

Ensuring the Stability of the Washington Monument Foundation

"At the 555-foot Washington Monument, crews found a 4-inch crack late Tuesday and Wednesday the National Park Service says engineers discovered several additional cracks in the top portion of the structure. The cracks were found during a daylong inspection of the interior of the monument. The first crack was discovered Tuesday during an inspection of the exterior by helicopter, shortly after the earthquake shook the capital. "

--Associated Press, August 24, 2011

"Any sizeable excavation into the hard crust, by weakening its cohesion in one region, would develop a line of cracking and to the starting of a mud wave in the substratum."

-- 1934 Congressional report, *Improvement of the Washington Monument Grounds*, which led Congress to abandon plans to implement the 1902 McMillan Plan design for the grounds. To address the potential threat, the report proposed underpinning the Monument to bedrock.

"The increased rate of settlement that has occurred since the late 1960's is very probably due to an effective increase in overburden stress as a result of lowering of the ground water level in the general area by construction activity."

-- 1984 letter to the National Park Service from consulting engineers Mueser Rutledge describing the effects of drawdown resulting from 12th Street tunnel construction

August 26, 2011

The Problem: The National Coalition to Save Our Mall was alerted a decade ago by a World Bank scientist about historical concerns over the stability of the Monument foundation -- **which is not built to bedrock but sits on a substratum of clay, sand, and gravel** -- and potential threats to the foundation's stability by ongoing and proposed new construction at and near the Monument. The Coalition educated itself about this history (soil conditions beneath and surrounding the obelisk, water table fluctuations, and subsidence rates) and regularly has raised questions about the Monument's stability whenever projects are proposed that may affect conditions at the foundation -- most recently the future **Smithsonian Museum of African American History and Culture** to be located northeast of the Monument and the **National Park Service's (NPS) proposed underground security screening/visitors center and tunnel** entrance into the Monument. **No substantive answers have ever been provided. The August 23, 2011 earthquake gives the question new urgency.**

Based on the historical data released by the Park Service and the Smithsonian in response to several recent Freedom of Information Act (FOIA) requests -- details are provided below, in "Background" -- it can be concluded that

- **No one seems to have a complete and accurate picture of the current status** of the Washington Monument's physical condition or of changes over time in ground water, soil conditions, tilt, and subsidence -- **including the historically important relationship between water table and settlement at the Monument.**
- **No one entity or agency has in place a program for routine testing of basic physical conditions at the Monument** and sharing that data with all relevant agencies and private contractors as needed.

The Need: The August 23rd earthquake **may have disturbed subsoil conditions beneath and around the Monument**, in the opinion of the Coalition's engineering consultants, and therefore calls for strong action:

1. Engineers called in by the National Park Service to evaluate cracks in the Monument **should also look underground at conditions beneath and around the Monument including** water table, subsidence, and tilt. This will determine if the Monument is stable now and will establish a benchmark against which any future change can be measured.
2. NPS should ask the **National Geodetic Survey (NGS) immediately to measure any height changes at the Monument** using the bench marks and GPS data NGS has collected over the past century.
3. **Congress should empower a public/private partnership of professional engineering societies and federal agencies with the relevant scientific expertise (Army Corps of Engineers, National Geodetic Survey) to create a comprehensive preservation program** to routinely monitor the physical condition and geotechnical status of the Monument (and other key buildings and monuments on and near the National Mall), report any changing conditions, and propose any necessary improvements to ensure stability.

BACKGROUND

The National Coalition to Save Our Mall originally prepared this statement on the need for regular monitoring of the Monument foundation in early August 2011, prior to the August 23rd earthquake, to encourage the National Park Service and other federal agencies with stewardship for this nationally significant landmark to protect the integrity of the obelisk. Consulting engineers tell us the earthquake may have disturbed conditions underground and therefore make attention to this matter more serious than ever.

Despite the long history of engineering and geotechnical concerns regarding the stability of the Monument foundation, it appears that there is a lack of data or regular monitoring of the Monument's physical condition. This is particularly worrisome in light of a number of projects that are underway or being planned at or near the obelisk that could potentially affect subsoil conditions, including the 17th Street levee, the African American Museum, and the proposed underground security/visitors center at the Monument.

The Coalition understands that private engineering contractors for federal projects are cautious and conservative. But what historical data can these contractors consult? What directions and instructions do federal and District agencies give contractors about the kinds of studies needed prior to any construction activity to ensure protection of the Monument's integrity? For example, it is not clear if the Smithsonian intends to evaluate fully the Monument's status and history as part of its Museum project or if NPS intends to do that before Museum construction moves ahead.¹ Studies prepared by Smithsonian and NPS to date are incomplete and, for example, do not include scientific measurements of height differences on the Monument carried out by the Geodetic Survey.²

1. The reports released by the NPS and the Smithsonian in response to recent Freedom of Information Act (FOIA) requests show that instead of routine monitoring, measurements of soil and water table levels generally occur only when NPS proposes new construction: in the 1970s a proposed underground visitors center, in 1984 re-grading for new walkways, and in 2002 new security barrier walls (completed) and underground security screening/visitors center and tunnel entrance (defunded by Congress and not built). These project-based reports provide geotechnical history and analysis by NPS contractors:

¹ In an email exchange between the Coalition and the Smithsonian on August 11th and 12th, 2011, the Coalition asked two questions: Who is monitoring Monument status to date and what is the existing condition? And, How much settlement might occur as a result of construction of the African American Museum and how much settlement is considered safe? The Smithsonian reply mentions future test borings and monitoring but it is not clear whether this will include water table and settlement studies at the Monument itself:

"Thank you for your detailed email which we have forwarded to the team developing the monitoring plans to be in place during the testing and construction phases of the project. Your issue deals a lot with water content and my understanding is that the slurry wall construction is intended to neutralize water level changes and is the safest way to go, but we will leave that to the engineers to establish how this monitoring and protection will be implemented. We will be doing some test borings in September if approved by the agencies as part of our due diligence and we will have a extensive noise and vibration equipment in place for that limited exercise. Water levels will not be affected by this first effort. This will also give us some baseline information on the existing conditions of datum lines for all the buildings around the NMAAHC site, including the small Lodge building, the monument itself, Commerce and NMAH."

On August 19, 2011, the Smithsonian released the Tier II Environmental Impact Statement for the Museum project which states on page C-32:

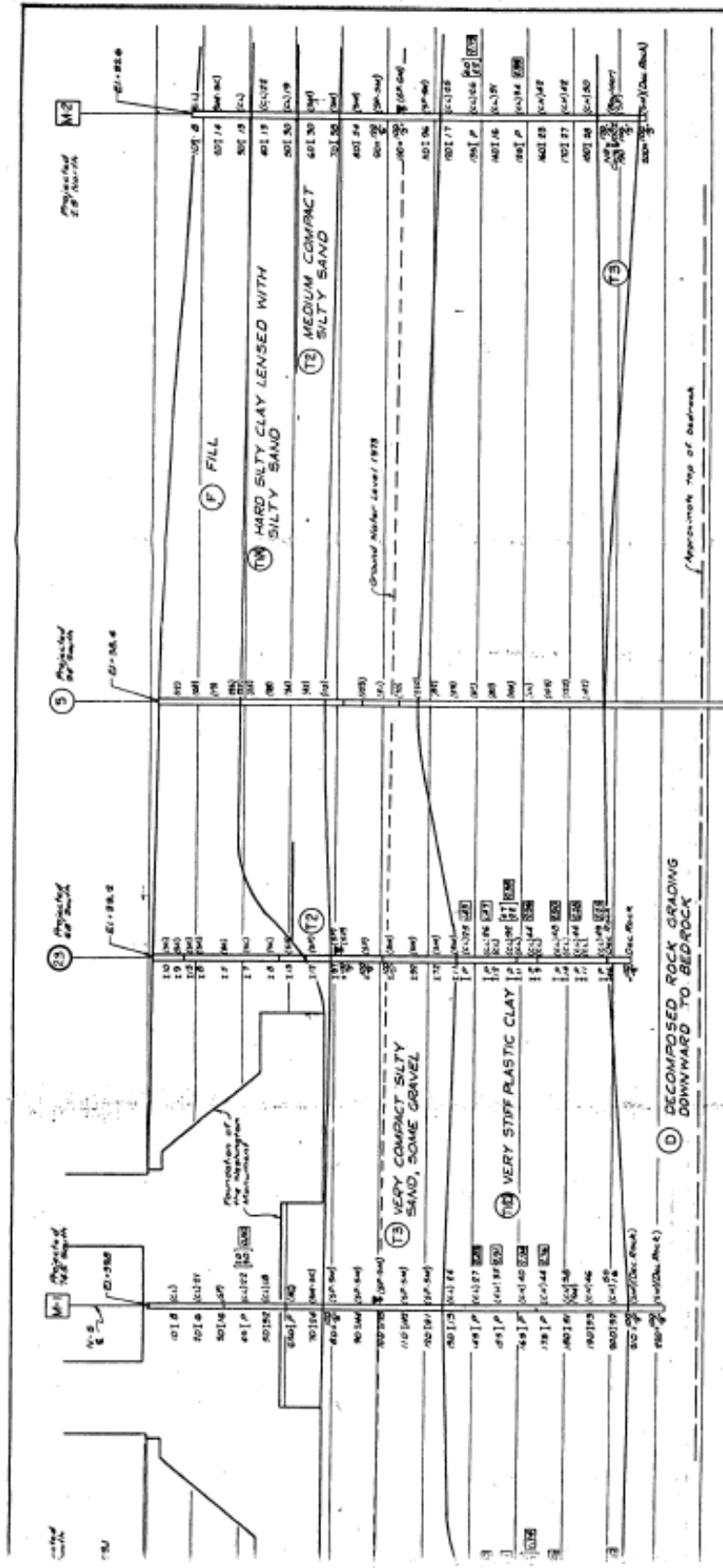
"The Smithsonian is committed to implementing a program of mitigation to avoid adverse impacts on groundwater and soil stability relating to surrounding structures, including the Washington Monument. The detailed plan for these mitigation measures must necessarily await further development of the design for the building's foundation and SOE design, as well as coordination with the project's Construction Manager, who will be engaged shortly."

² This data collected by the U.S. Coast & Geodetic Survey/National Geodetic Survey between 1907 and 2009 provides invaluable information in that it evaluates height changes at the area of the Washington Monument. However, NGS does not routinely carry out measurements because the Monument is under the jurisdiction of the National Park Service, which does not request this service. The NGS data on height measurements was provided by David R. Doyle, Chief Geodetic Surveyor in the National Spatial Reference System Division of the National Geodetic Survey in Silver Spring, Maryland.

- A description of subsoil conditions and settlement comes from a letter of February 13, 1984 from Mueser-Rutledge-Johnston-&-Desimone Consulting Engineers to William F. Ruback, Superintendent, National Park Service, National Capital Parks – Central [since renamed National Mall & Memorial Parks]: “The Monument is underlain by stream terrace deposits of Pleistocene times, directly over bedrock. The Pleistocene materials range from a medium plastic and slightly to moderately organic clay, to a very compact mixture of sand and gravel with some boulders. **It is the presence of a layer of this clay, designated Stratum T-1 (D), which has occasioned concern about stability of the Monument** [emphasis added]...The Magnitude of settlement that has occurred between 1898 and the late 1960’s is consistent with an appropriate theoretical rate of secondary compression of the underlying soil strata. The increased rate of settlement that has occurred since the late 1960’s is very probably due to an effective increase in overburden stress as a result of lowering of the ground water level in the general area by construction activity. Following extensive development in the Mall, involving deep basement excavation and depressed roadways, there has been a widespread drawdown of groundwater in the range of ten to 15 feet. The Mall area between 12th Street and the Monument has been dewatered to an appreciable extent by the construction along 12th Street.” See below the cross section showing the substrata.
 - This 1984 report includes a graph that shows an **"increased settlement rate due to general area groundwater lowering"** between 1962 and 1979. See the graph below.
 - Foundation underpinning and settlement is described in the June 10, 2002 report “Subsurface Investigation Monument Grounds and Visitor Facility, Washington Monument, Washington, DC” prepared for the NPS by Mueser Rutledge Consulting Engineers for the proposed underground visitor facility and tunnel entrance into the Monument: “...the foundations were constructed in 1848 and the shaft was begun at the end of 1848. **Construction halted in 1854 and resumed in 1878 with underpinning of the original foundations. The underpinning was carried to about Elev. +2.** The remainder of the Monument was constructed between 1878 and 1884. Settlement has been monitored throughout its history, but available records date back to 1878. They indicate that total settlement between 1879 and 1992 was about 7 inches, due to the compression of the T1(D) clay. During the 7-year completion of the Monument, 4.5 inches of this settlement occurred. During the subsequent 106 years (1886-1992) settlement has been less than 2.5 inches.”
2. In the Coalition’s recent conversations and emails with federal and District planners and preservation staff in association with public consultation meetings for the African American Museum and security tunnel projects, the agencies acknowledge the legitimacy of the Coalition’s questions and respond that it will be up to Smithsonian’s consulting engineers to evaluate and plan for current and future conditions, as quoted in Footnote 1.
 3. In August 2011 the Coalition spoke with the National Geodetic Survey, the federal agency cited in the 1984 Mueser Rutledge graph as the source for settlement data. NGS measures height differences to determine the status of structures. From NGS the Coalition received records from between 1907 and 2009 that show little change in Monument height (as determined by comparing bench marks placed by NGS on nearby buildings) over that period, a good sign. However,
 - The NGS monitoring dates do not correspond to those in the Mueser Rutledge report and graph. What is the basis for that graph data?
 - The NGS measurement data lacks any associated soil and water table information and so does not indicate what may be happening below ground
 - It is unknown whether this NGS data proves minimal subsidence or could be the result of fluctuations over time between uplift and subsidence

For more information contact:

*Judy Scott Feldman, PhD
 Chair & President
 National Coalition to Save Our Mall
jfeldman@savethemall.org
 301-340-3938*



WASHINGTON MONUMENT INTERPRETIVE FACILITY

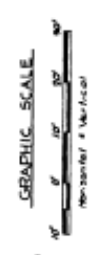
HARTMAN · COX, ARCHITECTS
 JAMES MADISON CUTTS
 STRUCTURAL ENGINEERS

WESLEY · BELLEUE · WERTWORTH & JOHNSON
 CONSULTING ENGINEERS
 415 MADISON AVE., NEW YORK, N.Y. 10017

SCALE: HORIZONTAL: 1" = 20' VERTICAL: 1" = 10'

DATE: 1962

EAST - WEST GEOLOGICAL SECTION GS-2



SECTION ON EAST-WEST CENTERLINE
 LOOKING NORTH

(M) - Symbol for sample location using the Unified Soil Classification System

(S) - Average original water content of sample

(F) - Sample length

(T) - Sample length

(D) - Sample length

(M1) - Sample length

(M2) - Sample length

(M3) - Sample length

(M4) - Sample length

(M5) - Sample length

(M6) - Sample length

(M7) - Sample length

(M8) - Sample length

(M9) - Sample length

(M10) - Sample length

(S1) - Sample length

(S2) - Sample length

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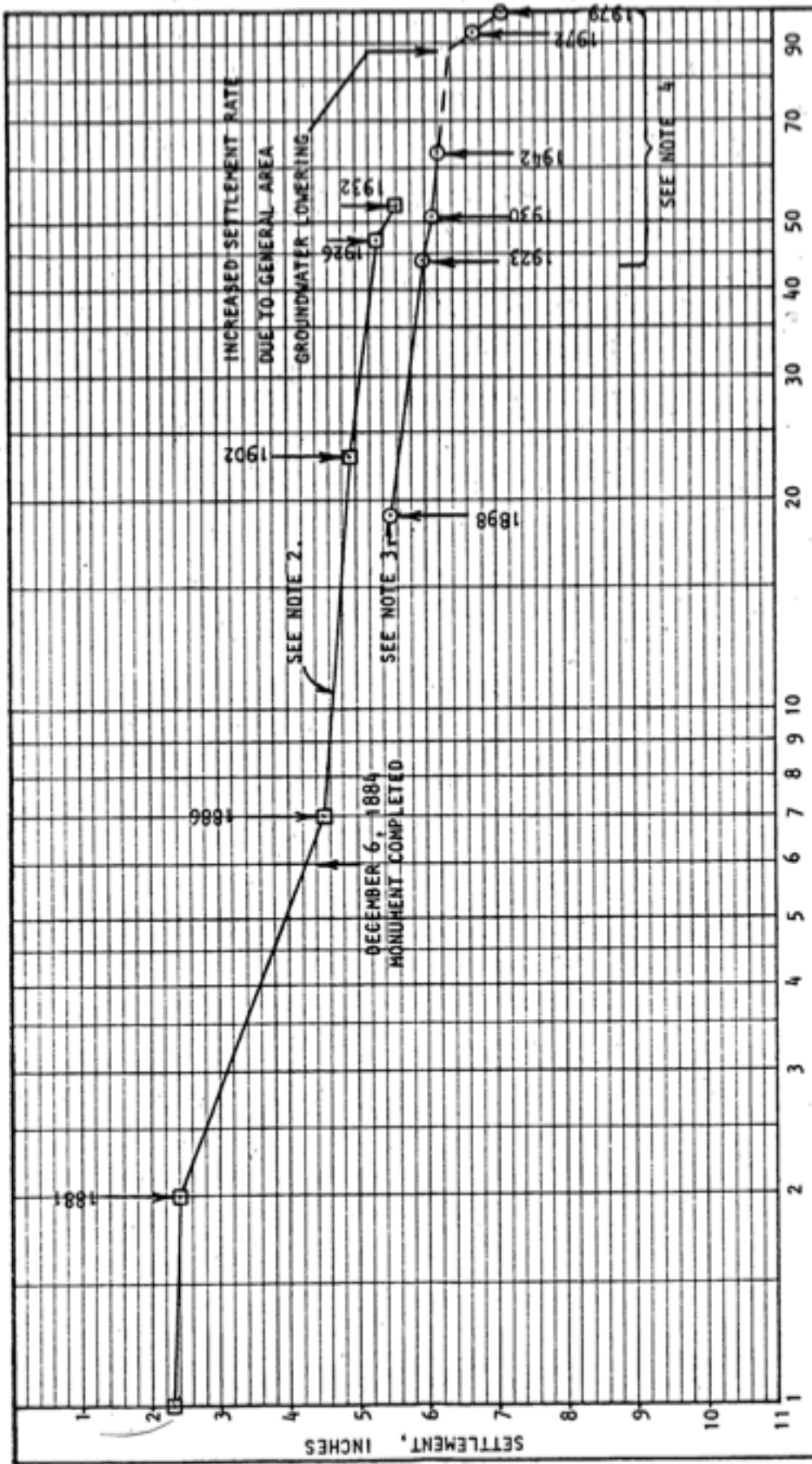
(D6) - Sample length

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WASHINGTON MONUMENT	
NATIONAL PARK SERVICE	
MUESER - RUTLEDGE - JOHNSTON & DESMONE CONSULTING ENGINEERS	
708 THIRD AVENUE, NEW YORK, N.Y. 10017	FILE NO.
DATE 2-02-84	5841
DRAWN BY	PLATE NO.
OBSERVED SETTLEMENT	1

NOTES

1. YEAR 0 AT 1879
2. SETTLEMENT OBSERVATIONS REPORTED BY THE SPECIAL COMMITTEE ON EARTH AND FOUNDATIONS, A.S.C.E. PROCEEDINGS, MAY, 1933.
3. SETTLEMENT REPORTED BY N.H. DARTON, GEOLOGICAL SURVEY PROFESSIONAL PAPER 217, 1950.
4. SETTLEMENT OBSERVATIONS RECORDED BY U.S. COAST AND GEODETIC SURVEY.

PLATE NO. 1