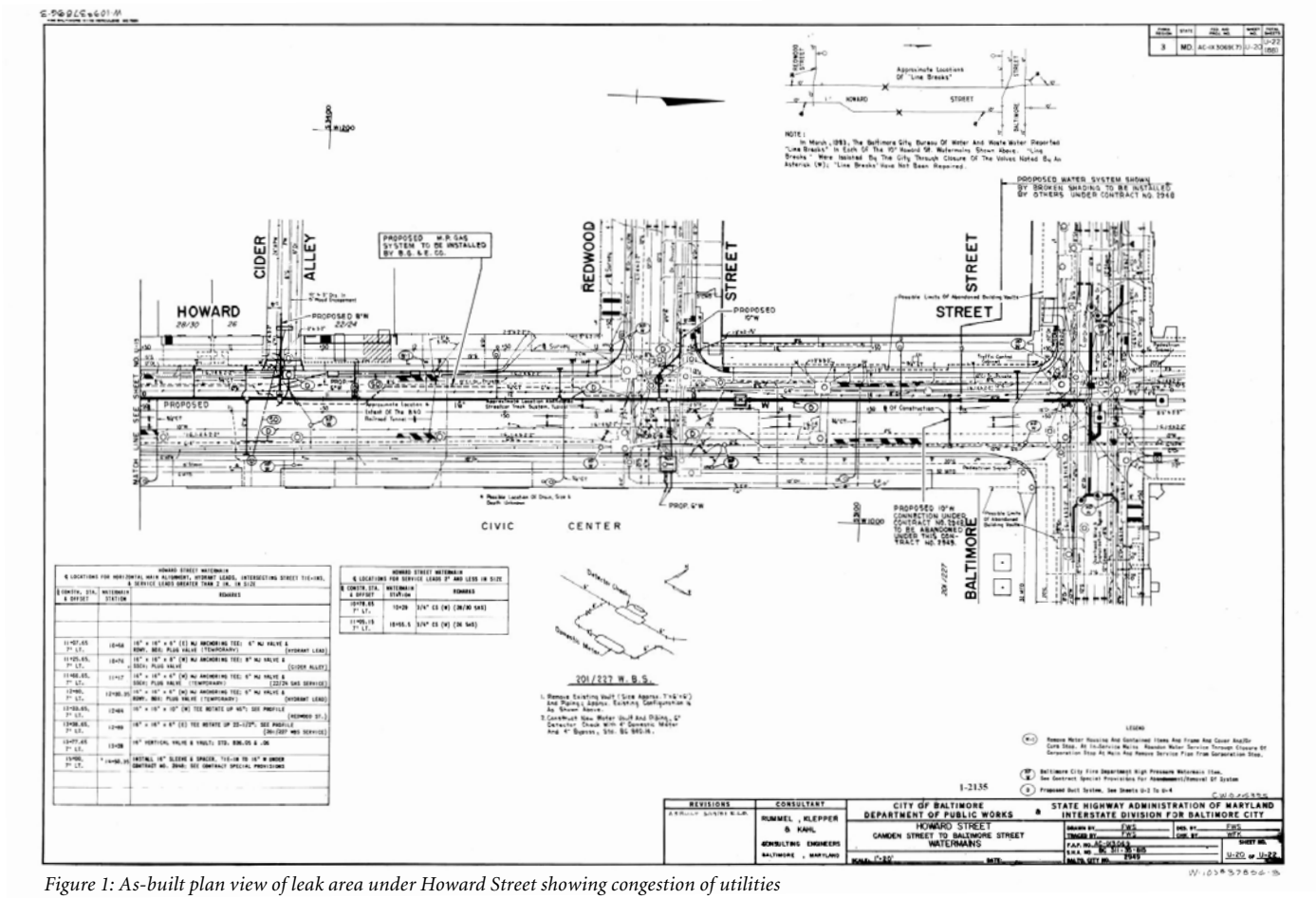

Figure 1: As-built plan view of leak area under Howard Street showing congestion of utilities

> ***"THE IMMEDIATE CONCERN WAS DUE TO THE FACT THAT THE LEAKS WERE NOT SURFACING BUT ENTERING THE CSX TUNNEL."***

at some locations. The water was clear and did not have an odor indicating likelihood of potable water.

The area of water infiltration did not exhibit evidence of structural distress. Bowing, buckling or cracking of the walls was not observed in the area of water infiltration. The mortar was intact and did not appear to be eroded due to the action of flowing water. However, the impounded water around the tunnel envelope was contributing to increased hydrostatic pressure on the walls and crown. The source of the water had to be identified and controlled to reduce the pressure. The increased pressure had potential to cause a failure of the tunnel envelope or blow out the tunnel bottom.

It was understood from discussion with CSX that the water infiltration had been occurring over a period of weeks or months and was steadily increasing. The problem had increased to the level where CSX notified the City of Baltimore and a response initiated. CSX indicated that the flow did not appear to be related to precipitation events. It had been relatively dry for a

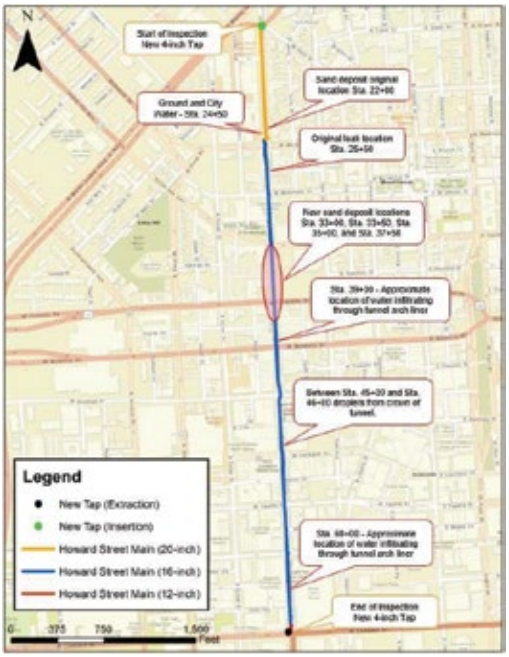

Figure 2: Plan of the SmartBall inspection

Figure 3: Installed entry port for the SmartBall was outside the special pad area of the light rail tracks

period of about two weeks but the flow had increased over this time. The collected water was being managed by a series of pumps in the tunnel, however, the flow was increasing to a level where the pumps could not manage the flow any longer.

It was advised that CSX inspect the tunnel after each train passed for evidence of structural distress. Evidence would include loss of bricks at the tunnel crown or buckling or cracking of the tunnel walls. There was also possibility of a bottom blowout. The source of the water needed to be controlled in an urgent manner or additional measures taken to protect the tunnel structure. It was noted that there was active building construction underway on the ground surface in the vicinity of the problem area. That location could be the ultimate source of the problem.

Additionally, it was understood that the City of Baltimore had been previously aware of the issue since they had been attempting to locate the source of a potential water main break on the ground surface for several weeks, without success. It is not clear if the effort to locate the break was limited to inspecting the larger water mains in the area, or if this effort also included service connections or smaller lines.

It was understood that the City of Baltimore was going to continue these efforts. The area had a great deal of utilities and other structures which need to be exactly located when any repairs were undertaken.

INSPECTION & ANALYSIS

It was not an easy task to find a water leak with unknown origin. Several utilities are present along Howard St including water, sewer, storm, steam, cable, electric, telecommunication, etc. Several utilities and structures were CCTVed, finally Pure Technologies was retained and performed analysis of the watermain by use of the trenchless technology inspection application, the Smart Ball. The location of the three leaks were identified and marked above ground on Howard Street. Normal procedures for locating the leaks were not applicable because of the Light Rail special pad along Howard Street. The installed entry point for the tool was just outside of this special pad area of the light rail tracks.

Figure 4: Dig Sheet showing location of Leak 1 under Howard Street

Figure 5: Dual use by vehicles and light rail was a complicating factor

Pure Technologies completed the SmartBall inspection on Sunday, August 8, 2021. The SmartBall leak and gas pocket detection survey used acoustic technology to detect potential leaks and any areas of trapped or entrained gas within the pipeline. The inspection spanned approximately 4,969 feet (0.94 miles) of the Howard Street Mall.

The analysis of the inspection data identified no acoustic events characteristic of entrained or trapped gas and three acoustic events characteristics of a leak. Based on the magnitude of the acoustic signature, the size of the first leak was estimated to be in the range of 2 - 10 gallons per minute (GPM). The size of the second and third leaks were estimated to be less than 2 GPM and were suspected feature-related leaks. This estimate was determined by comparing decibel levels of detected leaks with calibration data collected during test trials and validations. Pure Technologies' analytic process used tracking sensor data, along with the tool's internal rotational and heading data, to identify the location of each leak.

The first leak was located approximately 1,781 feet upstream from the 4-inch extraction tap at the intersection of Howard Street and West Lombard Street. Given the location and acoustic signature, Pure Technologies was uncertain whether the leak was located at the barrel or at the joint.

The second leak was located approximately 347 feet upstream from the 4-inch extraction tap at the intersection of Howard Street and West Lombard Street. Given its location near an 8-inch Combined Fire and Domestic Service outlet (Valve 030606V) and 0.75-inch Domestic Service Connection, this leak was suspected to be feature-related.

The third leak was located approximately 248 feet upstream from the 4-inch extraction tap at the intersection of Howard Street and West Lombard Street. Given the location, this leak was also suspected to be a feature-related leak, as it was nearby another 8-inch Combined Fire and Domestic Service (Valve 020463V) outlet.

REPAIR PROCEDURE

The entire repair procedure and investigation was determined by the location of the special pad for the Light Rail trains and the stipulation there was no cutting into the slab, which covered a good portion of the Howard Street width. Another complication was the dual use of Howard Street by vehicles and the Light Rail, with the tracks are on each side of the street and a travel lane in the center. The layout changed periodically through the 3 leak areas with a light rail stop in one area.

EBA chose to address the largest leak first that was releasing 2-10 gpm of water. The water main was located on the edge of the light rail slab and the road, so no tunneling was required. EBA prepared the design documents for the repair and obtained permit from MTA. Only night work was allowed to do the repair. EBA

> *"SAFETY WAS A HIGH PRIORITY FOR THIS PROJECT."*

Figure 6: Light rail stops were closed during repairs

Figure 7: One of the largest voids discovered under the light rail slab

first did the 2-inch test holes in the area identified by leak detection to confirm the leak. Both the test hole results came out dry. Excavation was carried out at the identified location but no leak was found. So PURE did the correlation and listening by tapping to the 16-inch water main and using ground mic to mark the leak location at a different location nearby at a 2-inch water house connection off of 16-inch water main. When the contractor excavated that area he found a leaking 2-inch galvanized water house connection. The house connection was turned off to stop the leak. Since this 2-inch water connection went under the MTA light rail concrete slab, large conduit in the road, and other utilities, it was decided to install the water house connection trenchless using the existing galvanized pipe as a casing pipe. So the new 1.5-inch water house connection was pulled inside the existing 2-inch pipe.

While the contractor was repairing the water house connection he discovered a large 16 x 22-foot sink hole that went all the way to the CSX tunnel. The leaking water from the house connection washed away all the soil into the CSX tunnel. MTA, Baltimore City DOT and CSX was immediately notified of the sink hole issue. Since the CSX tunnel inspection indicated there was silt entering with the leaking water, it was expected that there would be some voids under the light rail pad that would need to be filled. Train operation and

Figure 8: Grouting of major void with flowable fill, with access just outside of light rail slab

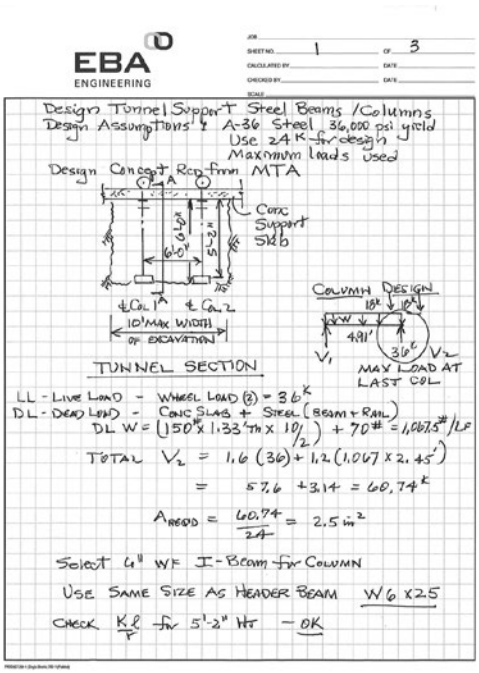

Figure 10: Sketch of tunnel design showing detail and calculations

all traffic was suspended, Right-of-Entry permit was obtained from MTA, workers were trained to work on MTA tracks, traffic control was placed and sink hole repair design was prepared and approved by all parties.

Controlled Low Strength Material (CLSM) was designed to fill the void and deliver at a rate so that it would not seep into the CSX tunnel underneath. Continuous monitoring of the CSX tunnel and settlement survey of the MTA slab was performed during the void filling operation.

While these designs were being developed, and the Contractor scheduling employees and equipment, EBA obtained the required permits to carry out the work and coordination with MTA, CSX and Baltimore City. However, after the Contractor scheduled mobilization to the site, MTA stopped the entire repair operation until full railroad safety training was performed and completed by all personnel working on or near the rails.

Railroad safety training was offered to the team, and a four-hour safety course was conducted on Dec 2, 2021. All Contractor and Engineer team members attended and obtained the required Certification. This delay was unforeseen, and added extra time and cost to the emergency repair. This event could have been avoided with foresight, since MTA

Figure 9: Location of leaking 8-inch valve. A tunnel was constructed to complete the repair

Figure 11: Construction of the steel tunnel system

closed down the tracks and bussed train passengers around the repair area anyways. There were no Light Rail trains on the tracks during the entire repair period.

Coordination with CSX, MTA and the City was necessary to determine a plan for the filling of the voids. Comments were received from each as to their requirements. The CSX tunnel was inspected and monitored while flowable fill was being installed to ensure no fill was coming into the tunnel. The mix was formulated to flow into the voids but thick enough to not infiltrate into the CSX tunnel.

All work was performed outside of the Light Rail special pad. Each of the three leaks involved differing requirements for repair. One leak was on a 1.5- inch service line. The corporation cock was outside of the Light Rail slab and able to be excavated to cut off the service.

The second leak was valve packing on an 8-inch valve on the 8-inch water service located at 10 S Howard Street between the North and South bound Light Rail tracks.

Figure 12: When tunneling towards the valve, a large gas line was encountered

The plan was developed to construct an 8 x 24-foot tunnel to access the valve under the Light Rail tracks and replace the packing to stop the leak.

The normal method of replacing the packing could not be used because no excavation could take place on the special light rail slab. Therefore, the Contractor was required to build a tunnel from outside the light rail slab area to the valve in order to complete the repair. EBA designed the tunnel and submitted for approval by the MTA and CSX. It was a very challenging design as the tunnel was designed under the MTA light rail and over the CSX tunnel, with several crossing utilities. Trenchless options were considered but none worked out due to site condition.

When tunneling toward the valve the shoring used to install CSX tunnel was encountered. EBA immediately coordinated a site meeting with the CSX and briefed them about the problem and possible solutions. CSX allowed the contractor to remove the shoring up to the wood lagging.

This complicated the tunneling operation and caused additional delay in the repair of the 8-inch valve.

Safety was a high priority for this project. Excavation shoring was essential for any excavations as there was some vehicular traffic still allowed during some of the repair work. A lot of work was required to be done at night to avoid traffic delays and impacts on businesses. Proper lighting and signage was required to protect the workers and any pedestrians on sidewalks. All tunneling safety measures were taken to ensure that no workers would be in danger while excavating the tunnel and installing the steel tunnel supports. Proper training and certification was required for all individuals involved in the work on Howard Street to repair the water leaks and to fill all voids and excavated areas.

These three leaks could not have been identified and repaired in such an efficient and quick manner without the use of trenchless technology equipment, methods and tunneling techniques.

ABOUT THE AUTHORS:

Richard Thomasson. P.E. *has more than 52 years of experience working in the water and wastewater fields. He has been closely involved with trenchless technology for nearly his entire career. While at the Washington Suburban Sanitary Commission, he directed many uses of new trenchless technologies, retiring after 31 years as the Director of Construction. He is currently a Senior Project Manager with EBA Engineering, Inc.*

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