CLEARANCE IMPROVEMENTS ALONG THE CSX TRENTON LINE

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Abstract

The Trenton Line is a critical and heavily utilized corridor within the CSX network, providing goods movement through Philadelphia to other major East Coast ports along I-95. To further maximize this line, CSX sought to improve the vertical clearance to allow the movement of double-stack container cars.

The project is comprised of 7 design-bid-build contracts, with 16 overhead crossings between Philadelphia and Bucks County, Pennsylvania which required track improvements to achieve the 21 foot minimum vertical clearance for double-stack operation. Track lowering is approximately 5 feet in some areas, to be accomplished by conventional excavation methods as well as through the use of track undercutter equipment. The staging of track lowering was designed to accommodate rail operations throughout construction.

The existing corridor had an aging and insufficient drainage infrastructure. Several areas of the project were already known to experience severe flooding problems prior to track lowering, and frequently required temporary pumping to restore track operations. To resolve these issues, several major stormwater management features were designed for the project including a detention basin and stormwater pump stations, one of which utilized jockey and main pumps to handle flows up to a maximum capacity of 15,000 GPM.

The design also addressed lowering the existing tracks while maintaining the integrity of century-old building and bridge foundations and shallow underground utility lines which were not feasible to relocate due to their size and service area. This paper will present the engineering design for the entire project, and construction completed to date.

Introduction

Project Purpose

The Trenton Line Clearance Improvement Project (TLCIP) was a joint effort by CSX Transportation and the Pennsylvania Department of Transportation to improve minimum vertical clearance over the railroad and remove restrictions to the movement of second-generation double stack cars between northern New Jersey and south Philadelphia, Pennsylvania.

Background / History

The Trenton Line corridor, formerly designated as the New York Short Line Railroad, was operated by the Philadelphia and Reading Railway until being merged into Conrail in the 1970s. Iconic industrial companies like Tasty Baking Company which is now Tastykake, the Midvale Steel and Ordnance Company (see Figure 1), and the Budd Company which fabricated metal components for the automobile industry and passenger rail cars, as well as many neighborhoods, developed and thrived alongside this rail line during the 20th century.

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Today, the Trenton Line is a heavily utilized freight line for CSX, providing goods movement through Philadelphia to other major East Coast ports along I-95. This rail corridor is closely bounded by dense industrial and residential development, with century-old building and bridge foundations and shallow underground utility lines. Many of the overhead structures are now 75 to 100 years old and provide several feet less than the required 21-foot minimum vertical clearance to operate today’s double-stack container cars. The age and types of the existing overhead structures combined with the location of underground utilities complicated the means by which vertical clearance could be achieved.

Project Scope

The project limits span from CP Nice in North Philadelphia approximately 22 miles northeast to CP Wood in Bucks County, Pennsylvania and include 16 overhead obstructions that required improved vertical clearance. It is an integral piece within the CSX Intermodal track system, as indicated on Figure 2. The project was completed through 8 design-bid-build contracts, with track lowering in excess of 5 feet in some areas to achieve a minimum vertical clearance of 21 feet. Methods of track lowering included conventional excavation, track shifting, and the use of track undercutter equipment.
In addition to the track lowering challenges, several areas of the project frequently flooded prior to track lowering and required pumping by track maintenance crews to maintain rail operations. The design addressed these flood-prone areas and included stormwater drainage systems to efficiently handle flows along the corridor.

**Engineering Investigations**

A thorough series of engineering investigations was performed for the project to collect and analyze site data in support of the design phase of the project. The investigations primarily involved surveys, geotechnical explorations, utility data collection, environmental permitting, structural information, and agency coordination.

**Survey / Mapping**

**Aerial Survey** - The collection of topographic and railroad asset information for engineering or database population along rail corridors and yards has traditionally required putting people on the tracks. John Chance Land Surveys, Inc. was utilized to provide Fast Laser Imaging-Mapping and Profiling (FLI-MAP) for this project. FLI-MAP minimized impacts to rail operations collected topographic data aerially, much more quickly and safely than traditional ground surveying.

FLI-MAP integrates several different technologies to gather geographic information and deliver it in a usable desktop format. Built around the Global Positioning System (GPS), the system geo-references data that is simultaneously gathered with video and LiDAR (Light Detection and Ranging) equipment. By correlating the GPS, video, and LiDAR data, the FLIP7® software package was used to compile information on terrain, vegetation and other features. This information was then transferred into a format compatible within MicroStation for the development of design drawings.

The FLI-MAP system, aboard a specially equipped Bell 206L helicopter (Figure 3), was flown over the railroad corridor collecting precise GPS, platform altitude, laser ranges, and imagery data. With a data collection rate of 10,000 ranges per second per laser, height above ground of approximately 150 feet (dependent upon height of structures and utility lines), and an aircraft velocity of 45 miles per hour, data collection density was approximately one survey point per square foot.
This data density made it possible to differentiate objects such as rails, signal equipment, turnouts, transmission line structures, conductors, distribution poles, buildings, and objects by recognizing patterns of points with spatial relationships (Figure 4).

**Figure 3:** FLI-MAP System on Helicopter

Ground Survey

Ground survey was performed by several survey firms to augment the FLI-MAP topographic survey. This survey collected points not able to be located by aerial mapping (due to obstructions), and to establish top of rail data and existing clearances more accurately for design purposes. Since the aerial mapping was performed first, it was critical that all subsequent ground surveys utilized the same primary control data to establish their GPS control.

**Figure 4:** FLI-MAP Data Density

**Geotechnical**

An Initial review of published geologic maps of the Philadelphia area indicated that the site is underlain by Wissahickon Formation, which consists of highly micaeous, coarsely crystalline, schist. To better understand the depth and quality of
subsurface materials, geotechnical explorations were conducted along the track alignment and at the obstructing bridges and utilities. The geotechnical explorations included: geophysical investigations, test borings, and test pits.

Seismic refraction was utilized to evaluate the depth and quality of the rock surface at multiple locations throughout the project. The seismic refraction survey created an induced compression wave by using various methods based upon site conditions and access, including a AWD-450, a 90 pound AWD, a Betsy Seisgun (Figure 5), and a 16 pound sledge hammer. Geophones were placed on the ground surface at selected distances to record the ground motion caused by the resultant wave.

A 24 channel ABEM Mark 6 seismograph was used to measure the time required for the resultant wave to arrive at each geophone. Analysis of the data (travel times and distances) provided seismic velocities of subsurface material and depths to significant velocity interfaces.

Results from the seismic refraction indicated varying subsurface conditions, with seismic velocities indicative of bedrock which varied from highly fractured or weathered to competent bedrock. A total of 65 ground truthing test pits were excavated using a Bobcat 325 rubber-tracked backhoe to verify and refine the geophysical data.

The seismic data for the project indicated that the shallow rock layer had seismic velocities in the range of 1,000-3,000 ft/sec, which is indicative of compact soil to very dense saprolite, while the deeper rock layer exhibited seismic velocities in the range of 3,000-16,000 ft/sec, which is indicative of highly weathered or fractured rock to competent rock.

At one site ground penetrating radar (GPR) was utilized to determine the depth to the competent rock layer. The data was collected using an all-terrain vehicle (ATV) to pull a sled carrying the GPR scanning equipment along the track centerline (Figure 6). The survey was conducted using both a 400 MHz and a 200 MHz antenna.
In addition to the geophysical investigations, a series of 27 test borings was performed using both an ATV mounted rig (Figure 7) and a CME 45C track rig. Borings were advanced through soil and cored into bedrock to depths ranging from 10 to 36 feet below ground surface. Continuous soil sampling was performed using a 1½ inch inside diameter, 2 foot long split spoon sampler. Rock coring was performed by an NQ wireline core barrel.

The core borings confirmed the overburden soils consisted primarily of micaceous silty sand classified as SM derived from the decomposition and weathering of the underlying mica schist bedrock (Figure 8).

![Figure 6: Ground Penetrating Radar Survey at Contract 6](image)

![Figure 7: Test Boring using ATV Mounted Rig](image)

![Figure 8: Core Samples from Test Borings](image)
The third component of the geotechnical investigations was a series of test pits excavated to determine foundation depth, type, configuration and bearing medium of the abutments or the piers of the overhead bridges and retaining walls, as well as to locate existing culverts and utilities that cross beneath the tracks. A total of 90 test pits were excavated using a Bobcat 325 rubber-tracked backhoe to confirm structure foundations and subsurface utilities (Figure 9). Test pits logs and photographs were prepared and cataloged which proved very useful for correlation with utility and bridge plans.

Utilities

Prior to the start of excavation, notification was placed with the Pennsylvania One-Call System to have existing utilities marked-out in the field and to make requests for existing facility plans from each utility company. Throughout the design phase, coordination continued in order to maintain current excavation serial numbers and obtain further existing information.

Due to the urban setting of the TLCIP corridor, there are many different utility providers in the vicinity of the project. Utility coordination was performed with the following utility providers and agencies:

- Aqua America Inc.
- Bucks County Water & Sewer Authority (BCWSA)
- City of Philadelphia Department of Streets
- Comcast
- Level 3 Communications
- Norfolk Southern Corporation
- PECO
- Pennsylvania Department of Transportation (PennDOT)
- Philadelphia Gas Works (PGW)
- Philadelphia Water Department (PWD)
- Southeastern Pennsylvania Transportation Authority (SEPTA)
- Verizon
- XO Communications
- Zayo Group
An extensive amount of plans were received from utility companies and were reviewed to incorporate existing facility information onto the design drawings. Figure 10 represents a sample sewer plan received from PWD. Plans of this nature were quite helpful in identifying potential obstructions to track lowering.

Figure 10: PWD Sewer Plan

In addition to collecting information from utility companies, coordination was also performed to notify CSX of proposed excavations along the tracks and to obtain data on their existing railroad communication and signal facilities along the corridor.

The information provided by the existing plans was sometimes difficult to interpret due to the age of the lines and the quality of the files received. In an effort to clarify the presence and location of several key utility lines, a series of subsurface utility investigations was performed that involved subsurface utility engineering (SUE) and pipe video services.

SoftDig was used to perform Quality Level A SUE investigation of several water lines. This level of investigation involved the nondestructive exposure of the underground lines using a vacuum truck, followed by the identification and precise mapping of the pipes. Pipe Data View Services was brought in to video several of the sewer lines that run below the track. A video camera mounted on a wheeled robotic vehicle (Figure 11) was guided through portions of the sewers and collected critical data that was used to confirm the existing lateral connections, condition of the pipe walls, and presence of flow. For one of the major sewer lines in the area, the pipe video provided information that was not clear from the plans - that the existing sewer had been closed off by a masonry wall and no longer ran below the CSX track (Figure 12).
Fiber optic lines were present longitudinally along much of the rail corridor, and required early coordination with those utility providers for relocation of portions of their lines prior to the proposed track shifting and slope grading designed for this project.

Environmental / Permitting

Due to funding participation by the Federal Highway Administration (FHWA) and PennDOT, the project needed to comply with the National Environmental Policy Act (NEPA) of 1969. Based upon the scoping field view conducted by FHWA and PennDOT, it was determined that this project met the criteria for NEPA Class II, Categorical Exclusion Evaluation (CEE).

The environmental resource investigation included wetlands, waterways, threatened and endangered species, hazardous waste and historic resources.

- **Wetlands / Waterways / Endangered Species** - The wetlands, waterways, and endangered species resource investigations were conducted by performing both a desktop review of available mapping and a wetland “absence/presence” determination of the natural areas surrounding each of the contracts. A formal review of known locations of endangered or threatened species in the project areas was coordinated with the U.S. Fish and Wildlife Service (USFWS), Pennsylvania Fish and Boat Commission (PF&BC), Pennsylvania Natural Diversity Inventory (PNDI), and the Pennsylvania Game Commission (PGC).

- **Hazardous Waste** – Phase I and Phase II Environmental Site Assessments were conducted for the project and included records review, site reconnaissance, sample collection and analysis, and reporting.

- **Historic Resources** - During the scoping field view, PENNDOT and the FHWA determined that the project meets the requirements under the “Programmatic Agreement for Minor Transportation Projects” (PA), Stipulation D.

Based upon the results of the environmental resource investigation and the potential impacts of the project, a Level 1b CEE was required and obtained for the TLCIP.

In addition to achieving environmental clearance for the project, the required permits and approvals for erosion and sediment control and stormwater management were developed and obtained for each contract.

**Structural**
As part of the design phase, the impacts to existing structures were determined. Coordination was performed with the City of Philadelphia, SEPTA, PennDOT, and private property owners to obtain plans of the existing overhead bridges, retaining walls, and buildings that could be affected by the proposed track lowering (Figure 13). In addition to obtaining plans of the existing structures, meetings were conducted with the affected parties to review the project and determine impacts to the structures.

Agency Coordination

Early in the design phase, the team contacted and held many meetings with various agencies and private property owners to obtain right-of-entry permits and coordinate the field investigations and the proposed design. Key agency stakeholders included the City of Philadelphia, PennDOT, SEPTA, Norfolk Southern, and industrial property owners. For each contract, coordination was also performed to obtain approval by the Pennsylvania Public Utility Commission (PUC) which has jurisdiction at each of the railroad crossings. These efforts were critical to achieve “build-in” of the input and concerns of these stakeholders into the design of the project.

Project Sites

The location of each of the contracts is provided on Figure 13. Design has been completed for all contracts, and construction is complete for 5 of the 7 contracts. It is anticipated that construction will be completed by the end of 2015.

One of the significant challenges of the project was the operational expenses of train traffic and the avoidance of train delays to achieve work windows required for the construction. As a result, detailed construction staging was developed for each contract.

It was not feasible to raise or modify any of the overhead bridges on this project due to structure type, age and the potentially severe impacts to the overhead travelling public.
For each contract below, the key design and construction issues have been highlighted. Additional photographs and images are provided in the presentation that accompanies this paper.

**Contract 1**

Contract 1 is located in the Nicetown section of North Philadelphia and included vertical clearance restriction at 4 overhead bridges: Fox Street, Stokley Street, Wissahickon Avenue, and the SEPTA 9th Street Branch. The existing 4-track section was reduced to 2 mainline tracks as also included improvements to the SEPTA Blue Line track and the Richmond Industrial Track which connect into the limits of Contract 1.

The overall length of this contract was 6800 feet and is bounded closely by industrial buildings, retaining walls, residential properties, and SEPTA bus and rail yards. The track design also included reducing the length of the existing interlocking (CP Nice) to improve track operations. Track lowering was approximately 5 feet and was achieved using multi-stage track phasing and conventional excavation methods. The maximum track grade designed and constructed through Contract 1 was 0.84%.

Soldier pile and lagging walls and gabion walls were constructed along existing foundations and at the toe of slopes to support existing subgrade soils. Shotcrete protection was used to encapsulate and protect portions of existing foundations that were on competent rock and where track lowering would not undermine the foundation.

Several large utilities exist at shallow elevations below the track, and it was not feasible to relocate them due to the potential large scale impact to the surrounding area. To accommodate the necessary track lowering over these utilities, cast-in-place concrete protection slabs were designed and constructed (Figure 14). Due to the need to maintain rail traffic during construction, the slabs were constructed in phases.

![Figure 14: Utility Protection Slab Detail](image)

Portions of Contract 1 routinely experienced flooding prior to the project due to poor grading and lack of a drainage system. To address the flooding and drainage issues, a new stormwater management system included a new network of ditches and cross pipes, a detention basin, and a pump station. The pump station uses a combination of 4 ITT Flygt submersible pumps (2 main, 2 jockey) that can handle maximum pump rates of approximately 15,000 gallons per minute.

**Contract 2**
Contract 2 is located immediately railroad east of Contract 1 and runs through the Germantown section of North Philadelphia. This contract included vertical clearance restrictions at 3 overhead bridges: SEPTA Liberty Yard Bridge, Wayne Avenue, and Germantown Avenue.

This contract is a single-track section with an overall length of 3000 feet. It is bounded closely by large concrete and masonry retaining walls that support an adjacent roadway (Clarissa Street) on one side and the SEPTA Regional Rail tracks on the other side, and is referred to as the “Low Grade” due to the track being 20 to 35 feet below the surrounding infrastructure.

This contract was broken into 2 bid packages, one for the track level construction, and the other for the relocation of approximately 1100 linear feet of sewer main that could not be protected or lowered further below the track. Extensive coordination was required to obtain design approval of the sewer relocation with PWD, as well as with private property owners with lateral connections to the sewer main.

The maximum track lowering was approximately 4 feet and was achieved using multiple track shifts and conventional excavation methods. The maximum track grade through Contract 2 was 1.15% which was required to accommodate clearance above an existing 6.5 foot diameter sewer line in close proximity to the Germantown Avenue overhead bridge.

Soldier pile and lagging walls were constructed along much of the existing retaining wall foundations to support existing subgrade soils with the designed track lowering (Figure 15). Shotcrete protection was used to encapsulate and protect portions of existing foundations that were on competent rock and where track lowering would not undermine the foundation.

![Figure 15: Soldier Pile and Lagging Footing Protection Detail](image)

Similar to Contract 1, Contract 2 routinely experienced flooding prior to the project due to the low elevation of this track relative to the surrounding area and lack of adequate drainage. To address the flooding and drainage issues, a new stormwater management system included a new network of ditches and cross pipes and a pump station. The pump station uses a series of 2 ITT Flygt submersible pumps that can handle maximum pump rates of approximately 1,960 gallons per minute.
**Contract 3**

Contract 3 included vertical clearance restrictions at the Olney Avenue overhead bridge. This contract is a single-track section with an overall length of 2250 feet and is adjacent to an active SEPTA Regional Rail track. Prior to this project, CSX separately performed track modifications to separate the CSX track from the SEPTA track, as well as remove unused catenary hangers that were a vertical restriction to double-stack clearance.

The maximum track lowering was approximately 9 inches and was achieved through conventional excavation methods and shifting the track to one side. The maximum track grade through Contract 3 was 0.83%. This contract also included improvements to the existing drainage system.

**Contract 4**

Contract 4 is located in northeast Burholme section of northeast Philadelphia and included vertical clearance restrictions at 2 overhead bridges: Cottman Avenue and the Oxford Avenue/Bleich Street intersection. This contract had an overall length of 2250 feet and is bounded by steep slopes and commercial and residential properties.

The maximum track lowering was approximately 1.2 feet and was achieved through shifting the single-track and conventional excavation methods. The maximum track grade through Contract 5 was 0.68%. This contract also included improvements to the existing drainage system that included regraded ditches and pipes in locations with limited clearance.

This contract also included major structural modifications to an existing PWD storm sewer to permit track lowering. The existing sewer was a 4 foot high by 6 foot wide concrete box section that required removal of the top portion and reducing the inside height by approximately 1.5 feet. To accomplish this and maintain the existing hydraulic capacity of the system, the proposed sewer was designed as a 3-chamber section with an inside height of 2.5 feet and an outside width of 20 feet. In addition, drainage along both sides of the track was designed to be conveyed through steel piping that was cast into the reconstructed top portion of the sewer as indicated in Figure 16.

![Figure 16: Contract 4 Sewer Reconstruction Plan](image-url)
Contract 5 is located in the northeast section of Philadelphia and included vertical clearance restrictions at 3 overhead bridges: Bustleton Avenue, Red Lion Road, and Byberry Road. This contract had an overall length of 7300 feet and is bounded by mostly commercial and residential properties.

The maximum track lowering was approximately 3 feet and was achieved through the use of on-track undercutter equipment. The maximum track grade through Contract 5 was 0.67%. This contract also included improvements to the existing drainage system that included regraded ditches and pipes in locations with limited clearance.

A soldier pile and lagging wall was constructed to support the existing subgrade soils at the Byberry Road overhead bridge. Due to the low overhead clearances, compact drilling equipment was required to construct the soldier pile and lagging wall.

Contract 6

Contract 6 is located in northeast section of Philadelphia and included vertical clearance restriction at the Southampton Road overhead bridge. This contract is a double-track section (mainline and siding) and had an overall length of 2400 feet. Residential and commercial properties and steep slopes with rock outcroppings are located on both sides of this site.

Prior to the start of construction at this site, coordination was performed with PECO to relocate several electrical transmission poles and guy wires that were impacted by the proposed slope grading to achieve track lowering (Figure 17).

The maximum track lowering at this site was approximately 2.5 feet and was achieved through the use of conventional excavation methods. The maximum track grade through Contract 6 was 1.00%. This contract also included improvements to the existing drainage system that included regraded ditches and pipes in locations with limited clearance.

A soldier pile and lagging wall was constructed to support the existing subgrade soils at the south abutment of the Southampton Road Bridge. Due to the low overhead clearances, compact drilling equipment was required to construct the soldier pile and lagging wall.

Contract 7

Contract 7 is located in Middletown, Bucks County and included vertical clearance restrictions at the Norfolk Southern Morrisville Line overhead bridge. This contract had an overall length of 2300 feet and is adjacent to 2 active SEPTA Regional Rail tracks and the Woodbourne Station.
The maximum track lowering was approximately 1.4 feet and was achieved through the use of on-track undercutter equipment. The maximum track grade through Contract 7 was 1.00%. This contract also included improvements to the existing drainage system that included regraded ditches and pipes in locations with limited clearance.

Conclusion

The Trenton Line Clearance Improvement Project involved unique design challenges as a result of the dense urban setting of this corridor and being surrounded by century-old buildings, retaining walls and large utilities. Through the use of a combination of traditional gravity flow systems and pump stations, stormwater flows and flooding issues were mitigated and impacts to rail operations from flooding greatly reduced. Now with double-stack clearance, the Trenton Line will serve an increased volume of good movement along the I-95 corridor, reduce the number of trucks on highways, and improve commerce in the region.

References

1) www.phillyhistory.org

The CSX Trenton Line
Clearance Improvements Along
System Map

- Project located in critical part of CSX system
- Heavily utilized corridor
- Provides goods movement through Philadelphia and East Coast ports along I-95

Track Design

- Double stack vertical clearance – 21’0” minimum
- Track lowered and shifted to achieve clearances
- Maintain CSX operations during construction

Survey

Aerial Survey
- LiDAR – FLI-MAP400

Ground Survey
- Total station

Survey Coordination
- Control points

Geotechnical Investigations

- Seismic Refraction
- Ground Penetrating Radar and Borings

Utility Plans
Sewer Investigations

Pipe Video Inspection

Environmental Permitting

- NEPA – Categorical Exclusion
- Stormwater Management
- Erosion & Sediment Control

Contract 1 – CP Nice

Pre-Construction

• Fox Street Bridge
• Stokley Street Bridge

CT1

Contract 1 – CP Nice

Pre-Construction

• Wissahickon Avenue Bridge
• SEPTA 9th Street Bridge

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Contract 1 – CP Nice

Construction

Soldier Pile and Lagging Wall

Historic Foulage Protection
**Contract 1 – CP Nice Construction**

**Contract 2 – Low Grade Pre-Construction**

**Contract 2 – Low Grade Construction**

### Contract 2 – Low Grade

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**Contract 2 – Low Grade**

*Construction*

**Contract 3 - Olney**

*Pre-Construction*

**Contract 3 - Olney**

*Construction*

**Contract 4 – Cottman & Oxford/Bleich**

*Pre-Construction*

**Contract 4 – Cottman & Oxford/Bleich**

*Construction*

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**Contract 3 - Olney**

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**Contract 4 – Cottman & Oxford/Bleich**

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### Contract 7 – NS Morrisville Line

#### Pre-Construction

- **NS Morrisville Line Bridge**
- **South Bridge Abutment**

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### Questions