Complex Utility and Highway Construction Coordination at the World Trade Center

Joseph T. Brown, PE  
Acting Regional Director, New York City Region  
New York State Department of Transportation  
47-40 21st Street  
Long Island City, NY 11101  
T) 718-482-4526  
F) 718-482-4525  
Joseph. Brown@dot.ny.gov

Toby Hansson, PE  
Senior Principal  
Stantec Consulting Services Inc  
50 West 23 Street, 8th Floor  
New York, NY 10010  
T) 212-366-5600  
F) 212-366-5629  
toby.hansson@stantec.com

Joseph T. Brown is the corresponding author

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Abstract

This paper will address the issues that were encountered to replace, upgrade and maintain the utility systems within the Route 9A Project, damaged after the attacks of September 11th in the busiest utility roadway in New York City. The project included the relocation and construction of major utility infrastructure, most serving the new World Trade Center site, while coordinating with and meeting the needs of adjacent projects and maintaining and rebuilding an eight lane urban boulevard, world class bicycle facility and pedestrian promenade.

Summary

The Route 9A Project, as part of the Lower Manhattan Redevelopment faced incredible challenges after the attacks on 9/11, including the complex construction of major utilities within the busiest utility corridor in New York City. Intensive planning and coordination was needed to minimize disruption and ensure continuous service in the nation’s most populous city all while raising the roadway grade up to seven feet and maintaining six lanes of traffic at all times, providing for 60,000 vehicles per day and more than 10,000 pedestrians that would cross the roadway during the morning rush hour at 9 signalized intersections. Further complicating the work were the on-going adjacent reconstruction projects at the World Trade Center (WTC) site, changing WTC project schedules, and the need to provide staging and access areas for these projects within our the highway right-of-way.

Due to the presence of poor soils there was a need to undercut four feet and raise the roadway grade up to seven feet over the existing roadway elevation to meet the proposed raised elevation of the WTC Site and National September 11th Memorial and Museum fronting Route 9A. The water table was also very high with Route 9A adjacent to the Hudson River resulting in the need for working with the tides, dewatering, and deep cofferdam construction. The project included the relocation and construction of four 66-inch diameter river water intake and discharge lines to provide cooling water for the Memorial and World Trade Center Chiller Plant, inspection and lining of a 50 year old 78-inch interceptor sewer that carries sewage for all of Manhattan south of 14th Street, as well as providing enhanced security measures to protect existing and proposed utilities.

The construction of replacement and new utility systems was further complicated by the presence of many underground features and the need for utility support on new pile foundations. The underground features included:

- Two Port Authority Trans-Hudson (PATH) transit system tubes to New Jersey;
- New and prior WTC site slurry wall tiebacks;
- Historic US Bulkhead and piers;
- Former WTC garage ramps;
- Former elevated Miller Highway substructures;
- The north and south slurry wall projections; and
- Elements of the extensive utility systems

Other key issues to address were obtaining agency approvals and the staging of utility work in order to maintain viable systems while shifting alignment, raising grade and providing access to key World Trade Center projects including 1 WTC, the Vehicle Security Center and the Memorial, all being constructed from Route 9A.
Another key element was to locate (or relocate) utilities away from security elements and to enable the extensive plantings of over 500 trees in the median and frontages along this one mile corridor.

Coordination of the work zone and maintaining 6 lanes of traffic during construction while the Port Authority completed construction of their subterranean concourse below NYSDOT’s workzone required weekly coordination meetings with the City of New York and all projects. As NYSDOT’s work zones shifted, so did the temporary roadway bridges crossing over the concourse project and utility bridges. Traffic enforcement agents, pedestrian managers and flagmen were used to protect workers, motorists and pedestrians. More than 70 traffic zone shifts were required to maintain highway, bicycle, and pedestrian traffic.

**Background**

The story of the West Side Highway (aka West Street and Route 9A), running approximately five miles from Battery Place (at the southern end of Manhattan Island) to West 59th Street, is full of significant engineering experiences; including the Westway project, the collapse of the elevated Miller Highway, and the implementation of FHWA’s policy on Flexibility in Highway Design. This paper will address the portion of the West Side Highway running adjacent to the World Trade Center Site in Lower Manhattan and the issues associated with the reconstruction of the roadway and extensive utility systems after the terrorist attacks of September 11, 2001.
When the New York State Department of Transportation (NYSDOT) decided to abandon the controversial plans for the Westway Project in the 1980’s and provide an Urban Boulevard along the west side of Manhattan, the construction was divided up into seven separate segments with the portion adjacent to the World Trade Center site designated as Segment #2. Segment #2 was the last segment to be constructed and was 95% complete on September 11th, 2001, when the collapse of the Trade Center Towers and the ensuing rescue and recovery efforts caused significant damage to the roadway and the utility infrastructure in West Street.

After the removal of the debris and the opening of a temporary six lane West Side Highway in April 2002, the coordination, planning, design and eventual construction of a replacement roadway began.

![Figure 4 - Route 9A adjacent to the NS11MM site, October 2012 – photo courtesy of PANYNJ](image)

Recognizing the significant role that West Street plays in Lower Manhattan, the WTC Site Redevelopment and to the National September 11th Memorial and Museum (NS11MM), NYSDOT provided technical support and guidance while the Port Authority of New York and New Jersey (PANYNJ) and numerous stakeholders determined the final configuration of the WTC Site and the NS11MM. The concept plan developed by Studio Daniel Libeskind for the WTC site, and the “Reflecting Absence” plan developed by Michael Arad for the Memorial site called for the shifting of the roadway approximately 40 feet to the west from its pre-9/11 location, which was supported in part within the WTC site ‘bathtub’, as well as raising the roadway by as much as seven feet to provide a smooth transition between the WTC site and West Street. These changes caused significant design and construction challenges.

It is difficult to concisely convey the numerous complicated coordination and design issues associated with the reconstruction of West Street over the last 10+ years in a single technical
paper. For obvious reasons, we will refrain from discussions of security issues associated with the design. While two design alternatives were studied; a by-pass tunnel and an at-grade roadway; we will focus on the selected option of an eight lane at-grade roadway for this paper.

**Complex Utility System under Route 9A**

A number of subsurface utility lines and structures, both private and publicly owned, are located beneath the Route 9A roadway within the project limits. These utility lines include combined sewers, interceptor sewers, regulator and tide gate chambers, high and low pressure water mains; telephone ducts, cables and fiber optics; electric, gas and steam lines, and other structures such as the World Trade Center (WTC) site river water cooling lines. Relocation and/or protection of these utilities were required by the selected 8-lane At-Grade Alternative. All utilities are permitted in the Route 9A right-of-way at the discretion of the New York State Department of Transportation (NYSDOT). Both publicly and privately owned utilities must relocate their facilities when required by highway reconstruction and/or maintenance. The specific utility involvement minimized impacts and assured continuous utility service.

In addition to utility relocations necessary to accommodate the realignment and re-profiling of Route 9A, new utilities, improvements and relocations were required for the following Lower Manhattan Development Corporation (LMDC) and Port Authority of New York and New Jersey (PANYNJ) projects:

- WTC PATH Terminal’s pedestrian concourse, transverse beneath Route 9A;
- PATH ventilation system and emergency egress;
- One World Trade Center and World Financial Center site security features;
- Elements of the WTC Site Memorial and 1 WTC (Tower One) construction;
- Southern extension of the WTC Site and slurry wall (vehicle screening center site);
- Temporary pedestrian and roadway bridges; and
- Intake and discharge lines for the WTC Site river water cooling system.

New utility systems for Con Edison (gas & electric) and ECS/Verizon (communications)

![Figure 5 - Adjacent projects requiring utility connection from, and coordination with Route 9A Project](image-url)
The common goal of all Lower Manhattan Recovery Projects was for an efficient and coordinated process that minimized the adverse effects of construction for major utilities in Route 9A. While there are many utilities in the Route 9A corridor, there are two major utility facilities in the area from West Thames Street to Chambers Street that added to the challenges of the project under Route 9A. These are a New York City Department of Environmental Protection (NYCDEP) 78-inch combined (storm water and sanitary sewer) interceptor sewer line with regulator chambers and outfall sewers, and a network of complex ECS / Verizon ducts with communication lines that tie into the Verizon building at West Street and Vesey Street.

Figure 6 - Route 9A -- Busiest Utility Corridor in NYC

A summary description of the underground utilities at this location includes:

Sewers – NYCDEP maintains the sewer system in NYC. Storm and sanitary sewers are combined in this portion of Manhattan into a north-south 78-inch interceptor sewer line. During heavy rains, when the capacity of the interceptor sewer is exceeded, excess combined storm and sanitary flows are diverted through regulator chambers and outfalls into the Hudson River. Tide gate chambers, regulators and large size piping on piles exist throughout the corridor.

Water – NYCDEP maintains several major water main systems in the Route 9A corridor. These mains, varying in size up to 48 inches in diameter, generally run north and south under the roadway. A new 48-inch water main, located generally to the west of the southbound roadway, was installed as part of the Segment 2 – Route 9A Reconstruction Project prior to September 11th.

River Water – PANYNJ has river water intake cooling and discharge lines adjacent to the WTC site. These lines, which became inactive after September 11th, include dual 66-inch and 60-inch diameter pipes that will be used to provide HVAC cooling water for the rebuilt WTC site. The discharge lines are similar in size and connect the site with sizeable discharge chambers on the west side of the Route 9A right-of-way.

Communication – Verizon has one of the world’s largest switching stations at the Verizon Building, 140 West Street (at Vesey Street). Hundreds of telephone conduits and cables exist in the southwest corner of this building and run north-south under Route 9A serving the financial
district, as well as crossing Route 9A into Battery Park City. Empire City Subway (ECS) owns most of this communication infrastructure. The communication lines between Vesey and Liberty Streets are housed in an 84-inch duct bank.

Electric – Consolidated Edison maintains high voltage power and electric service lines throughout the project limits running under Route 9A.

Gas – Consolidated Edison maintains gas mains throughout the project limits, ranging in size from 6 to 16 inches. The gas mains run under and across Route 9A.

Steam – Consolidated Edison has a 16-inch steam line under Route 9A from Vesey Street north to Murray Street.

**78” Interceptor Sewer**

The first task was to identify utilities that were to remain, and those that needed to be replaced/.upgraded because of the change in roadway grade and location. The largest existing utility was the 78-inch Interceptor Sewer, running north-south along the frontage. The additional loading caused by the additional seven feet of earth above the facility required further investigation and coordination with the NYCDEP. To obtain NYCDEP approval, NYS DOT was required to line the interior with an approved material, repairing any minor spalls along the way. This solution will provide an additional service life to the sewer. Constructability and diversions of the sewer flow were studied, and it was determined that the flow was the lowest during the midnight to 5 AM period, and a conceptual design was developed so that the work could be completed at this low flow time period. The design involved the installation of a smaller diversion pipe within the 78-inch sewer to accommodate the low flow while lining repairs would be made with quick drying epoxy material. Additionally, six manhole chambers were rebuilt requiring the construction of two cofferdams.

![Figure 7 - 78” Interceptor Sewer lining concept and cross section of sewer](image)

**Lightweight Fill Concept**

Due to the compressible soils layer located beneath the roadway, adding seven feet of fill would have caused an unacceptable amount of settlement. It was decided that for every foot of grade change, a half foot of soil would be removed and replaced with lightweight fill. Therefore, at the locations where NYS DOT was raising the grade seven feet, four feet of soil was removed and replaced with an equal amount of 11 feet of lightweight manufactured fill (less than ½ the weight of regular fill) installed. The roadway and utility systems needed to be raised in 18 inch lifts and in longitudinal sections requiring complex staging to accommodate existing, temporary and permanent utility connections and pavement. To achieve this in the tight work zones, GRES
(Geosynthetic Retaining Earth System) walls were used. The re-profiled utilities were, in many cases, higher than the existing grades which required numerous temporary connections as the grade was raised to insure that vital services were not interrupted.

Figure 8 - Lightweight Fill

Verizon

Adjacent to the WTC site, Verizon has a significant switching facility, which services Lower Manhattan including Wall Street and the Financial District. Conduit duct banks, with nearly 150 conduits carrying both copper and fiber optic cables, run under the western edge of the roadway. Existing facilities were repaired and new facilities needed to be added to connect the new development at the WTC Site.

Figure 9 - Verizon duct bank
River Water Lines

The former WTC site was cooled with water taken from the nearby Hudson River thru a series of 66-inch river water intake and discharge lines. While the raising of the grade would not impact these facilities, the concept to leave a portion of the slurry wall exposed for the public to view required the relocation of these facilities as part of the roadway reconstruction.

The Hudson River water will cool and dehumidify the new National September 11 Memorial and Museum and serve other WTC projects. Four large underground pipes—some 42-inch wide and others 66-inch wide, large enough to crawl or even stand in—connect the Memorial site to the Hudson River. Two access pipes will draw water from the river, pumping it underneath the World Financial Center and ultimately to a chiller plant underneath the Memorial. The river water will be used to chill the air supply, helping to cool the buildings on the site, including the visitors’ center and museum, as well as the underground passageway to the World Financial Center. The water will then be sent back to the river via two discharge pipes.

A similar system was used to cool the original WTC complex, but the pipes were destroyed during the September 11 attacks. The new pipes are much better for the environment, using only 24 percent of the maximum water flow of the original system.

In 2008 it became clear that the schedule for replacement of the river water lines by the PANYNJ would be extended and would delay the completion of shallower utilities. NYSDOT / Stantec provided an alternative design that would run the river water lines up an abandoned garage ramp to the old WTC. This allowed the work to be completed two years ahead of the new schedule and to avoid delays to other Route 9A utilities and fill. The work was part of a cooperative effort by NYSDOT and the Port Authority to identify work that can be performed more quickly and less expensively.
500 Trees

A unique feature of this project was that utilities were relocated to allow the placement of over 500 street trees in order to achieve the landscaped boulevard and pedestrian promenade and “sense of place” for this critical roadway in lower Manhattan. Sewers, watermain, gas, electric and telephone lines were all strategically located to enable as many plantings as possible, further complicated by NYCDEP criteria with minimal offsets from their facilities. Faced with the possibility of not being allowed to plant 200 of the 500 designed trees due to these conflicts, NYS DOT / Stantec proposed additional protection measures to enable future maintenance and prevent possible root infiltration. These measures included adding vinyl sheeting and concrete slabs as vertical and horizontal barriers.

Figure 11 - Typical water main protection detail
Construction Staging

These utility relocations posed a significant challenge to the NYSDOT and their contractor and what complicated the matter the most was that in addition to all the utility and roadway work being performed by the State on Route 9A, the roadway was being used as the staging area for the construction of the many projects at WTC site thereby limiting the NYSDOT work zones.

Our initial staging concept for 5 construction stages evolved into a series of much smaller confined construction stages to ensure utility systems were made continuously viable with existing, temporary and new components as the grade was raised and the road shifted in multi-longitudinal sections.

Figure 12 - Initial 5 phase construction staging vs. current 16 phase plan involving more than 70 traffic schemes (stages)

10th Anniversary of 9/11 Attacks

With the goal of the Governor and Mayor to open the Memorial to public viewing on the 10th Anniversary of the 9/11 attacks, NYSDOT was called upon to ensure that all critical utility connections (sewer, water, communications, and electric) for the Memorial were in place so that public access to the Memorial would be unimpeded.

Figure 13 - NS11MM access from Route 9A
It was determined that public access to the Memorial would need to be via Route 9A, so the NYSDOT team had to shift sections of the roadway it had completed to enable accelerated construction of a protected pedestrian way in a former roadway area. Access to the Memorial was not possible from other directions due to the extensive PANYNJ construction on the other sides of the Memorial. With less than a year to design and build the temporary entrance and new utility plan for the Memorial operations, NYS DOT / Stantec accelerated the design and Tully / EE Cruz JV accelerated the construction. The required utility systems were placed and the temporary Route 9A ITS and lighting systems, as well as installation of NYPD utility infrastructure, were installed to meet the overall schedule requirements to open the Memorial by the 10th anniversary on September 11, 2011 and allow for opening ceremonies to occur in Route 9A.

Conclusion

The Route 9A project could not achieve its goals of restoring the 8 lane roadway into a world-class landscaped boulevard, bicycle facility and pedestrian promenade to the Memorial without an extensive communication program and day to day coordination at all levels by the dedicated NYSDOT team and involved stakeholders. While the surface plantings, bikeway, granite walkways and other urban design features are what people will notice, what goes unnoticed is the work and effort involved to restore the complex utility network below the ground from its somewhat chaotic nature to systems that enable what appears above to function.

Figure 14 - Route 9A final roadway section

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