1. NAME OF PROPERTY

Historic Name: Holland Tunnel

Other Name/Site Number:

2. LOCATION

Street & Number: Connecting Lower Manhattan and Jersey City, Running Under the Hudson River

City/Town:Vicinity: New York City & Jersey City State: NY & NJ

County: NY & Hudson Code: 061 & 017 Zip Code: 07310 & 10013

3. CLASSIFICATION

Ownership of Property
Private: ___
Public-local: ___
Public-State: X
Public-Federal: ___

Category of Property
Building(s): ___
District: ___
Site: ___
Structure: X
Object: ___

Number of Resources within Property

Contributing	Noncontributing	
		buildings
		sites
5		structures
		objects
5		Total

Number of Contributing Resources Previously Listed in the National Register: 0

Name of related multiple property listing:

4. STATE/FEDERAL AGENCY CERTIFICATION

As the designated authority under the National Historic Preservation Act of 1986, as amended, I hereby certify that this ____ nomination ____ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property ____ meets ____ does not meet the National Register Criteria.

Signature of Certifying Official Date

State or Federal Agency and Bureau

In my opinion, the property ____ meets ____ does not meet the National Register criteria.

Signature of Commenting or Other Official Date

State or Federal Agency and Bureau

5. NATIONAL PARK SERVICE CERTIFICATION

I, hereby certify that this property is:

____ Entered in the National Register
____ Determined eligible for the National Register
____ Determined not eligible for the National Register
____ Removed from the National Register
____ Other (explain): ______________________________

Signature of Keeper Date of Action

6. FUNCTION OR USE

Historic: TRANSPORTATION Sub: vehicular

Current: TRANSPORTATION Sub: vehicular

7. DESCRIPTION

ARCHITECTURAL CLASSIFICATION: Other: Cast iron subaqueous tunnel

MATERIALS:
Foundation: N/A
Walls: Cast iron tubes
Roof: N/A
Other: Glazed tile walls (interior)

Describe Present and Historic Physical Appearance.

The Holland Tunnel carries vehicular traffic through two parallel tubes beneath the Hudson River, connecting the lower west side of Manhattan, New York with Jersey City, New Jersey. The nominated resource includes the twin tubes and four large ventilation buildings. [See Figure #1] The overall length of the nominated resource is 9,210′ for the north tube and 9,275′ for the south tube. Portal to portal, the north tube of the Holland Tunnel is 8,558′ long and the south tube is 8371′ long.

The north tube carries two lanes of traffic from New York to New Jersey, and the south tube carries two lanes of traffic from New Jersey to New York. The design of each tube is best understood when broken down into its three components: the central subaqueous portion, the enclosed approach tunnels on either side of the subaqueous portion, and the open-cut approach ramps which connect the enclosed approach tunnels to the surface grade level.

The subaqueous portions of the twin tubes are slightly more than a mile long (5,480′). Constructed by the shield method of tunneling, these cylindrical tubes are 29′5" in diameter and run approximately 15′ apart.[1] The tunnel lining is made up of cast iron rings 2.5′ wide. Each ring is made up of fourteen 6′ long

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[1]The original planned tunnel diameter of 29′ was expanded by a half foot after design tests showed that larger fresh air intake and foul air exhaust ducts below and above the tunnel roadway would reduce the cost of ventilation. "Building the Hudson River Vehicular Tunnel," Engineering News-Record (May 8, 1924): 798.

segment pieces, plus a smaller arch key piece, all of which are connected with steel alloy bolts.[2]

After thousands of these rings were assembled, the interior of the tube was lined with 19" of concrete. The cylindrical shape of the subaqueous portion of the tunnel is not evident to the commuter because a dropped ceiling, raised roadway, and perpendicular walls give the exposed throughway a rectangular appearance. The two-lane roadway of the subaqueous portion of tunnel is 20' wide, 12.5' tall, and maintains a nearly level grade. [See Photograph #1] The original plan called for painting the concrete and leaving it as the final interior surface. This was modified, however, after the project's Chief Engineer made a tunnel inspection trip to Europe. After noting the advantages in lighting, appearance and sanitary conditions which a wall of glazed ceramic tiles afforded, the Chief Engineer sought and won approval for incurring the additional cost of high grade tile. The side walls were covered with white tile which was trimmed with two rows of yellow/orange tile along the bottom and two rows along the top. It was reported that under the advice of a "color psychologist," tiles of blue, green, or red tints were rejected due to their "depressing effects."[3]

On either end of the north and south subaqueous tubes are the enclosed approach tunnels. These portions of tunnel are approximately 1000' on the New York side, and 500' on the New Jersey side, terminating at the tunnel portals. Their construction is rectangular in cross section as opposed to the circular tube of the subaqueous portion, and they were constructed using the cut-and-cover method New Yorkers were familiar with in their subway construction. If not for the noticeable increase in grade in the approach tunnels, the motorist would be unable to distinguish the approach tunnels from the subaqueous portion of the tunnels; the roadway, tile walls and ceiling appear identical. The approach tunnels deviate from the parallel course of the subaqueous tubes, following irregular paths so that the exit and entrance portals on either side of the river end up two blocks apart to diffuse traffic congestion. [See Figure #1]

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[2] Cast steel segments were used in the rings adjacent to the river air shafts.

[3] "Hudson Vehicular Tunnel at New York," Railway Review (February 26, 1921); "Lining Procedure in Holland Vehicular Tunnel," Engineering News-Record (December 3, 1925): 905-6; and Carl C. Gray, The Eighth Wonder, (Cambridge, MA.: The University Press, 1927) p. 22. The north tube was lined with domestic tile and the south tube was half lined with Czechoslovakian tile and half with tile from the Saar region of Germany. "Lining Procedure in Holland Vehicular Tunnel," p. 906.

The entire length of the tunnel was originally paved with granite blocks from Maine. In 1955 the granite was replaced with an asphalt roadway.[4]

Extending east of the New York portals and west of the New Jersey portals are the open-cut approach ramps which rise from the portals to street grade. The ramps are flanked by granite-faced concrete retaining walls, which reach an average height of 18' at the portals. [See Photographs #2 & #3] The extant ornamental lighting fixtures replaced the original fixtures in the 1950s. The width of the ramp at the portal is 30'.

The tunnel utilizes the transverse-flow type of ventilation system. In addition to the two tubes, the tunnel includes two land and two river ventilation buildings, one of each near either shore. The foundations for these large structures were laid by caissons and after they were grounded at the appropriate subaqueous elevation, the tunnel was excavated so that the traffic tubes would run through the steel caissons. The land and river ventilation buildings are of steel and reinforced concrete construction, and are faced with buff-colored brick. The five-story New York Land Ventilation Building is 122' tall. [See Photograph #4] The perimeter of this structure is trapezoidal to fit on its irregularly shaped lot. It is 50' wide, and 184' long on the east side and 154' long on the west side. The four-story New York River Ventilation Building stands in the river, approximately 900' west of the Manhattan shoreline. [See Photograph #5] It measures 50' by 106' and stands 107' above the pier deck (which is 7' above mean high tide). The four-story (plus a raised foundation) New Jersey Land Ventilation Building is 84' tall and measures 75' by 115'. [See Photograph #6] The four-story New Jersey River Ventilation Building measures 50' by 105' and is 107' tall above the pier deck. [See Photograph #7]

A series of 8' diameter intake fans draw fresh air from outside the ventilation buildings through louvers along the buildings exterior walls. That volume of air is then divided among fourteen fresh air ducts and blown into a 17' wide duct which runs beneath the two-lane roadways of each tube. [See Figure #2 & Photograph #8] From these ducts, the fresh air enters a series of small air supply ports located 10 to 15 feet apart along the curb of the roadways. The incoming fresh air then combines with the hot gases generated by the traffic, and rises toward the dropped ceiling. A series of 8' diameter exhaust fans located in the ventilation buildings then draws the fouled air through long narrow slits in the ceiling, into the 21' wide domed exhaust air duct which is 5'8" high at the apex. From there, the air is drawn through one of fourteen exhaust air ducts, into the

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[4] "Vehicular Tunnel Under Hudson River Paved With Granite," Engineering News-Record (October 29, 1925): 726; Letter from Sandra McCullough, Port Authority of NY & NJ, to Robie Lange, National Park Service (November 17, 1992) (History Division NHL File).

enclosed exhaust air ducts in the ventilation building, and out the building's exhaust stacks. The exhaust fans are enclosed within a duct, and the intake fans are in the open, close to the building's louvers. [See Photographs #9 & #10] Each of the fourteen intake and fourteen exhaust ducts work in conjunction with three adjustable-speed fans, only two of which are required to provide the maximum quantity of air movement (the third is held in reserve). A total of 84 fans comprise the heart of the ventilation system. When operating at full speed, they can completely replenish the air in the tunnel every 1.5 minutes.[5] Twenty-four hours a day, automatic recording devices in the exhaust ducts report information on the tunnels' carbon monoxide levels to the central control station.[6]

To facilitate evacuation during a severe fire or other emergency, the tunnel contains five cross connections through which motorists can, after abandoning their vehicles, walk from one tube to the other. These passages are located at the base of each land and river shaft, and at the mid-river sump pump.[7] [See Figure #1]

Large piers were originally constructed above the tunnel from the shore to the river ventilation buildings. [See Photograph #7] They served to protect the shallower ends of the tunnel from possible damage caused by deep draft boats, but they were also used as shipping piers. The New Jersey pier remains, but only the pilings remain from the New York pier after its demolition in 1985. Although the Newport Development Company owns this pier, the Port Authority maintains access rights for maintenance and for use as an emergency exit from the tunnel via the river ventilation building.

Despite modifications to the toll plazas (new toll booths and lane patterns), the general traffic patterns, as established by the separation of the exit and entrance portals, remains largely as designed.[8]

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[5]"The Holland Tunnel and Its Ceramic Tiling," The Ceramic Age (July 1927): 7.

[6]The ventilation system continues to use the same type of centrifugal fans as those designed in the 1920s. The fans' original chain drives have been replace with belt drives, and some of the generators have been replaced. The ventilation system is currently controlled from the New Jersey garage #2, but local control of the fans in an individual ventilation building is also possible from each ventilation building.

[7]"Method of Operating Holland Vehicular Tunnels," Engineering News-Record (November 3, 1927): 702.

[8]The original toll plazas [See Photograph #11] were redesigned in 1954 and again in 1988. Until 1971 tolls were collected in both directions; at that point the New York toll

Other modifications to the tunnel include new lighting, paving, a new computer-monitored traffic control system, automatic traffic detectors, closed circuit television and two or three generations of enclosed observation stations which were introduced some years after the tunnel's completion. Finally, powered catwalk cars were recently added to transport the tunnel police to these observation stations.[9]

The contributing elements of the nominated property are the twin tunnels (considered a single structure, which includes the two subaqueous portions, the four enclosed approach tunnel sections, and the four open approach ramps), and the two land and two river ventilation buildings. The toll plazas east and west of the New York and New Jersey open approach ramps, respectively, have undergone several reconstructions and thus, maintain insufficient levels of historic integrity to be identified as contributing to this nominated property. The original Administration Buildings (located next to the exit ramps), no longer house air quality and traffic monitoring facilities, and therefore, do not contribute in an important way to this property's national significance. The 1940s New Jersey Service Building #2, which currently houses the monitoring activities, is not original to the tunnel project, and therefore, does not contribute in an important way to this property's national significance.

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collection booths were removed. In 1982-3 the original small Plaza Office Building at the New York plaza was removed.

[9]Additional minor modifications include: the realignment of the westernmost end of the south retaining wall near the New Jersey toll booths; the installation of "billboard steel framing" in the vicinity of the portals to block debris from falling onto the open-cut approach ramps; the 1980s' replacement of the tunnel's original cast concrete slab ceiling with sections of precast reinforced concrete, covered with ceramic tile; the modification of the curb drains in 1988; the replacement of the original 32" high porcelainized steel, single-rail railing along the tunnel's sidewalk with a 42" high double rail of stainless steel; the 1988 replacement of the original bronze metal finishing around the various utility openings in the tunnel walls with more durable stainless steel; the installation of a steel-wedged ceiling at the first 100 feet of each tunnel entrance which was designed to stop oversize vehicles from entering; and the replacement of the original incandescent light boxes with a continuous line of florescent lighting.

8. STATEMENT OF SIGNIFICANCE

Certifying official has considered the significance of this property in relation to other properties: Nationally: X Statewide:___ Locally:___

Applicable National Register Criteria: A X B___ C X D___

Criteria Considerations (Exceptions): A___ B___ C___ D___ E___ F___ G___

NHL Criteria: I & IV

NHL Theme(s): XIV-G TRANSPORTATION-AUTOMOBILES
XVIII-B TECHNOLOGY-TRANSPORTATION
XVIII-H TECHNOLOGY-CONSTRUCTION
XXX-D AMERICAN WAYS OF LIFE-URBAN LIFE

Areas of Significance: ENGINEERING
TRANSPORTATION

Period(s) of Significance: 1920-1927

Significant Dates: 1920
1927

Significant Person(s):

Cultural Affiliation:

Architect/Builder: Holland, Clifford (Chief Engineer)

State Significance of Property, and Justify Criteria, Criteria Considerations, and Areas and Periods of Significance Noted Above.

Opened in 1927, the Holland Tunnel was the first subaqueous tunnel in the world specifically designed for the requirements of automotive traffic.[1] The most significant aspect of its design was the extensive program of clinical research conducted to determine the effects of auto emissions on tunnel motorists, and the most efficient ventilation system to eliminate the associated health and safety risks. The conclusions of this research influenced the design of every subsequent subaqueous vehicular tunnel.

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[1]The Holland Tunnel is one of three subaqueous tunnels nominated for NHL designation as part of an engineering theme study. The other two are the 1891 St. Clair River Railroad Tunnel and the 1909 Detroit River Railroad Tunnel.

History

Although the Hudson River was finally crossed by subway and railroad tunnels in the early 20th century, there were no tunnels or bridges to carry the ever-increasing vehicular traffic between the nation's largest city and the mainland. [See Photograph #12] Until the late 1920s, all automobiles, trucks, and horse-driven vehicles were carried across the Hudson by ferry. A survey conducted between 1913 and 1919 found that at least three out of four vehicles ferried between New York City and New Jersey crossed the Hudson on ferries operating in the vicinity of the proposed tunnel. While 90% of these vehicles were horse-drawn in 1913, by 1919 the rapid rise in automobile traffic reduced horse-drawn traffic on these ferries by 50%.[2]

The greatest single complaint about the river ferry service was the delays. One report indicates that when the traffic was at its worst, such as on weekends and holidays, vehicles often had to wait hours on line for their turn to board one of the ferries.[3] In addition, strong tidal currents and occasional ice or fog made this crossing very dangerous. This danger was exacerbated by the heavy maritime traffic running up and down the river. On a few occasions, ferry service was virtually eliminated, as occurred in 1919, when labor strikes by boatmen threatened to isolate the occupants of Manhattan Island from the mainland to the west.[4]

As early as 1868 charters had been granted to build bridges connecting New Jersey with Manhattan, but no feasible bridge designs were forthcoming. Another half century was to pass before plans for a crossing of any type were presented which were both technologically and economically feasible. Finally, on July 11, 1919, President Woodrow Wilson signed a Congressional resolution calling for a tunnel.[5]

By 1920 the method of driving subaqueous tunnels had been soundly established. All earlier subaqueous transportation tunnels, however, were designed for rail or for horse-drawn transportation. The provision of adequate ventilation, however, was far more critical for automotive tunnels than for railroad tunnels. While this is not to minimize the risks to train crews

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[2]"Largest American Shield Tunnel Designed to Carry Vehicular Traffic Under Hudson River," Engineering News-Record (February 19, 1920): 358-361.

[3]Frank W. Skinner, "The Holland Vehicular Tunnel Under the Hudson River," Engineering (November 11, 1927): 602.

[4]Robert G. Skerrett, "Driving With Air the Hudson Vehicular Twin Tubes," Compressed Air Magazine (August, 1920): 9741.

[5]"The Holland Tunnel and Its Ceramic Tiling," The Ceramic Age (July, 1927): 3.

and passengers of being exposed to toxic gases when a steam engine remained too long within a tunnel, the crew needed merely to keep the train moving along its guided rails until fresh air was reached at the other portal. Such rare accidents were reduced significantly early in the 20th century, when "cleaner" electric locomotives began to replace steam locomotives. A vehicular tunnel, however, carried thousands of individually operated automobiles each day. Insufficient ventilation of automobile exhausts could cause health risks to the motorists, or could temporarily impair a drivers ability to safely operate a vehicle.

Most notable among the very few pre-Holland Tunnel subaqueous tunnels designed for other than rail traffic, were two built under the Thames River in England. The 27' diameter Blackwall Tunnel was built in 1897, and the 20' diameter Rotherhithe Tunnel was built in 1908. Designed when the internal combustion engine was a rarity, neither of these tunnels required mechanical ventilation. In contrast, the Holland Tunnel was designed during the early 1920s when automobiles began to outnumber animal-driven wagons.[6]

Early in the planning phase for the Holland Tunnel, consideration was given to utilizing the trench method of construction. As pioneered on the Detroit River Railway Tunnel, this method utilized sections of preconstructed tunnel tubing which were floated into position before being sunk into a prepared trench in the river bed.[7] Despite the presence on the project's advisory board of one of the principal engineers for the Detroit tunnel, concerns about the trench method's applicability to the Hudson River led the board to select the more established shield method of excavation.[8]

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[6]The tunnel's planners indicated that by 1937 the decreasing number of animal driven vehicles could be restricted from the tunnel. Skerrett, "Driving With Air the Hudson Vehicular Twin Tubes," pp. 9742-3.

[7]See Detroit River Railroad Tunnel NHL nomination, History Division, National Park Service, Washington, D.C., 1993.

[8]The engineers were concerned about the obstructions to river commerce which the trench method's "floating plant" would have required. It was pointed out that the nature of the river traffic in Detroit is different from that of New York. Most Detroit River vessels operate under their own power and are more able to maneuver around such obstacles, whereas much of the Hudson River traffic includes the largest ocean going ships guided by tug boat. Additionally, they feared that the Hudson's river bed, known for its fluid character, would be too unstable to maintain the underground trench before the tube sections could be sunk into them. "Hudson Vehicular Tunnel at New York," Railway Review, p. 311. For a discussion on the development of the shield method of tunnel excavation, see the St. Clair River

After the trench method was ruled out, the engineers were asked to consider an unusual variation on the shield method of tunnel excavation proposed by General George Washington Goethals, the builder of the Panama Canal and one of the foremost engineers of the early 20th century. Goethals proposed a 42′ diameter tunnel, nearly one-and-a-half times the size of any previously attempted subaqueous tunnel. Yet, the most unconventional element of his plan was constructing the tunnel lining of concrete block instead of the conventional cast iron segments. Despite the respect commanded by Goethals, concern that concrete block would not seal as well as the bolted cast iron segments caused the more established tunnel lining to be selected.

The design selected for the subaqueous portion of the tunnel incorporated two cast iron tubes 29′ in diameter, each containing a 20′ wide two-lane roadway. Before construction began, however, the diameter was increased to 29.5′ to afford more efficient ventilation. The Holland Tunnel became the largest diameter subaqueous tunnel in the United States. The traffic in each tube runs one way, the two lanes in the northern tube travel from New York to New Jersey, and the two lanes in the southern tube travel eastbound. Both tubes are divided longitudinally into three areas. [See Photographs #1 & #8] The space beneath the roadway serves as a large fresh air duct and the space above the 13.5′ high roadway ceiling, serves as a large exhaust air duct.

The New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission, which shared overall responsibility for the tunnel project, selected Clifford M. Holland as chief engineer.[9] Holland was born on March 13, 1883, in Somerset, Massachusetts. The day after graduating from Harvard University in 1906 he began a career of working with New York City's tunnel projects. During his short career he worked on 28 tunnels of every type. Holland died of angina pectoris in 1924 at the age of 41, only two days before the north tube of the Holland Tunnel was "holed through." He was succeeded by his assistant, Milton H. Freeman, until Freeman himself died from pneumonia five months later. Ole Singstad, Holland's engineer of design for the tunnel, then completed the project.[10] Before its opening, the tunnel was named for Holland, and the toll plaza on the New York side was named after Freeman.

Tunnel NHL nomination, History Division, National Park Service, Washington, D.C, 1993.

[9]The project also included a board of consulting engineers which was made up of Col. W.J. Wilgus, J.A. Bensel, William H. Burr, Edward A. Byrne and J.V. Davis. "Largest American Shield Tunnel Designed to Carry Vehicular Traffic Under Hudson River," Engineering News-Record.

[10]Skerrett, "Driving With Air the Hudson Vehicular Twin Tubes," p. 9745; "The Holland Tunnel and Its Ceramic Tiling," The Ceramic Age, p. 10.

Holland and his associates understood that their work was complicated by the fact that the design and use of an automobile tunnel introduced more independent variables than did a railroad tunnel (e.g., different sizes of vehicles, different speeds, different abilities to climb grades, and, unlike the relatively orderly train schedule, no central control over the time when vehicles would arrive en masse to travel through the tunnel). The most challenging element posed by an automotive tunnel was the problem of ventilation. Prior to the design and construction of the Holland Tunnel there was little information on the requirements of ventilation for automobiles. Early in the design process, consideration was given to eliminating the need for mechanical ventilation by utilizing some form of mechanical haulage with moving platforms, flat cars, and hauling cables. Yet these schemes were found to be too problematic and were abandoned.[11] The engineers had no alternatives--the ventilation problem would have to be solved. Proceeding in an exceedingly rational and scientific manner, the New York and New Jersey tunnel commissions set out to address this problem. Their inquiries focused on three areas of study: 1) to determine the amount and composition of exhaust gases emanating from motor vehicles; 2) to determine the degree of dilution necessary to render such gases harmless; and, 3) to determine the method and equipment needed to produce the required ventilation capability at a reasonable operating cost.

In relation to the first area of inquiry, the U.S. Bureau of Mines conducted tests at the Pittsburgh Experimental Station to determine the amount and composition of exhaust gases produced by automobiles. These tests concluded that carbon monoxide was the only "asphyxial gas" of the many gases given off in automobile exhaust.[12] After testing 101 randomly selected passenger cars and trucks of various sizes under all conditions (accelerating, idling, climbing, descending, and operating under different seasonal conditions), chemist A.C. Fieldner conclusively determined the amount and composition of their exhaust gases.[13] In relation to the second point, those tests under the direction of Dr. Yendel Henderson of Yale sought to determine the amount and rate of which carbon monoxide could be absorbed by the body

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[11]"Largest American Shield Tunnel Designed to Carry Vehicular Traffic Under Hudson River," Engineering News-Record, p. 362.

[12]On the basis of later advances in science and medicine, the tunnel staff now also monitors nitrogen dioxide, sulfur dioxide, total particulates, and airborne lead. Letter from McCullough, Port Authority of NY & NJ, to Lange, National Park Service (November 17, 1992) (History Division NHL File).

[13]"Tests Fix Vehicle Tunnel Ventilation Policies," Engineering News-Record (April 7, 1921): 602.

without harmful effect.[14] Humans and animals (horses and dogs) were tested in small airtight chambers where measured amounts of carbon monoxide were admitted. At intervals blood samples were taken from the subjects to determine the effects of the varied amounts of carbon monoxide in their bodies. Dr. Henderson found that a one-hour exposure to 4 parts per 10,000 of carbon monoxide was acceptable. With 6 parts per 10,000, the chance of headache increased, and with 8 parts per 10,000 discomfort was more serious.[15] Prior to these tests, it was estimated that the maximum safe exposure to carbon monoxide was 3 parts per 10,000. While Dr. Henderson's findings seemed to represent a savings in operating the ventilation system and a broader margin of safety, Dr. Fieldner's tests at Pittsburgh, however, offset some of this advantage after reporting that motor vehicles produce more carbon monoxide than was originally assumed.[16]

The third element of this preliminary research sought to establish the most efficient means to provide the required ventilation. The customary way to artificially ventilate a tunnel was to place high volume fans at the portals to draw air in at one end and have it forced out the other. When possible, vertical air shafts were also incorporated to discharge tainted air to the surface. Several factors made these methods of ventilation impractical for a tunnel such as this. The length (more than a mile) of this tunnel would have placed traffic in the center of the tunnel exceedingly far from the source of fresh air at the portals. Even if sufficient quantities of fresh air could be blown in from the portals, the required velocity of the air would introduce a hinderance to the operation of vehicles. Additionally, any smoke produced by car fires would be carried through the tunnel, expanding the area of the hazard. Fortunately, experiments conducted by the Public Service Corporation of New Jersey in 1916 had pointed to a new method of ventilation. These experiments utilized an automobile in a test chamber. Test results indicated that the most effective way to ventilate automobile exhaust from a tunnel was to duct fresh air beneath the roadway where it would rise up with the hot gases generated by the automobiles and exit through an exhaust chamber above the roadway.

To follow up on these findings, research was conducted through the Bureau of Mines with the University of Illinois' engineering

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[14]The symptoms associated with carbon monoxide poisoning include headache, nausea, weakness of the limbs, and unconsciousness.

[15]Skerrett, "Driving With Air the Hudson Vehicular Twin Tubes," p. 9747; Robert G. Skerrett, "Research Reveals How to Ventilate the Hudson Tunnel," Compressed Air Magazine (April 1922): 103.

[16]Robert G. Skerrett, "Research Settles the Problem of Tunnel Ventilation," Scientific American (March 1922): 169.

experiment station at Urbana. The purpose of these tests was to determine the most efficient way to move air through concrete ducts, and the best shape and size of the inlet and exhaust ports and the exhaust stacks. Under Professor A.C. Willard, a 300' long timber and concrete structure was built to represent a half-scale model of the air duct to be built beneath the roadway. These important experiments yielded information which reversed previously held theoretical assumptions about the mechanical movement of air.[17]

To test these conclusions against genuine ventilation requirements, a final series of tests was conducted at an experimental coal mine in Bruceton, Pennsylvania. By adding two curved sections to connect two parallel coal tunnels, an oval "speedway" was created 130' below ground. This oval course was fashioned into a large-scale model of the proposed Holland Tunnel ventilation configuration, with a fresh air duct beneath the roadway area and an exhaust duct above. Gauges and other apparatus in the test vehicles and elsewhere in the test track sampled the air quality and flow.[18]

In addition to designing a state of the art ventilation system, more routine design and operation elements were studied. Some of these issues were resolved in consultation with an advisory transportation committee made up of twelve representatives of automobile manufacturers and other transportation interests. After analyzing existing and future traffic requirements, the advisory committee made recommendations on the required clearance and width of traffic lanes, speed restrictions, procedures for dealing with fires and removing disabled vehicles, and lane markings and signal devices.[19]

Having painstakingly concluded the planning phase, the tunnel's commissioners were confident that the tunnel would not only operate safely and efficiently, but would yield enough in toll revenue to reimburse the entire construction cost after a dozen years. These estimates also projected that after 20 years, the tunnel would realize a surplus for the two states of more than $66,000,000.[20]

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[17]Ibid.; "Studies and Methods Adopted for Ventilating the Holland Vehicular Tunnels," Engineering News-Record (June 9, 1927): 936.

[18]Skerrett, "Research Settles the Problem of Tunnel Ventilation," p. 169; Skerrett, "Research Reveals How to Ventilate the Hudson Tunnel," p. 106.

[19]"Traffic Policies for Vehicular Tunnels Endorsed," Engineering News-Record (February 17, 1921): 293.

[20]For example, in 1991 $9,600,000 net income was generated from tolls. Letter from McCullough to Lange. "A Highway Under the Hudson," Engineering News-Record (February 19, 1920): 356.

On March 28, 1922, the firm of Booth & Flinn, Ltd., of New York City, was awarded the principle contract for the construction of the subaqueous portion of the tunnel.[21] Ground was broken on October 12, 1920, and the north and south tubes were holed through almost four years to the day later. The final cost of the tunnel was $48,000,000.[22] Each tube was expected to have a daily capacity of 46,000 vehicles.[23] However, on opening day, November 12, 1927, 52,285 vehicles passed through what many described as the eighth wonder of the world. Even still, the tunnel's ventilation system proved more capable than expected, and the carbon monoxide level remained below 1.6 parts per 10,000, far lower than the permissible level of 4 parts per 10,000.[24]

More than six decades later, the projected peak hourly traffic of 1800 automobiles in a single two-lane tube, frequently exceeds 3000. Today the tunnel serves a total of 20,000,000 motorists a year.[25] Nevertheless, the aging ventilation system not only continues to perform its job, but does so by meeting significantly more stringent air quality standards, reducing the threshold of carbon monoxide from 4 parts per 10,000, to 1.25 parts per 10,000.

The significance of the Holland Tunnel and its ventilation system were recognized in 1984 when it received the distinction of being designated a National Engineering Landmark by both the American Society of Civil Engineers and the American Society of Mechanical Engineers.

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[21] "Specification Details of Hudson River Vehicular Tunnel," Engineering News-Record (April 6, 1922): 574.

[22] One account reports that the project was accomplished at the cost of the lives of 13 workers, plus the two chief engineers. Ernest A. McKay, "Tunneling to New York," Invention & Technology (Fall 1988): 31.

[23] Sidney Mornington, "Great Vehicular Tunnel Under the Hudson Opened for Service," Compressed Air Magazine (November 1927): 2232. Daily one-way capacity is currently 64,800, and average daily one-way traffic is 40,000. Letter from McCullough Lange.

[24] Frank W. Skinner, "The Holland Vehicular Tunnel Under the Hudson River," Engineering (November 25, 1927): 667; "The Future of Vehicular Tunnels," Engineering News-Record (December 27, 1928): 940; Ernest A. McKay, "Tunneling to New York," p. 31.

[25] Holland Tunnel Civil Engineering Landmark Nomination, American Society of Civil Engineers, Washington, D.C., p. 8.

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Previous documentation on file (NPS):

___ Preliminary Determination of Individual Listing (36 CFR 67) has been requested.
___ Previously Listed in the National Register.
___ Previously Determined Eligible by the National Register.
___ Designated a National Historic Landmark.
___ Recorded by Historic American Buildings Survey: #______
_X_ Recorded by Historic American Engineering Record: #NY-161

Primary Location of Additional Data:

___ State Historic Preservation Office
___ Other State Agency
___ Federal Agency
___ Local Government
___ University
_X_ Other (Specify Repository): Library of Congress

10. GEOGRAPHICAL DATA

Acreage of Property: Approximately 28 Acres

UTM References:

	Zone	Northing	Easting		Zone	Northing	Easting
A	18	4508640	584040	B	18	4508220	584150
C	18	4508880	582870	D	18	4509200	582800

Verbal Boundary Description:

The boundary of the nominated property is delineated by the polygon whose vertices are marked by the above listed UTM reference points on the Jersey City Quadrangle USGS map. Due to the highly developed land use of this urban area, an additional clarification of the boundary is required. With the exception of the above ground ventilation buildings, all surface streets and standing structures beneath which the underground portion of this resource passes, are not considered contributing to the Holland Tunnel's national significance.

Boundary Justification:

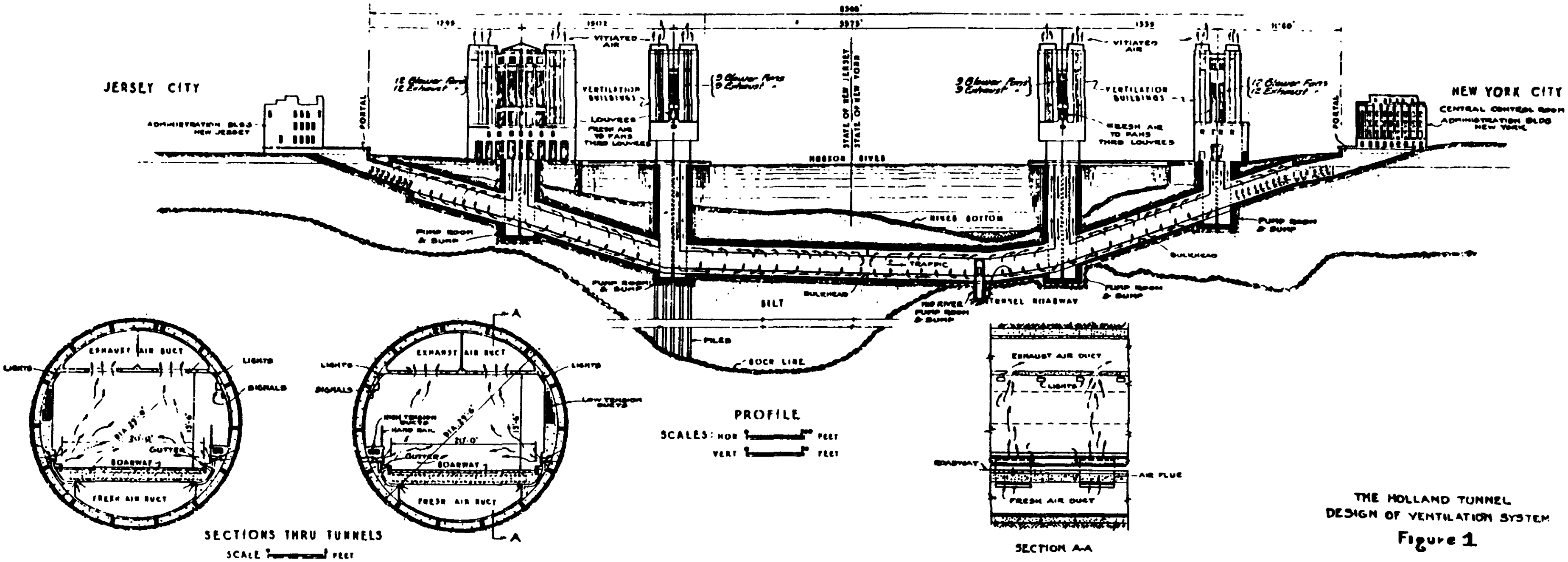
The boundary includes the four large ventilation buildings and the below grade roadways and features of the tunnel's two tubes (as distinguished at its extreme ends by the approach ramp retaining walls) [See Figure #1]. This boundary excludes those auxiliary features which, due to the relocation of ventilation monitoring equipment, no longer maintain their nationally significant association with the tunnel (the administration and maintenance buildings), and those features which no longer possess high levels of historic integrity (the toll plazas).

11. FORM PREPARED BY

Name/Title: Robie S. Lange / Historian Org.: History Division, NPS

Street: P.O. Box 37127 City/Town: Washington State: DC

ZIP: 20013-3127 Telephone: 202-343-0350 Date: March, 1993



SHADED AREA INDICATES NHL BOUNDARY

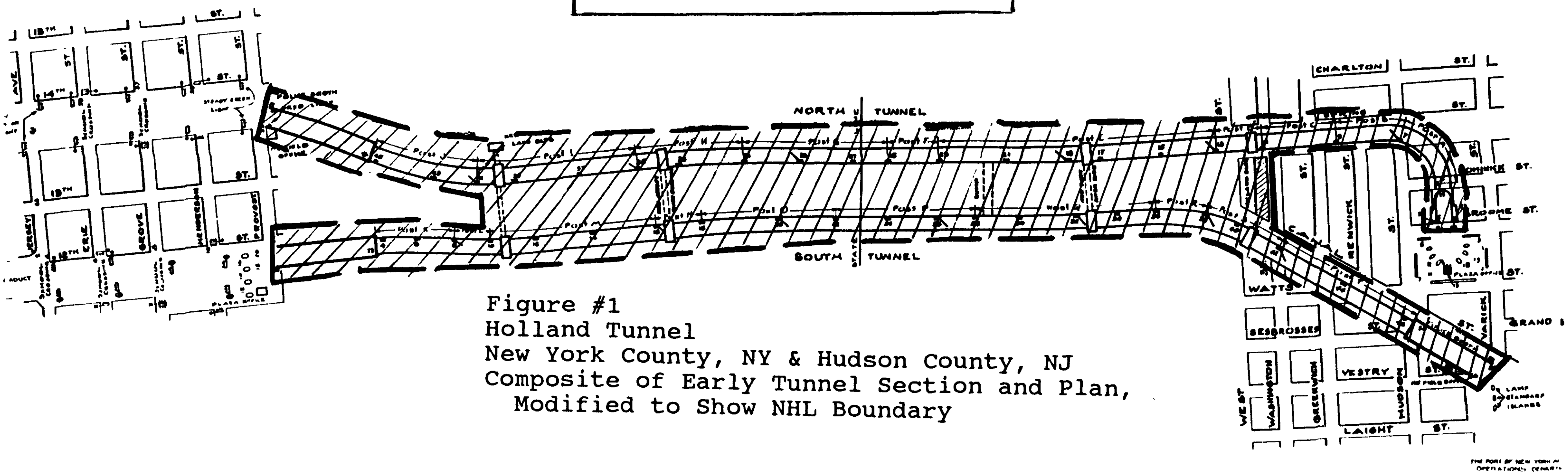


Figure #1
Holland Tunnel
New York County, NY & Hudson County, NJ
Composite of Early Tunnel Section and Plan,
Modified to Show NHL Boundary

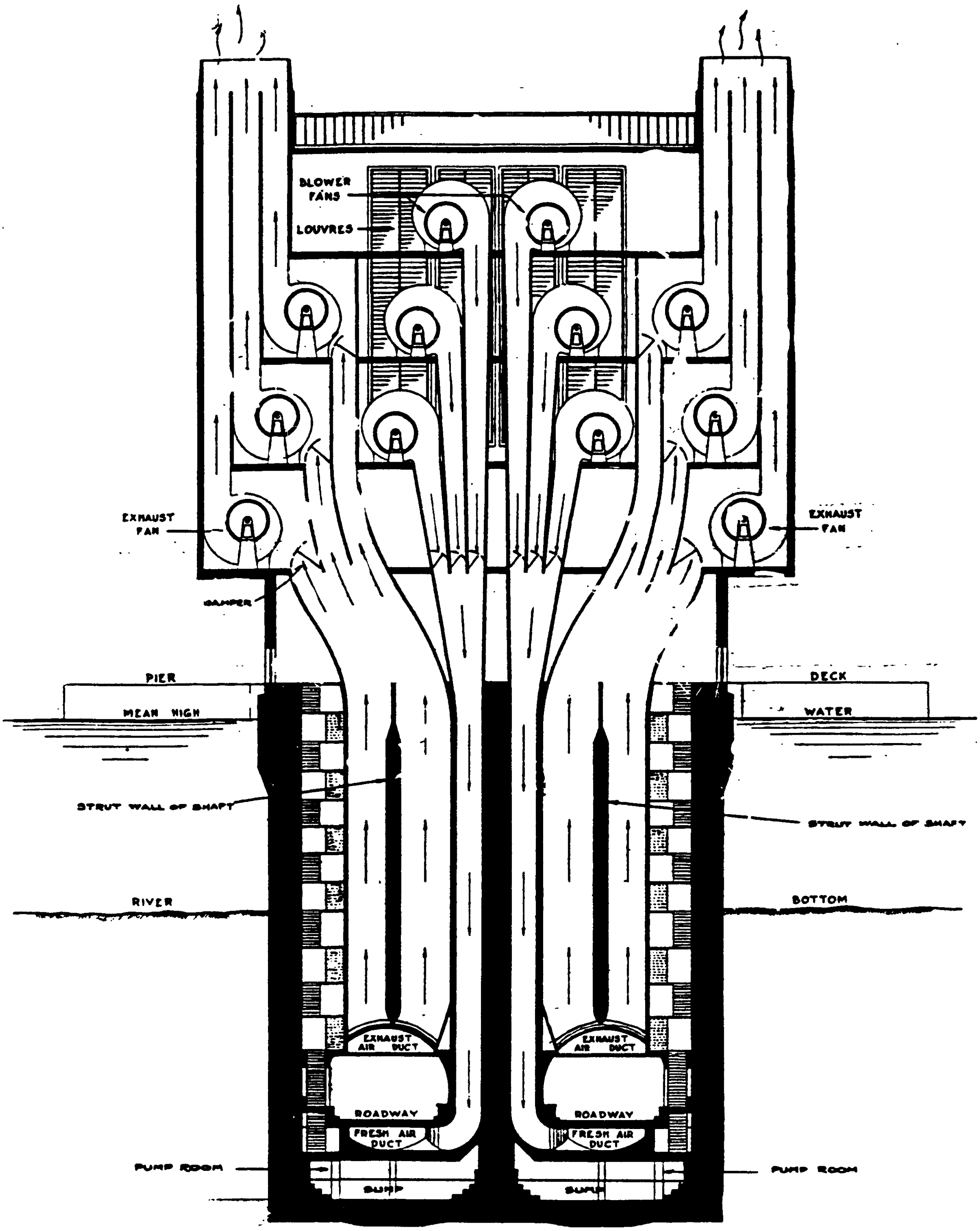


Figure #2
Holland Tunnel
New York County, NY & Hudson County, NJ
Section: Typical River Ventilation Building
<u>Heating, Piping and Air Conditioning</u>, October 1930