MILE ROCK TUNNEL
UNDER 48th AVENUE FROM CABRILLO STREET TO
SAN FRANCISCO BAY NEAR POINT LOBOS
SAN FRANCISCO VICINITY
SAN FRANCISCO COUNTY
CALIFORNIA

HAER NO. CA-162

HAER
CAL
38-SANFRA,
196-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
NATIONAL PARK SERVICE
WESTERN REGION
DEPARTMENT OF THE INTERIOR
SAN FRANCISCO, CALIFORNIA 94107

HISTORIC AMERICAN ENGINEERING RECORD
MILE ROCK TUNNEL

HAER
CAL
38-SANFRA,
196-

HAER No. CA-162

Location: Beginning on the south side of Cabrillo Street, Mile Rock tunnel extends north under 48th Avenue, to exit at the San Francisco Bay near Point Lobos in the vicinity of Mile Rock. The alignment trends approximately east/west for the first 50 or 60 feet in from the portal, then the tunnel makes a bend and aligns approximately north/south for a distance of approximately 4,175 feet. City of San Francisco, San Francisco County, California

USGS 7.5 minute San Francisco North, California quadrangle (1973 Revsion)
Universal Transverse Mercator Coordinates: Section 10,
543360 m Easting/ 4180560 m Northing (Cabrillo Street)
543060 m Easting/ 4181760 m Northing (Outfall)

Date(s) of Construction: 1914 - 1915

Engineer: Michael M. O'Shaughnessy (City Engineer)

Builders: Edward Malley (January to July 1914) (hiatus 7/1914 - 1/1915)
R.C. Storrie and Company (January 1915 to August 1915)

Present Owner: City and County of San Francisco
Department of Public Works
P.O. Box 429360
San Francisco, CA 94142

Present Use: Storm Water Drain (to be modified 1994-1995)

Significance: The Mile Rock tunnel was constructed in 1914 and 1915 and is an example of the whole-scale reconstruction and reconfiguration of the City of San Francisco's public works system that occurred following the 1906 earthquake. This reconstruction effort drew worldwide interest and support, and offered challenges and career opportunities to engineers all over the nation. Designed by M. M. O'Shaughnessy, a renowned civil engineer best known for his design of Hetch Hetchy Water System, the tunnel was the first constructed in the city that used a combination of open cut timber cribbing and boring through solid rock and represented a technological and engineering innovation in the city. It served as the storm drainage facility for the Sunset and West Mission districts and portions of the Richmond and Ingleside districts.

The tunnel has experienced little modification through the years. Ongoing, occasional maintenance has occurred, but there has been no major reconstruction or redesign and the tunnel retains a high degree of integrity of location, design, setting, and workmanship.

Report Prepared By: Mary L. Maniery, Historian
PAR ENVIRONMENTAL SERVICES, INC.
P.O. Box 160756
Sacramento, CA 95816-0756

Date: February 1995

I. HISTORIC NARRATIVE

Background and Early Planning

A long-range design and plan for a city-wide sewer system for the growing metropolis of San Francisco was well underway by the 1890s. At this time, the heavily populated areas of the city were already excessively sewered and in need of extension, and it was necessary to identify new areas of potential outfall where sewage delivery into the ocean would be the least harmful and offensive (Grunsky 1899:25). It was also proposed during this time that a combined system of storm water and sewage drains would decrease the total number of conduits needed and also serve to "flush out" the sewer lines with comparatively clean storm water run-off (Grunsky 1899:26).

Tidal directions, distance from habitation areas, and observation of areas already fouled with improperly delivered sewage led to the identification of several new outfall points around the perimeter of the San Francisco peninsula: North Point, Hunter's Point, off-shore at the end of 27th Avenue, off-shore at the foot of Scott Street, near Point Lobos, and near Fort Point (Grunsky 1899:34). It was thought that sometime in the indefinite future Point Lobos and Fort Point would be equipped with outfalls that would replace all of the others on the northern frontage of the city.

A New Water System for San Francisco

The "indefinite future" was soon realized by the unforeseen and destructive results of the 1906 earthquake and the three day fire that followed the catastrophic event. With the sudden prospect of rebuilding much of San Francisco's public works, Chief Engineer Carl E. Grunsky and his assistant, Marsden Manson, began to implement some of their earlier ideas into a redevelopment program for a modern water system that would never again leave the city in flames for lack of water. It was also because of the 1906 fire that the campaign for the Hetch Hetchy Water System was eventually pushed forward with renewed vigor (Hanson 1985:21).

The years following the fire were busy ones for San Francisco public works engineers, as Manson replaced Grunsky as chief. In September of 1912, San Francisco Mayor "Sunny Jim" Rolph appointed Michael M. O'Shaughnessy as city engineer, following Manson. O'Shaughnessy, an Irish-born civil engineer, was well known in the Bay Area, having worked on numerous water projects in the region, as well as the California Midwinter International Exposition (1893-1894) (Hart 1978:313; Detwiler 1929:266). Although it was Rolph's intention that O'Shaughnessy would primarily be the chief engineer for Hetch Hetchy, there were numerous local projects to be completed as land acquisitions and political struggles over Hetch Hetchy slowly proceeded (Greene 1987:497; Hanson 1985:21). O'Shaughnessy, with decades of experience behind him, enthusiastically began planning for the city's future.

Chief Engineer O'Shaughnessy

Michael Maurice O'Shaughnessy was born in Limerick, Ireland, on May 28, 1864. He received a B.A. degree in Engineering from the Royal University of Dublin in 1884 and came to San Francisco in 1885, sailing around the Horn. Not able to immediately find work in San Francisco, he designed the street system for the town of Mill Valley, and also helped to raise the Alpine Dam for Marin County (Hanson 1985:28). He served as assistant engineer for the Southern Pacific Railroad (1886-1887) and in 1893 was chief engineer for the California Midwinter Exposition in San Francisco. In 1895-1896 O'Shaughnessy tried his hand at mining, serving as Chief Engineer for the Mountain Copper Company and then operated a consulting business in San Francisco in 1887 and 1888. From 1899 to 1906, O'Shaughnessy worked as a construction hydraulic engineer during the planning and building of 20 sugar plantations in California (Byington 1931:153; Detwiler 1929:266). After returning to California in 1906, he became the chief engineer for the Southern California Mountain Water Company, supervising the construction of a huge dam near San Diego (Hanson 1985:28; Hart 1978:313). By the time he was offered the job as San Francisco's chief engineer, O'Shaughnessy was 48 years old and had built a successful consulting practice of his own (*San Francisco Chronicle* October 13, 1934).

O'Shaughnessy's appointment as San Francisco's chief engineer was made by Mayor "Sunny Jim" Rolph in September, 1912, and came at a time when San Francisco was experiencing an engineering boom during the years of rebuilding after the 1906 fire. The challenge of creating a new water and sewer system for the city drew a gold mine of talented engineers who came to participate in the public works projects. As chief, O'Shaughnessy would have the freedom and the opportunity to create engineering structures such as Hetch Hetchy.

Aware that he was being offered the challenge of a lifetime, O'Shaughnessy gave up his prosperous practice in southern California and accepted the position as chief city engineer of San Francisco for a mere $15,000 annual salary (*San Francisco Chronicle* October 13, 1934). Immediately, he took over construction of the municipal railway, which was planned to service the Panama Pacific Exposition. Before turning his attention to the supervision of the Hetch Hetchy Water System, however, O'Shaughnessy undertook a number of "small" tasks within the municipal water department including creating major sewerage and transportation systems and a high-pressure water system for fire fighting (*San Francisco Chronicle* October 13, 1934). O'Shaughnessy also laid out the municipal railway streetcar system with its Twin Peaks Tunnel and Stockton and Duboce street tunnels (Hart 1978:313; *San Francisco Chronicle* October 13, 1934).

By the time of his death in 1934, O'Shaughnessy had created a legacy of dams, roads, sewerage systems, and railways throughout San Francisco. He passed away two weeks before waters were expected to flow from O'Shaughnessy Dam through the Hetch Hetchy aqueduct to San Francisco (*San Francisco Chronicle* October 13, 1934). Today, his mastery and work can be seen in the Eleanor, O'Shaughnessy, and Priest dams, Priest and Hetch Hetchy aqueduct, the Great Highway and other roadways in the city, the Municipal Railway system, and numerous tunnels used for transportation and sewer/storm drainage including the Stockton Street, Duboce, Twin Peaks, Sunset, and Mile Rock tunnels (Byington 1931:153-154).

Mile Rock Tunnel

One of O'Shaughnessy's first jobs in his new position as chief was to design portions of the city's new boulevard system and supervise construction of the big bond-issue sewer jobs taking place as part of the post-fire redevelopment (*San Francisco Chronicle* January 16, 1915). It was during this period that he laid out the Drumm and Sansome street sewer tunnels and the big Mile Rock outfall tunnel (O'Shaughnessy 1913; *San Francisco Chronicle* January 12, 1916).

The general idea of building an outfall tunnel to provide drainage for the Sunset and West Mission sewer districts was discussed in the public works department for several years before O'Shaughnessy arrived in the city. In 1910, an article in the *San Francisco Call* (April 23, 1910) claimed that the Mile Rock tunnel would soon be built, and that construction would begin as early as that summer. The paper described the tunnel as the largest individual municipal sewerage enterprise that the city had ever attempted and suggested that property values would increase accordingly once the system was complete (*San Francisco Call* April 23, 1910). For some reason, possibly because of difficulties in securing a right-of-way through the Sutro estate, the tunnel was not built at that time.

In 1913 and 1914 O'Shaughnessy and Mayor Rolph worked together to gain a right-of-way through Sutro Heights for the proposed tunnel. Concurrent with land acquisition efforts, O'Shaughnessy began designing the new sewer, planning for a combination of timber cribbing and boring through solid rock. Manholes were also designed and plotted in anticipation of the tunnel's approval (O'Shaughnessy 1913; *San Francisco Examiner* August 26, 1915).

The Tunnel Builders

In January of 1914, O'Shaughnessy's plans for the Mile Rock tunnel were approved by the San Francisco Board of Public Works. The tunnel as planned would furnish an outfall for storm water drainage from the Sunset and West Mission districts (*San Francisco Examiner* January 8, 1914) and portions of the Richmond and Ingleside districts (San Francisco Board of Supervisors 1914/1915:344). Construction of this project was funded by the 1908 Sewer Bond (San Francisco Board of Supervisors 1915/1916:786-787). Although a preliminary estimate for the cost of the tunnel was $225,000, a low construction bid of $193,314 was accepted from local builder Edward Malley and the contract was awarded (*San Francisco Examiner* January 9, 1914). In February, problems arose concerning the amount of the bid, and the Public Works Board threatened to forfeit the contractor's bond (*San Francisco Examiner* February 12, 1914). Malley proceeded with the work, but was unable to complete the job because of the high cost of insurance required by the city. He turned it over to the Commonwealth Bonding and Casualty Insurance Company only five months later (San Francisco Board of Supervisors 1914/15:348; *San Francisco Examiner* July 17, 1914).

The project was resumed at the onset of the new year by a new builder, R. C. Storrie and Company, well-known as a firm with a reputation for persistence and quality work (*San Francisco Chronicle* January 16, 1915). R. C. Storrie and his partner, Robert Muir, were both Scotsmen with long histories of successful engineering and building projects completed in numerous other states. R. C. Storrie and Company also received other construction contracts from the Public Works department prior to and after the completion of the Mile Rock Tunnel, including the Hunter's Point and Lincoln Way outlet sewers and the Twin Peaks transportation tunnel (*San Francisco Chronicle* January 16, 1915).

Construction of the Tunnel

The Mile Rock Tunnel runs from 48th Avenue and Balboa to its outlet at the Golden Gate. At the 48th Avenue end, an open cut connection was made to the junction of the tunnel with the Sunset Sewer just south of Cabrillo (*San Francisco Chronicle* April 13, 1915). The length of the Mile Rock conduit to the sewer junction is 4,233 feet (Ames Engineering 1978:2). The tunnel itself is the outfall for this sewer, which drains storm water and delivers it into the ocean near Mile Rock.

Construction occurred along both a north and a south heading. Two piston drills were used in the north heading where the ground was hard. Hand drills were used in the softer ground at the south heading. In the soft soils, 30 pounds of 40 percent dynamite was used for each charge. However, in the harder soils of the north heading, an average of 60 pounds of dynamite was used in the 18 six-foot deep boles that were drilled during each shift. Great accuracy was maintained in the alignment of the two headings. When the two headings were jointed there was less than a 1/4-inch discrepancy (San Francisco Board of Supervisors 1914/1915:344).

Since more than 900 feet of the tunnel was bored through solid rock, the city was faced with the task of disposing of the rubble from the construction. Excavated material was removed in 3/4-yard narrow gage muck cars with mule traction. Rocks from the tunnel were transported by barge to the northern end of Ocean Beach, where they were used as fill. Unfortunately, a storm in early December 1915 washed many of the rocks and rubble away (Olmsted and Olmsted 1979:18).

Of the tunnel portion, parts of which are 300 feet below the ground surface (see photograph CA-162-10), approximately 2,600 feet required timber support cribbing, while 954 feet was through hard rock (Ames Engineering 1978; *San Francisco Chronicle* April 13, 1915). Timber consisted of two-post, five-segment arches of 8- by 8-inch timbers spaced at five centers (San Francisco Board of Supervisors 1914/1915:344). Reinforcing steel was used only in the open cut portion of the sewer construction, and the concrete used throughout was "standard mix" (Ames Engineering 1978:2) (see photographs CA-162-11 and CA-162-12). The concrete lining was placed using the MacMichael Pneumatic System. This was the first successful application in San Francisco of the pneumatic mixing and placing concrete using compressed air. Concrete was placed in 1/4-yard batches into a hopper and then forced by compressed air along with mixing water into the distributer pipe to the tunnel forms. An average of 32 batches of concrete per hour were placed when the distance from the mixer to the discharge point was as great as 2,000 feet (San Francisco Board of Supervisors 1914/1915:344).

The closing section was constructed in an open cut located at 48th Avenue and Cabrillo Street and extended north 536 feet. The soils excavated in the closing section were sand. The north end of the section was excavated to a depth of 51 feet from the crown of the road. At the south end of this section, the excavation reached a depth of 34 feet from the crown of the road. A drag line excavator was used to create a trench the entire width of the street to a depth of 12 feet. Here, the drag line excavated 6,307 cubic yards of material (San Francisco Board of Supervisors 1915/1916:783-784).

Two sets of lagging were used between the surface and the subgrade (see photograph CA-162-9). The lagging started at 10 feet below street grade. The upper set was 17 feet wide and the lower set was 14 feet wide. All lagging was 3- by 8-inch pine, surfaced on two edges. A total of 238.680 feet (before milling) of timber was used for the laggings in this section. Rangers were made out of 8- by 10-inch pine and spreaders were 8- by 8-inch timber in the first set and 8 by 10 inches in the second set. A total of 119.61 feet (before milling) of timber was used for the rangers and spreaders in this section (San Francisco Board of Supervisors 1915/1916:783-784).

A turntable derrick rig with a 40-foot boom was used for some of the excavation. The rig had an excavating capacity of approximately 200 yards per day near the surface but was only able to excavate about 50 yards per day in the deep parts of the excavation. The derrick rig excavated a total of 12,655 cubic yards of material in this section. All of the lagging, spreaders, and bracers were removed by the derrick rig (San Francisco Board of Supervisors 1915/1916:783-784).

According to newspaper accounts, the biggest problem encountered by Storrie and Muir was the water that flowed into the excavation (*San Francisco Chronicle* January 16, 1915). Groundwater levels in this area, at the time of construction, were ten feet below the road surface. Considerable difficulty was encountered in keeping the ground water from flowing into the bottom of the excavation. Temporary bulkheads were installed by driving in a second set of lagging about 4 feet below subgrade and covering the bottom of the excavation with gravel. It was also necessary to plug all of the joints in the second set of lagging with okum (San Francisco Board of Supervisors 1915/1916:783-784).

A 10-inch underdrain was used to carry the groundwater to two sumps, one located at 48th Avenue and Balboa Street and the other at 48th Avenue and Cabrillo Street. A 3-inch and a 4-inch diameter centrifugal pump were used at the 48th Avenue and Balboa Street sump. At the 48th Avenue and Balboa Street sump the two pumps were 6-inch and 4-inch diameter. About 1,250,000 gallons of water were pumped every 24 hours. Of this, about 407,000 gallons per day, over a 35 day period, were discharged into the completed sewer at Cabrillo Street. This discharge was handled by the city pumping station at 48th Avenue and Fulton Street (San Francisco Board of Supervisors 1915/1916:783-784).

The flow of the entire construction was on a uniform grade of 0.1605 to 100 feet from south to north. The invert had a width of 11 feet and the difference from the spring line of invert to the flow line was 18 inches. Side walls were two feet high to the spring line of the arch and the arch was constructed on a uniform curve to a radius of 5.5 feet. Side walls were 15 inches thick and reduced gradually to 9.5 inches at the crown of the arch. The invert had a minimum thickness of 12 inches at the flow line with the subgrade being level transversely. This section was reinforced throughout with 1/2-inch steel bars on six-inch centers. This required 31.1 tons of steel. The concrete mix was proportioned 1:2.5:5.5. The invert required 417 cubic yards of concrete. The sides and arch of the tunnel required 660 cubic yards of concrete. Niles River gravel and sand from the excavation was used for the concrete (San Francisco Board of Supervisors 1915/1916:783-784).

Completion and Final Inspection

Although the contract with Storrie for the Mile Rock Tunnel was not finalized until March 1, 1916 (Ames Engineering 1978), the tunnel was in use by September 1915. The total cost for the construction of the tunnel was $218,617.47 (San Francisco Board of Supervisors 1915/1916:786-787). A party of officials (see photograph CA-162-15), including Mayor Rolph, O'Shaughnessy, Robert Muir, and the president of the Board of Public Works, Timothy Reardon, was present for the inspection ceremony on August 26, 1915 (*San Francisco Chronicle* August 27, 1915). This inspection consisted of driving a car through the mile length of the tunnel to its outfall, where the incoming tide was held back with a temporary barrier (see photograph CA-162-14). A ramp for the car to enter was specially constructed at 48th Avenue, and the tunnel was strung with electric lights for the purpose of the ceremony. A five-passenger touring car was used by the mayor and his party, with the only drawback being that they had to back the car all the way out. The tunnel was put on line a few days after the official tour (*San Francisco Examiner* August 27, 1915).

Operation and Maintenance of the Tunnel

The Mile Rock tunnel has been in operation since it was brought on line. In 1925, local newspapers reported that some of the beaches, including Baker Beach, were to be quarantined as a result of contamination from sewage. These beaches were sprayed with disinfectant regularly until the sewage dispersed (*San Francisco Chronicle* December 5, 1925). The Mile Rock tunnel outfall area is not specifically mentioned as requiring treatment, although early photographs of the tunnel portal show that the area was posted with warning signs.

In 1935, plans were produced to construct a catch basin gate at the south end of the tunnel. This gate was apparently built as intended, but has since been removed and is no longer evident (Maiolini 1993). Maintenance files kept at DPW indicate that improvements to the Mile Rock Tunnel have been limited and minor in scope. A 1978 structural inspection evaluated the tunnel as deteriorating but structurally sound and failed to note any post-construction improvements (Ames Engineering 1978).

II. DESCRIPTION OF MILE ROCK TUNNEL

The Mile Rock tunnel is 4,233 feet long. Beginning on the south side of Cabrillo Street, it extends north underneath the route of 48th Avenue, to exit at the bay near Point Lobos in the vicinity of Mile Rock (see photograph CA-162-17). The tunnel alignment trends approximately east/west for the first 50 or 60 feet in from the portal, then the tunnel makes a bend and aligns approximately north/south. The tunnel measures 9 feet high and 11 feet wide and is shaped like a horseshoe or an inverted "U" (see photographs CA-162-13 and CA-162-18). It is constructed of rock in some portions and reinforced concrete with wood cribbing in others. Wall thickness varies from 9.5 inches at the top to 14 inches at the bottom of the sides. Parts of the tunnel were constructed through solid rock and lie 300 feet underground.

The tunnel originally was substantial in size, but tidal action over the years has resulted in a thick deposit of sand inside the tunnel. Today, the tunnel is about 6 feet tall near the outfall entrance, but narrows to only 3 feet from floor to ceiling about 110 feet from the portal. In places the concrete tunnel lining has eroded away as the result of scouring action, revealing the solid sandstone bedrock and rows of metal rebar, particularly in the open cut areas and near the outfall. Generally, the tunnel has not been modified over time.

Several surface features are visible and relate to the tunnel construction, including the outfall portal and a manhole. The portal is composed of rock and concrete, with an interior coat of concrete over steel rebar. The top of the portal is flat and contains evidence of the concrete crown of the tunnel (see photographs CA-162-8). The outfall is located between the boat loading area (consisting of a flat slab of concrete suspended between two rocks) and the manhole (see photographs CA-162-1 and CA-162-7).

O'Shaughnessy designed the manhole as a stack, providing air and access to the tunnel (see photograph CA-162-19). The original manhole design was revised during initial construction and ended at a square base, without the cylindrical stack designed by O'Shaughnessy. In later years, it was found that a taller manhole was more appropriate due to erosion and slope slumping, and an addition (built in the original configuration of O'Shaughnessy's plans) was added to the top (see photographs CA-162-2).

This addition is built of brick and is a slightly tapered cylindrical stack. The brick has been covered with a thin veneer of concrete. Small brick walls extend between the manhole and the surrounding rock cliff, supporting the structure. These brick supports vary from two bricks wedged lengthwise between the manhole and the cliff face, to an actual mortared wall measuring 45 inches in length and 22 to 30 inches in height. The opening of the manhole is "U-shaped" and includes metal rebar supports covered with a brick and concrete facade (see photograph CA-162-3). The cast iron lid from the manhole was found in the rocks below.

Next to the manhole is the remains of an abandoned tunnel portal, complete with wing walls (see photographs CA-162-4 and CA-162-5). This abandoned portal measures 118 inches in width and is filled with rock rubble and concrete. Two wing walls extend diagonally from the edges of the portal and measure 39 inches and 103 inches in width. These are composed of rock and concrete. It appears that this tunnel represents the first outfall during initial construction efforts. It was probably abandoned when it became evident that it was at a higher elevation than the tunnel required.

The City of San Francisco proposes to rehabilitate the Mile Rock tunnel as part of the proposed Richmond Transport System project. The proposed Richmond Transport System will consist of a new tunnel extending from Sutro Heights Park to the Presidio. The proposed transport system decline tunnel will intersect the historic Mile Rock tunnel. The existing Mile

Rock tunnel overflow system will be rehabilitated as part of the tunnel project. Plans for the historic tunnel rehabilitation include breaking into the historic tunnel from the decline tunnel, installing a temporary bulkhead and excavating all sand from the tunnel between the bulkhead and the southern limit of rehabilitation, cleaning and preserving exposed existing concrete, repairing lining, installing rock dowels in the existing tunnel, contact grouting and bonding, applying a shotcrete overlay, and then removing the temporary bulkhead.

This undertaking will have an effect on the Mile Rock tunnel, a property eligible for inclusion in the National Register of Historic Places. A Memorandum of Agreement between the National Park Service, the California State Historic Preservation Officer, the Advisory Council on Historic Preservation and the City and County of San Francisco necessitates mitigating the effects of this project through HAER documentation.

REFERENCES CITED

Ames Engineering
1978 *Structural Inspection of Mile Rock Sewer.* On file, Department of Public Works, San Francisco.

Byington, Lewis Francis
1931 *The History of San Francisco*, vol. 3. S. J. Clarke Publishing Company, San Francisco.

Detwiler, Justice B., editor
1929 *Who's Who in California, A Biographical Directory 1928-1929.* Who's Who Publishing Company, San Francisco.

Greene, Linda Wedel
1987 *Yosemite Historic Resource Study*, vol 1 of 3: *Historical Narrative.* U. S. Department of the Interior, National Park Service.

Grunsky, C. E.
1899 *Report Upon a System of Sewerage for the City and County of San Francisco.* The Hinton Printing Company, San Francisco.

Hanson, Warren D.
1985 *San Francisco Water and Power.* Department of Public Works, San Francisco.

Hart, James D.
1978 *A Companion to California.* Oxford University Press, New York.

Maiolini, Steve
1993 Personal communication with James Gary Maniery.

Maniery, Mary L., and Leslie Fryman
1993 *National Register of Historic Places Evaluation of Mile Rock Tunnel, City of San Francisco, San Francisco County, California.* Submitted to City and County of San Francisco, San Francisco, California. Prepared by PAR ENVIRONMENTAL SERVICES, INC., Sacramento.

National Park Service (NPS)
1991 *How to Apply the National Register Criteria for Evaluation.* NPS Bulletin 15. U. S. Government Printing Office, Washington, D. C.

O'Shaughnessy, M. M.
1913 Mile Rock Tunnel, Contract No. 39, Plans for Sewers, December 1913. On file, Department of Public Works, San Francisco.

Olmstead, Roger, and Nancy Olmstead
1979 *Ocean Beach Study: A Survey of Historic Maps and Photographs.* Prepared for San Francisco Wastewater Program. On file, Department of Public Works, San Francisco.

San Francisco Board of Supervisors
1915/1916 *San Francisco Municipal Reports,* 1915-1916. On file, San Francisco Public Library.

1914/1915 *San Francisco Municipal Reports,* 1914-1915. On file, San Francisco Public Library.

Taylor, C.M.
1919 *DISCUSSION of the PNEUMATIC PROCESS of MIXING AND PLACING CONCRETE BY COMPRESSED AIR as used during the construction of the MILE ROCK TUNNEL.* On file, San Francisco Public Library.

Wall, Glennie Murray
1993 *Section 106 Report, Richmond Transport.* Prepared by Preservation Planning, Montara, California. On file, Department of Public Works, San Francisco.