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Tunnel Boring Machine for Delaware Aqueduct Repair to be Named for Trailblazing Engineer

Unique Machine to Honor Nora Stanton Blatch Deforest Barney, Noted Suffragist and First Woman to Earn a Civil Engineering Degree in the United States

Tunnel Boring Machine Part of Largest Repair in NYC Water Supply History; Click for Photos and Video

The New York City Department of Environmental Protection (DEP) today announced that it will pay tribute to a trailblazing engineer and civil rights activist by naming one of the world's most advanced tunnel boring machines in her honor. An Ohio company has recently completed the manufacture and testing of a $30 million tunnel boring machine that will be used to repair New York City's Delaware Aqueduct, the world's longest tunnel. DEP will name the massive machine after Nora Stanton Blatch Deforest Barney, noted suffragist and the first woman in the United States to earn a civil engineering degree. Nora, who worked as a draftsman on the City's first reservoir and aqueduct in the Catskill Mountains, was also the first female member of the American Society of Civil Engineers.

"The month of March is set aside each year to celebrate the extraordinary achievements and contributions of women in our country," **DEP Acting Commissioner Vincent Sapienza** said. "Nora Stanton Blatch Barney was a talented engineer, architect and mathematician who paved the way for other women to employ their talents in these fields. While she worked on the City's landmark water supply facilities in the Catskills, Nora also led the fight for women's rights at the voting booth and in the workplace. Her achievements will

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provide considerable inspiration as we forge ahead with the largest repair in the history of New York City's water supply."

"Grandma's success in life is not spontaneous combustion," said **Coline Jenkins, Nora's granddaughter**. "As a child, she learned from Elizabeth Cady Stanton, her grandmother, guide and philosopher. Nora learned the facts of life and the history of women and her long subjugation. Later Nora became the embodiment of Elizabeth's vision of women by gaining access to higher education and professions, long denied to women. We're happy that New York City is recognizing Nora's important contributions by putting her name at the head of this impressive tunneling machine. There is great symbolism in this—Nora will be pushing forward and breaking ground, as she did in life."

Nora's daughter, Rhoada Barney Jenkins, also reflected on her mother's contributions. "She always believed in pushing," she said. "You don't question a hurricane."

"It's important to take time to appreciate the individuals, values and grit that shaped our public infrastructure," said **Eric Jenkins-Sahlin, Nora's great grandson**. "Naming this uniquely advanced tunnel boring machine after Nora is a fun celebration of a visionary who worked tirelessly towards a brighter future, both technically and socially. I will never take a sip of New York tap water for granted again!"

"Cornell Engineering has been producing amazing female engineers since our beginning," said **Lance R. Collins, the Joseph Silbert Dean of Engineering at Cornell University**. "It is therefore fitting that the tunnel boring machine for the Delaware Aqueduct be named after Nora Stanton Blatch Barney, C.E 1905, as it represents her courage and her can-do attitude, at a time when women had not been given access to those roles."

"As the first woman to earn junior member status in the American Society of Civil Engineers and now a fellow in the Society, Nora Stanton Blatch embodies ASCE's vision to build a better quality of life, as will the tunnel boring machine that now bears her name," said **Norma Jean Mattei, P.E., Ph.D., President of the American Society of Civil Engineers**. "It is fitting that this innovative, groundbreaking machine that will improve the New York City water supply system be named after a problem solver like Nora, as this is the type of work she advocated for and pursued in her—at the time—unconventional career."

Nora attended Cornell University and earned a bachelor's degree in civil engineering in 1905. She was the first woman in the United States to earn a college degree in civil engineering. That year, she also became first woman to gain membership in the American Society of Civil Engineers, as a junior member. After she graduated from Cornell, Nora worked as an engineer and draftsman for the American Bridge Company, Radley Steel Construction Company, and the New York Public Service Commission. Later in life she became a developer and architect on Long Island and in Greenwich, Connecticut.

From 1906–1908, Nora worked as a draftsman for the New York City Board of Water Supply, which was developing the first parts of the Catskill Water Supply System. She was paid $1,200 per year for her work—the highest salary for draftsmen at the project. All the others fulfilling that job were men. Little exact information is known about Nora's work on water supply infrastructure in the Catskills. But a 1908 story from The New York Times said she had "done much difficult work on dams and weirs" for the project—an explanation that would suggest she drafted some of the infrastructure for Ashokan Reservoir and the headworks of the Catskill Aqueduct.

Nora was also noted for her work in the women's rights movement. Her involvement was something of an heirloom passed down by her grandmother and mother. Her grandmother, Elizabeth Cady Stanton, authored the "Declaration of Sentiments" that was presented at the Seneca Falls Convention of 1848, marking the start of an organized push for women's rights and women's suffrage in the United States. Nora's mother, Harriot Stanton Blatch, was also a noted suffragist

who injected new energy by broadening the movement to include working-class women in New York City, and by organizing parades up Fifth Avenue, protests at Carnegie Hall, and lobbying efforts at the State Capitol in Albany. Nora continued in that tradition. She founded a suffrage club at Cornell, became president of the Women's Political Union in 1915, and led the charge for an Equal Rights Amendment to the U.S. Constitution that would have guaranteed women equal rights in the workplace. The amendment was not ratified, but it has been debated in Congress almost every year since it was introduced, including as recently as 2015.

Nora Stanton Blatch Deforest Barney died in 1971 at the age of 87.

In her honor, DEP has emblazoned "NORA" on a unique tunnel boring machine (TBM) that will be used to repair the Delaware Aqueduct. The Robbins Company, based in Ohio, recently completed the manufacture and testing of the TBM. The machine will be dismantled and shipped in pieces to DEP's construction site in Newburgh, NY, beginning this month. All parts of the TBM are expected to arrive by early summer.

The TBM is an integral part of DEP's program to fix two leaks in the 85-mile-long Delaware Aqueduct. The largest of the two leaks is located along the western banks of the Hudson River in Newburgh. The TBM will be used to build a 14-foot diameter bypass tunnel alongside this section of the aqueduct. The 2.5-mile bypass will be constructed 600 feet below the Hudson River, between Newburgh and Wappinger. It will be connected to structurally sound portions of the existing Delaware Aqueduct to convey water around the leaking section. The leaking stretch will be plugged and permanently taken out of service.

The new tunnel will be driven by the TBM and more than 100 workers at the site. The TBM is a massive and unique piece of equipment. The entire machine—including its cutter head, body and trailing gear—is more than 470 feet long and weighs 2.7 million pounds. Its cutter head is 21.6 feet in diameter. The TBM was built to withstand 30 bar of pressure—believed to be the most of any TBM ever manufactured. (That's about 11 times the amount of pressure from a garden hose.) The machine needs to withstand that much pressure because workers encountered huge inflows of water under immense head pressure when the aqueduct was first built more than 70 years ago. The TBM is also equipped with dewatering equipment to pump 2,500 gallons per minute away from the tunnel as the machine drives it. In addition, the machine is outfitted with equipment to install and grout the concrete lining of the tunnel, and to convey pulverized rock to a system of railroad cars that will follow the TBM as it pushes forward.

Repairing and Monitoring Leaks in the Delaware Aqueduct

DEP has monitored the two portions of the aqueduct with leaks—one in the Orange County town of Newburgh, and the other in the Ulster County town of Wawarsing—since the 1990s. The leaks release an estimated 20 million gallons per day, about 95 percent of that escaping the tunnel through the leak in Newburgh. DEP has continuously tested and monitored the leaks by using dye, backflow, and hydrostatic tests, and hourly flow monitors provide near real-time data on the location and volume of the leaks. In 2003, 2009 and 2014, DEP used an Autonomous Underwater Vehicle (AUV)—a cutting-edge, self-propelled submarine-shaped vehicle built in partnership with engineers at Woods Hole Oceanographic Institution in Massachusetts—to conduct a detailed survey of the entire 45-mile length of tunnel between Rondout Reservoir and West Branch Reservoir. The AUV took 360-degree photographs while gathering sonar, velocity, and pressure data to assist in determining the location, size and characteristics of the leaks. All the data gathered thus far clearly show that the rate of water leaking from the tunnel has remained constant and the cracks have not worsened since DEP began monitoring them in 1992.

In 2010, the City announced a plan to address the leaks by building the bypass tunnel around the portion of the aqueduct in Newburgh, and also grouting closed the smaller leaks in Wawarsing. The project began with the excavation of two vertical shafts in Newburgh and Wappinger to gain access to the subsurface.

These shafts, 845 and 675 feet deep respectively, were completed last year. Workers are currently building an underground chamber at the bottom of the Newburgh shaft. The chamber—about 40 feet high, 40 feet wide and 100 feet long—will serve as a staging area for the tunnel boring machine and the spot from which excavated rock is brought to the surface by a crane. The tunnel boring machine is expected to drive about 50 feet of the tunnel each day.

The existing Delaware Aqueduct will stay in service while the bypass tunnel is under construction. Once the bypass tunnel is nearly complete and water supply augmentation and conservation measures are in place, the existing tunnel will be taken out of service and excavation will begin to connect the bypass tunnel to structurally sound portions of the existing aqueduct. This work is anticipated to happen late in the year 2022. Engineers expect it will take roughly five to eight months to connect the bypass tunnel. While the Delaware Aqueduct is shut down, work crews will also enter the aqueduct in Wawarsing to seal the small leaks there, roughly 35 miles northwest of the bypass tunnel.

The project, which comprises the largest repair effort in the 175-year history of New York City's upstate water supply, will mark the first time that the Delaware Aqueduct will be drained since 1958. In 2013, City employees installed new pumps inside a shaft at the lowest point of the Delaware Aqueduct to eventually dewater the tunnel. Those pumps will be tested several times before the tunnel is drained in 2021. The nine pumps are capable of removing a maximum of 80 million gallons of water a day from the tunnel—more than quadruple the capacity of the pumps they replaced from the 1940s. The largest of the pumps are three vertical turbine pumps that each measure 23 feet tall and weigh 9 tons.

The bypass tunnel project is expected to create nearly 200 jobs over the next eight years. In 2012, DEP signed a project labor agreement (PLA) with the Hudson Valley Building and Construction Trade Council that ensured the vast majority of those jobs would be filled by local workers. Also, the PLA is expected to save the City up to $23 million over the life of the project. With 18 different local labor agreements that could potentially apply to the project, the PLA provides for a unified approach to shifts and time off, and the increased coordination under one agreement allows for more cost-effective scheduling and increased flexibility.

DEP manages New York City's water supply, providing more than 1 billion gallons of high-quality water each day to more than 9.5 million New Yorkers. This includes more than 70 upstate communities and institutions in Ulster, Orange, Putnam and Westchester counties who consume an average of 110 million total gallons of drinking water daily from New York City's water supply system. This water comes from the Catskill, Delaware, and Croton watersheds that extend more than 125 miles from the City, and the system comprises 19 reservoirs, three controlled lakes, and numerous tunnels and aqueducts. DEP has nearly 6,000 employees, including almost 1,000 scientists, engineers, surveyors, watershed maintainers and other professionals in the watershed. In addition to its $70 million payroll and $166 million in annual taxes paid in upstate counties, DEP has invested more than $1.7 billion in watershed protection programs—including partnership organizations such as the Catskill Watershed Corporation and the Watershed Agricultural Council—that support sustainable farming practices, environmentally sensitive economic development, and local economic opportunity. In addition, DEP has a robust capital program with $20.7 billion in investments planned over the next 10 years that will create up to 3,000 construction-related jobs per year. For more information, visit nyc.gov/dep, like us on Facebook, or follow us on Twitter.

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