



WATER-RIGHT DOCKET

Fort Sumter National Monument

Docket No: 1

WELL #3, #4, & #5

Supporting Hydro Data

09-08-1971: memorandum to asst. dir. from superintendent regarding chemical analysis of water

D5031

Fort Sumter National Monument
Drawer R
Sullivan's Island, S. C. 29482

September 8, 1971

EASTERN SERVICE CENTER SEP 10 1971	
☐	Director ESC
☐	Chief Admin
☐	Chief CSM
☐	Chief EPD
☐	Chief HHA
☐	Chief L&W
☐	Chief PM
☒	Files

Memorandum

To: Asst. Dir., Park Support Services, SERO

From: Superintendent, Fort Sumter NM

Subject: Chemical analysis of water - Ft Sumter wells

Please find enclosed a copy of the second chemical analysis of the water wells at Fort Sumter. We suspect that the great drop in specific conductivity is the result of the heavy rainfall (11 inches) on August 19th and 20th. We are presently trying to contact the instrument distributor in Atlanta to determine why the "salt sensitive" recorder does not appear to be registering the changes in conductivity.

Until we have determined that the sensing device is functioning properly, we won't pump any water into the cisterns.

Lloyd K. Whitt

Enclosure

cc;

Mr. Ketcham, ESC, Wash. D.C.

Mr. Siple, Geo. Survey, Columbia, S.C.

PARKER LABORATORY, INC.
 CONSULTING CHEMISTS
 40 BROAD STREET
 P. O. BOX 791
 CHARLESTON, S. C. 29402

Analysis No. 4819

Sample of water

Received 8/31/71

From Ft. Sumter, Nat. Mnt.

Marked: Water sample submitted 8/31/71 for chemical analysis
 marked: 4:30pm 8/30/71.

CERTIFICATE OF ANALYSIS	Parts per Million
Turbidity	0
Color	5
Chloride (Cl)	5
Total alkalinity (CaCO ₃)	8
Carbonate " "	0
Bicarbonate " "	8
Hardness " "	8
Free Carbon Dioxide (CO ₂)	2
Iron (Fe)	.14
Manganese (Mn)	.00
Copper (Cu)	.00
Aluminum (Al)	.00
Silica (SiO ₂)	.00
Calcium (Ca)	3.2
Magnesium (Mg)	.00
Sulfates (SO ₄)	.00
Fluoride (F)	.00
pH value	7.30
Total dissolved solids	18
Specific conductance at 25°C.	30 ✓
Remark: Water meets the U.S. Public Health Service Recommended limits for chemical quality	

To:

Ft. Sumter
 Drawer R
 Sullivan's Island, S.C. 29482
 Attn: Mr. L.K. Whitt

Respectfully submitted,
 PARKER LABORATORY, INC.

QUICK PRESS

PARKER LABORATORY, INC.
CONSULTING CHEMISTS
40 BROAD STREET
P. O. BOX 791
CHARLESTON, S. C. 29402

Analysis No. 4784

Sample of water

Received 8/23/71

From Ft. Sumter, Nat. Mnt.

Marked: Water sample submitted 8/23/71 marked: Ft. Sumter Well

<u>CERTIFICATE OF ANALYSIS</u>		Parts per Million
Turbidity		0
Color		5
Chloride (Cl)		46
Total alkalinity (CaCO ₃)		260
Carbonate "	"	.00
Bicarbonate "	"	260
Hardness "	"	246
Free Carbon Dioxide (CO ₂)		2
Iron (Fe)		.20
Manganese (Mn)		.00
Copper (Cu)		.00
Aluminum (Al)		.00
Calcium (Ca)		53.6
Magnesium (Mg)		27.3
Fluoride (F)		0.20
pH value		8.0
Total dissolved solids		390
Specific conductance at 25°C.		650
Sulfate (SO ₄)		11
Silica (SiO ₂)		10
Remarks: Analysis indicates that the water meets the U.S. Public Health Service Recommended limits for chemical quality.		

To:

Ft. Sumter Nt. Mnt.

Drawer R

Sullivan's Island, S.C. 29482 PARKER LABORATORY, INC.

Attn: Mr. L.K. Whitt

Respectfully submitted,



QDOR PRESS

L54 ESC-LN

August 25, 1971

MEMORANDUM

To: Chief, Division of Water Resources, WRSO

From: Supervisory Hydraulic Engineer, ESC

Subject: Field Trip to Fort Sumter

The purpose of the subject field trip was to make a final inspection of the new shallow well water supply system within the Fort. I'll be damned if it doesn't work!!

Construction was completed in accordance with the drawing entitled "Water System Additions" dated May 1, 1970. The slight modifications included running the header parallel to the interior parade ground wall and placing the pump and conductivity control under the first flight of stairs leading to the Visitors Center Area. The three wells tied together were Nos. 6, 3 and 2 all of which, of course, contain fresh water. As constructed drawings are now being prepared.

Each of the wells had been tested individually, but at the time I was present, all three were producing water simultaneously as planned for normal operation. The pump was producing 1,040 g.p.d. (gallons per day) which is about what we specified to the manufacturer. This very low rate of pumping should maintain the relative location of the fresh water, salt water interface if our past research proves reliable.

One of the primary purposes of the trip was to set the rating of the conductivity control to prevent any accidental pumping of high salinity water into the system. Figure No. 1 relates the two quantities that we have encountered at Fort Sumter in the past. We selected to set the cam that disengages the pump at 1,500 micromhos on the conductivity scale. This represents about 300 ppm chlorides in the water. The conductivity will also be recorded on a continuous chart that will be sent to this office periodically. We, of course, can examine the effects of salt water inundation by simply moving the control to a very high conductivity and running the water to waste.

Water samples were taken for both chemical and bacteriological analysis. These tests will be made at Charleston the week of August 22. All work should be complete this same week, and if the quality tests are normal the new water supply will be directed into the existing reservoirs.

(Sgd.) Richard W. Ketcham

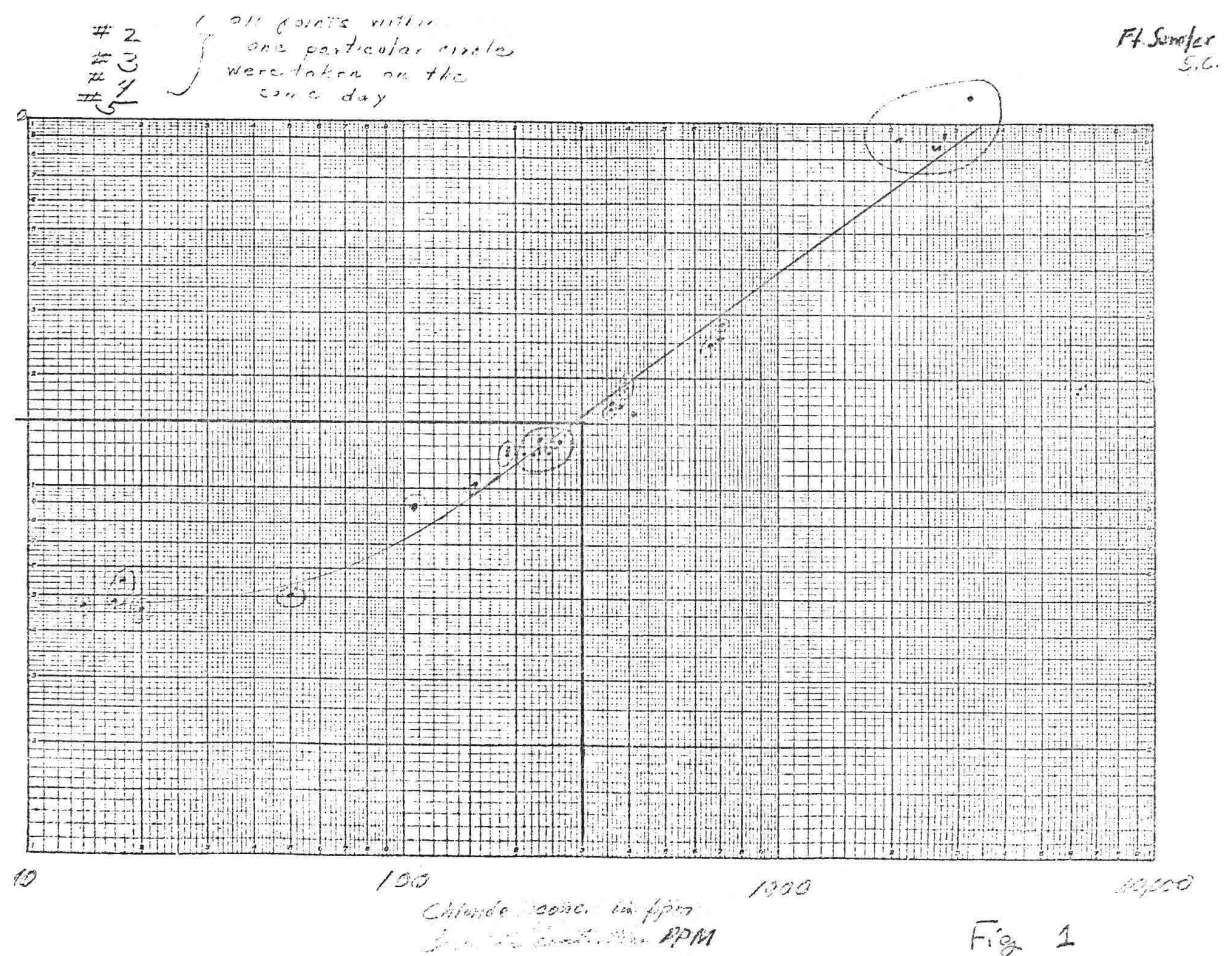
Richard W. Ketcham

cc:

Director, Southeast Region w/enc
Superintendent, Fort Sumter w/enc
ESC-MED Attn: Mr. J. Longworth w/enc.
ESC-OPN w/enc.

ESC-LW Water Resources (Fort Sumter)

RWKetcham/cs/8/25/71





UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division
Room 10 - 1100 Laurel Street
Columbia, South Carolina 29201

March 27, 1970

Mr. Richard W. Ketcham
Supervisory Hydraulic Engineer, WSC
U.S. Department of the Interior
National Park Service
4228 Wisconsin Avenue, N.W.
Washington, D.C. 20242

Dear Mr. Ketcham:

In accordance with our recent telephone conversation, I am forwarding the latest information regarding surveys and plans for future activities at the Fort Sumter National Monument.

In the light of past knowledge acquired concerning the possible water supplies for Fort Sumter, I believe that it would be feasible and probably economically advantageous to begin development of the shallow well system.

Initially we would like this to be done under test conditions. However, for most practical purposes, these would be identical to those required for a permanent water withdrawal system.

All our previous tests indicate that the wells from which the fresher waters are likely to be obtained over the longest duration of time are wells 2, 3 and 6. During our test of last year, one of these wells (no. 6) was pumped continuously for 30 days at a rate of approximately 1.5 gpm. There appeared to be no significant increase in chlorides in any of the three wells, although a heavy rain near the end of the test may have affected this result to some extent. However, if all three wells were pumped at a rate of about 1/3 gpm, we think this would simulate practical pumping conditions and allow us to monitor the results of such pumping in the other wells on the island.

I have discussed the proposed set-up with Mr. Taylor. Some time ago he submitted a bid for the installation of a similar system and I think he and Mr. Swartz had agreed that the pump, which would draw from the three wells, would be placed near the concrete wall and housed in such a manner as to appear or function like a seating bench. He was thinking of 3/4- or 1/2-inch copper tubing, and burying it in the concrete to bring it over to the supply cisterns. As you mentioned, each well should be valved and tapped to enable specific sampling at that well.

With regard to the automatic conductivity control instrumentation, I contacted the Beckman Instrument Co. (formerly Industrial Instruments, Inc.), of Cedar Grove, N.J. They suggested the use of either their model REI-182 Solu Bridge Controller (\$310) with an epoxy VH10T conductivity cell (\$88) or an RA-5 Solu Meter (\$355) with a VK4-T cell (\$74) and an alarm control T-48 (\$26). The REI is calibrated from 0 to 20 micromhos but it could be adjusted to range from 0 to 2000 micromhos, with a logarithmic scale. The center of scale would read 400 mhos. The electrical output is 0 to 110 watts and the range of temperature configuration is from 34 to 140°F. (The range on the RA-5 is 32 to 122°F, so that either one would be appropriate.) When I called the manufacturer several months ago, their delivery time was quoted as 8 weeks. The specifications and descriptions of the equipment are contained in their catalogue #30.

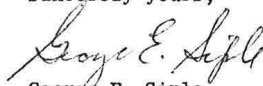
Another company which sent me some literature on this was McNab, Inc., New York City, with the nearest representative indicated as Ashmead-Danks Co., 1511 Warrensville Center Road, Cleveland, Ohio 44121, telephone (216) 382-2323. Their Bulletin 652 (one sheet) illustrates an "Aqua-Purometer", described as a precision-type instrument designed to measure and monitor the electrolytic conductivity of water and other fluids -- that is, it employs a remotely installed sensing cell, providing accurate monitoring against a calibrated meter scale and alarm setting dial. In addition, automatic dumping acts as a control to bypass fluid during an alarm condition. Presumably any of these instruments could be set up to connect with a starter or relay to the pump which would automatically shut off at a pre-set maximum concentration.

The range of conductivities used will depend in part on several factors. First, if the water is not to be mixed, then the conductivity limit would be lower than if mixed and if the well water is to be mixed with the rain water the proportion of this mix would control the maximum chloride permissible from the wells. In the course of our tests, generally waters with conductivities of 1500 mhos or less contained chloride concentrations of 250 ppm or less. In the test of well 3, the maximum conductivity was 855 mhos whereas the maximum chloride content was 275 ppm. So in a system using 100% well water, a maximum conductivity of 1000 to 1500 mhos would appear to be satisfactory. However, this is based on comparatively short-term pumping tests and pumping for longer periods might require more conservative limits. But then, if the water is mixed with rain water (and the control instrument is placed between the pump and the cistern), higher limits would be allowable. The control mechanism might be placed between the cistern and the pressure tank or chlorinator, and in this case, the conductivity limits would have to be determined or estimated on the basis of how much rain water would, during most of the time, be mixed with the well water. This could probably be adjusted to some extent as rainfall conditions changed.

We will be interested in knowing what your decisions are with respect to this installation. For the next month to six weeks, our manpower supply will be practically nil in view of a dye-study project in Port Royal Sound. After that, there should be no difficulty. But we would like to have our monitoring equipment installed on the other wells when the pumping of wells 2, 3 and 6 begins.

We obtained geophysical (gamma-ray) logs in all the wells except numbers 1 and 2. Unfortunately, the results did not constitute much in the way of additional data concerning probable connection of sand lenses between wells. We are monitoring the 450-foot aquifer in the Charleston area to help evaluate this as an alternate system and also the deeper Cretaceous sand aquifer, in order to provide you with information concerning possible alternatives in the ground-water supply at this location. I sincerely hope these efforts will be continued until a reasonable estimate of these potentials have been attained.

Sincerely yours,

A handwritten signature in cursive script, reading "George E. Siple".

George E. Siple
Staff Hydrologist

Enclosure (Copy -
McNab Bull. 652)



UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
WASHINGTON PLANNING AND SERVICE CENTER
1730 NORTH LYNN STREET
ARLINGTON, VIRGINIA 22209

IN REPLY REFER TO:
L54 WSC-OLW

February 20, 1968

Handwritten: CML
2/27
WJ

Memorandum

To: Chief, Branch of Water Resources, WASO
Through: Chief, Office of Land and Water Rights, WSC *WJ*

From: Supervisory Hydraulic Engineer, WSC

Subject: Field Trip to Fort Sumter

As suggested by Mr. Siple in his letter of November 16, 1967, transmitting the U. S. Geological Survey progress report to Fort Sumter, a meeting was held at this area on February 6 and 7. The Superintendent had just been released from the hospital, after surgery, and we appreciated his effort to meet with us in his office. Those present included: Superintendent, Paul Swartz; George Siple, U. S. Geological Survey; Frank Taylor, Contractor; and Richard W. Ketcham, WSC.

In my field report, written February 8, 1967, I tried to analyze water use at Fort Sumter from very empirical data. This data was projected into a future peak water use of about 2,400 gpd. At the same time the Park agreed to have the water meter on the distribution system repaired and read periodically during the year. This has been done and the readings are considered accurate since April 1 of last year. The results are:

Total water used - April 1, 1967 - January 30, 1968 = 75,450 gallons
Visitation - April 1, 1967 - January 30, 1968 = 74,753 persons

Neglecting Park personnel on the Island, this is very close to an overall average use of one gallon per visitor and represents a future water use of about 1,500 gallons per day. As stated above the trip report of a year ago calculated a peak load of 2,400 gallons per day. However, our conclusion is the same. The shallow water aquifer as a supplement to the rain catchment system, now in use, should supply Fort Sumter with all the water it will need in the foreseeable future. This, of course, should be used in conjunction with the new reservoir to be constructed this spring. One additional supply of water, not now being utilized is recharge of the ground water table by additional rain catchment diversion to the Parade Field. This could be incorporated into our final water supply system if we felt at a later date it would be required.

A horizontal well was discussed for some time and certain objections were pointed out. Mr. Taylor stated that to lay the pipe at grade, he would have to dewater the trench with a sump pump and thereby indanger the aquifer. Using hand methods to construct the trench because of the danger of unexploded ammunition, Mr. Taylor said he would not even quote a bid. My opinion from the discussion is that it would be prohibitively expensive to obtain even the shortest length of trench into the fresh water zone under the Parade Ground. Therefore this type of system is not recommended.

To provide the best possible shallow water system, it was decided to proceed with Mr. Siples recommendation to install another well point 65 feet north of Well No. 2 and about the same distance away from the concrete wall of Battery Huger. One last observation well should be placed some distance north of the new production well. Wells Nos. 2, 3, and 6 will then be connected as shown on the enclosed sketch. This system will achieve about the same results as a horizontal well, and I should have a cost for this work by next week. The U. S. Geological Survey would like to test the new well for a short while before construction of the water supply system.

The discussion included some of the design considerations for a new water supply and they are noted here only as suggestions that Design and Construction, PSC, might consider when preparing plans. It is suggested that pumping system consist of a short stroke, reciprocating piston pump capable of delivering 1.0 gpm against 25 feet of head - 10 feet of suction lift and 15 feet of positive head. The pump should be located as close to the source as possible to reduce the suction lift, and if possible near the side of the Parade Field. It could be easily covered with a small sitting bench. The piping for the system might be 200 # 1" PVC buried 6 inches under the ground with brass or bronze gate and check valves located at the wells. We, also, recommend that the reservoir be valved so that they can be filled and drained separately. This will permit the Park to clean each separately and allow for flexibility in the distribution system. As one final check and control, it is recommended that an automatic shut off device be installed to disengage the pump when the conductivity indicates the chlorides are in excess of 250 ppm. We will provide data on this type of instrumentation at a later date if it is decided that this would be desirable.

There was some indication that the quality of the ground water was not as good as that from the rain catchment system. I have found, however, that those drinking rain catchment water, complain about crystal clear spring water. Those drinking crystal clear spring water, complain about surface

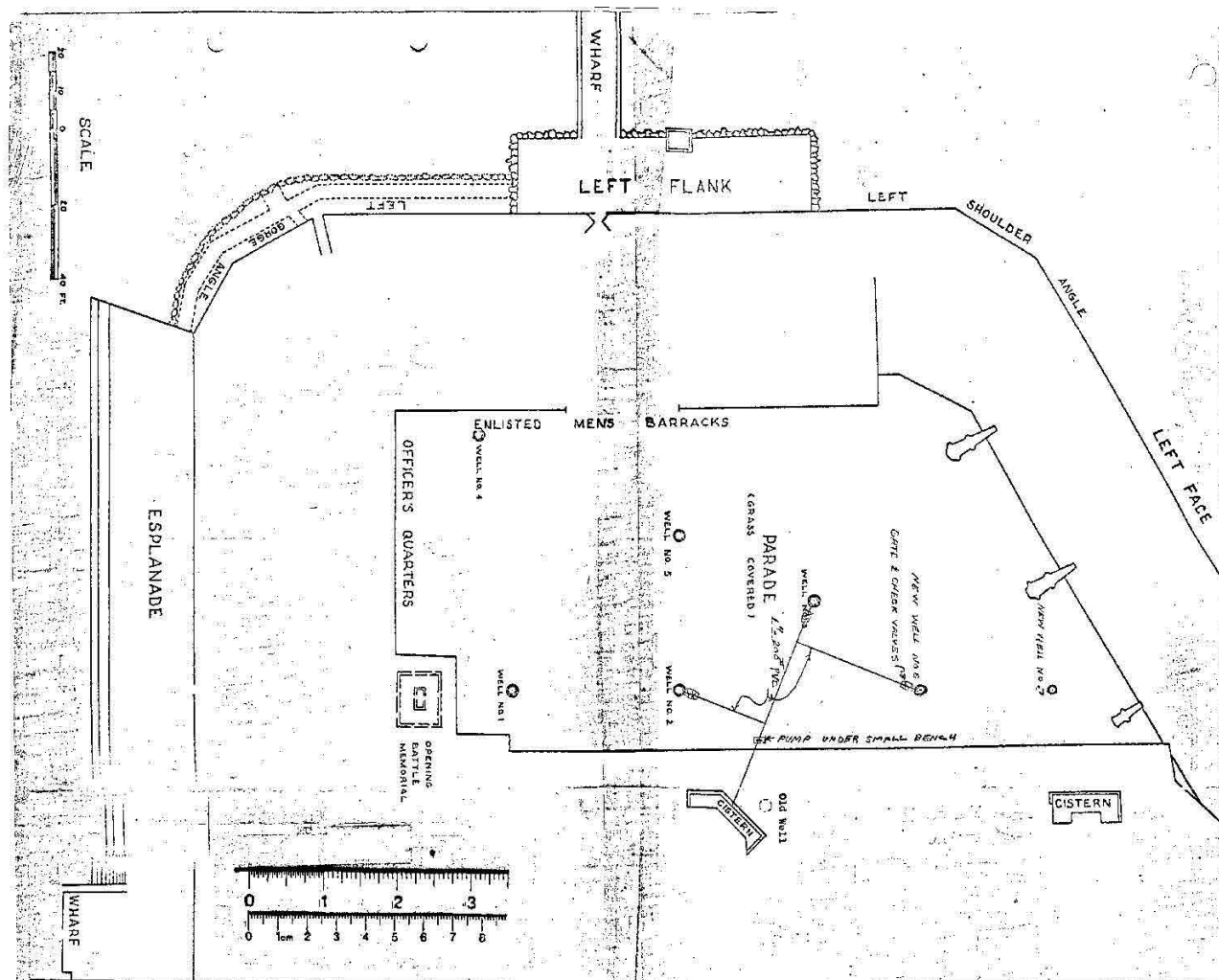
water. Those drinking surface water, complain about saline or soda water; and those drinking saline and soda water after one year, don't complain about anything. They just become accustomed to it.



Richard W. Ketcham

Enclosure

cc:
Regional Director, Southeast w/enc.
Superintendent, Fort Sumter w/enc.
Chief, D&C, PSC



Other Supporting Information

MEMORANDUM REPORT ON USGS INVESTIGATIONS
AT FORT SUMTER NATIONAL MONUMENT, 1967

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2. Construction diagram of shallow test wells No. 3, No. 4, and No. 5 at Fort Sumter, S.C.
 3. Relative stages of predicted (USC&GS) tide, observed tide, and water level fluctuations in observation well No. 2, compared with measured conductivities in well No. 3, Fort Sumter, S.C.

Table 1. Summary of Fort Sumter pumping test data, 1967

MEMORANDUM REPORT ON USGS INVESTIGATIONS
AT FORT SUMTER NATIONAL MONUMENT, 1967

During the past year the South Carolina District of the Water Resources Division, USGS, has been engaged in an investigation of the possible ground water supplies available to the Fort Sumter National Monument of the National Park Service, located in Charleston Harbor, South Carolina. The purpose of this report is to summarize the activities during this year, in particular the installation of new wells and the data obtained from pumping tests. Please refer to previous memorandum progress reports dated January 10, 1967, March 6, 1967, and May 17, 1967 for additional detail, most of which is not repeated herein.

The investigation is divided into three phases to identify and evaluate the (I) shallow, (II) intermediate and (III) deep aquifers or aquifer systems as suitable sources for additional water required for drinking and sanitary facilities at Fort Sumter. Our efforts during the past year have been concentrated primarily on Phase I and to a lesser extent on the preliminary activities required in Phase II.

Activities Under Phase I

Figure 1 shows the location of the present test wells on the parade

Figure 1. Location of shallow test wells at Fort Sumter National Monument.

ground at Fort Sumter. Only two wells (No. 1 and No. 2), both of which were 1½ inches in diameter, were installed as of the beginning of the year. Several invitations to bid on proposed additional test wells

were not accepted by any of the drillers contacted, so a 2-inch test and
 (No. 3)
 observation well^A was installed 44 feet from existing well No. 2 by USGS
 personnel. This well consisted of a 3-3/4 foot jet-point screen, connected by 8½ feet of 2-inch galvanized pipe with a 2-inch bell coupling, making a total length of about 12½ feet, with about 2½ feet of the casing above ground level. The successful results of this pilot operation, together with subsequent discussion by the undersigned and the Park Superintendent with one of the local drillers, provided the impetus for his contracting to install two additional wells on the parade ground. One well was 2½ inches and the other 4 inches in diameter. These wells are indicated as No. 4 and No. 5, respectively, on figure 1.

All wells were drilled to approximately the same depth. A shallower depth was specified for well No. 4 because of its proximity to the edge of the parade ground and salt water. The dimensions and constructional features of each well are illustrated in figure 2.

Figure 2. Construction diagram of shallow test wells No. 3, No. 4, and No. 5 at Fort Sumter, S.C.

The first parameter measured during the present study at Fort Sumter was the change in water-table stage as affected by natural factors, i.e. -- variation in tide, wind, air pressure, and rainfall. This water-level fluctuation was recorded on continuous recorders of various types but because most measurements to date were obtained in the small diameter

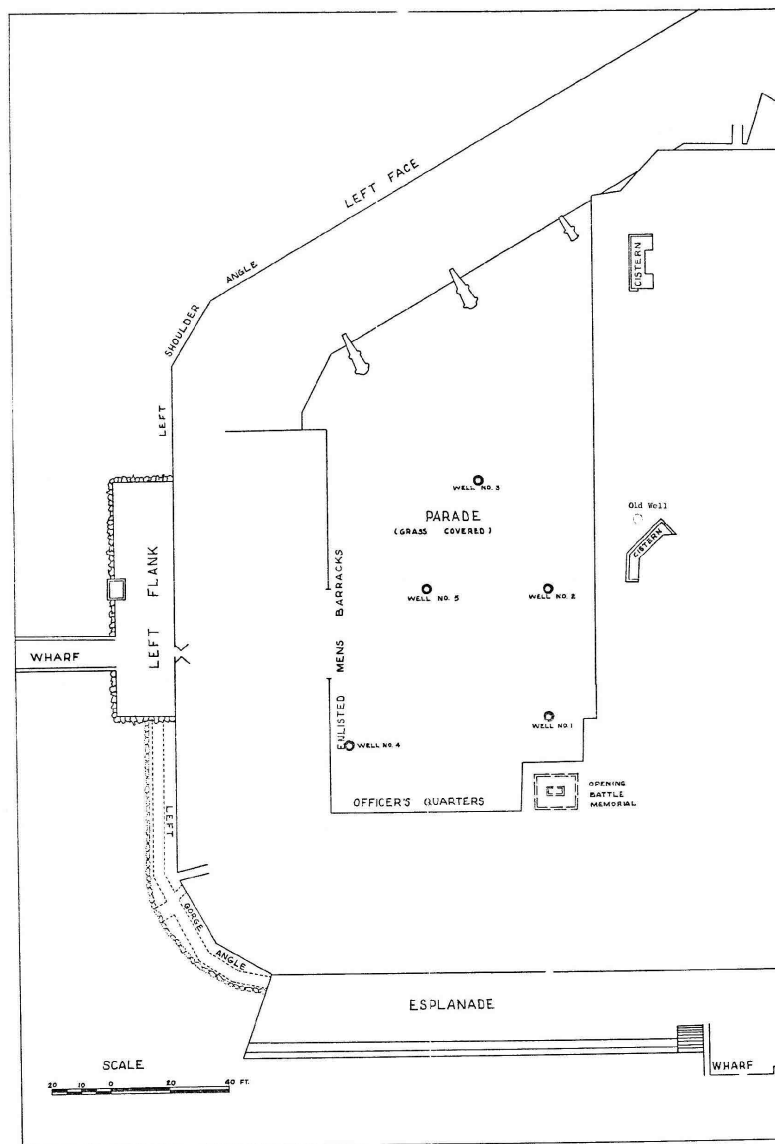
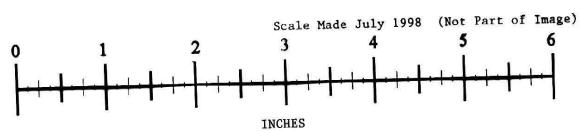


Figure 1.. Location of shallow test wells at Port Sumter National Monument, Port Sumter, S.C., November 1967



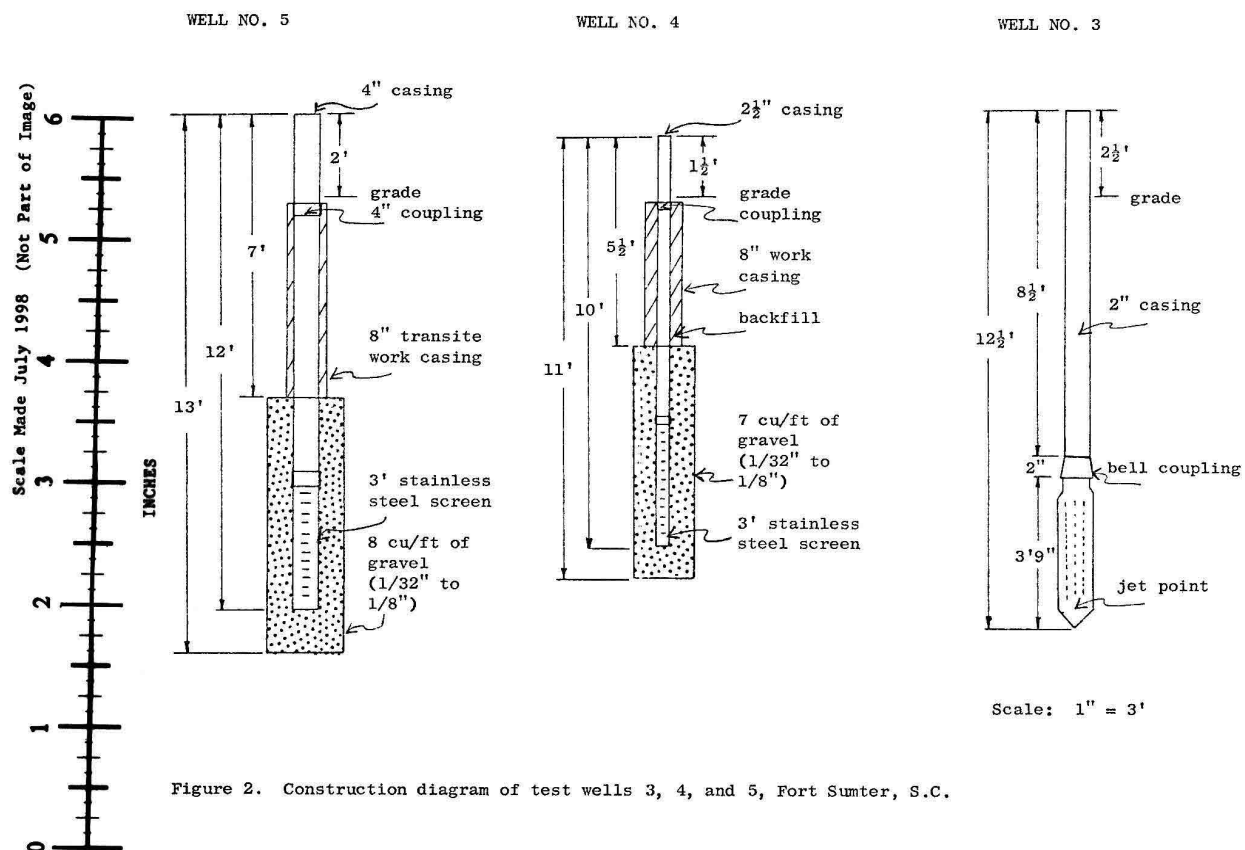


Figure 2. Construction diagram of test wells 3, 4, and 5, Fort Sumter, S.C.

(1 $\frac{1}{4}$ inch) wells, much difficulty has been experienced in obtaining continuity of record or accuracy in the recording mechanism. In order to circumvent one additional difficulty involved in water-stage evaluation, that concerning the exact definition of datum planes in a coastal area, we installed a tidal gage outside the Fort, attached to a piling on the boat dock. This consists of a stilling well of 4-inch diameter galvanized pipe strapped to the piling and on top of which a platform supports a digital tape recorder and shelter. A small-diameter float inside the pipe responds to water-level change due to tide and a battery-driven motor punches a 2-inch tape to record changes in stage. The tape is subsequently fed into a computer to obtain readouts of 15-minute stage, plus daily maximum and minimum stages and corresponding times of the actual tides.

Well No. 3 was equipped with a conductivity sensor which also activates a digital recorder and obtains a punched tape record of 15-minute changes in conductivity. The instrument is temperature compensated. Thus a standard or normal monitoring arrangement at Ft. Sumter at the present time includes a Stevens Type F weekly mechanical recorder in well No. 1; a Stevens Type A-35 continuous recorder (mechanical) in well No. 2; an electric conductivity recorder, built by our USGS Research Section and coupled to a Fisher & Porter, Model 1542, digital recorder, in well No. 3; a tidal gage equipped with a Fisher & Porter digital recorder on the boat dock; and a centrifugal pump in well No. 5.

Whereas such difficulties as indicated above have been experienced to date in obtaining definitive records of extended continuity concerning the relation of water-level change in the aquifer as affected by ~~various~~ various parameters, especially during a period when a stress such as pumping is imposed upon the hydraulic system, nonetheless the natural steady-state conditions have been monitored with some success, at least to the point where it can be said that the major factor affecting change in the water level in any well is that of the tidal range. The tidal efficiency or amount of water-level change in the well during one tidal cycle as a function of the tidal range taking place in the harbor, is approximately 20-percent -- or every tidal change of one foot will produce a 0.2 foot change of water level in the well or aquifer.

Figure 3 shows the interrelationships of predicted tide, actual or measured tide, water-level in an observation well, and conductivity in

Figure 3. Relative stages of predicted (USC&GS) tide, observed tide, and water level fluctuations in observation well No. 2, compared with measured conductivities in well No. 3, Fort Sumter, S.C.

another observation well.

The depiction of the steady-state conditions reflected in figure 3 indicates a 20 percent tidal efficiency for water wells in the shallow sands beneath the parade ground, a time lapse of from 48-108 minutes between the crest of water level and actual tide (which should not be considered inclusive because of the short period of observation), a tidal stage

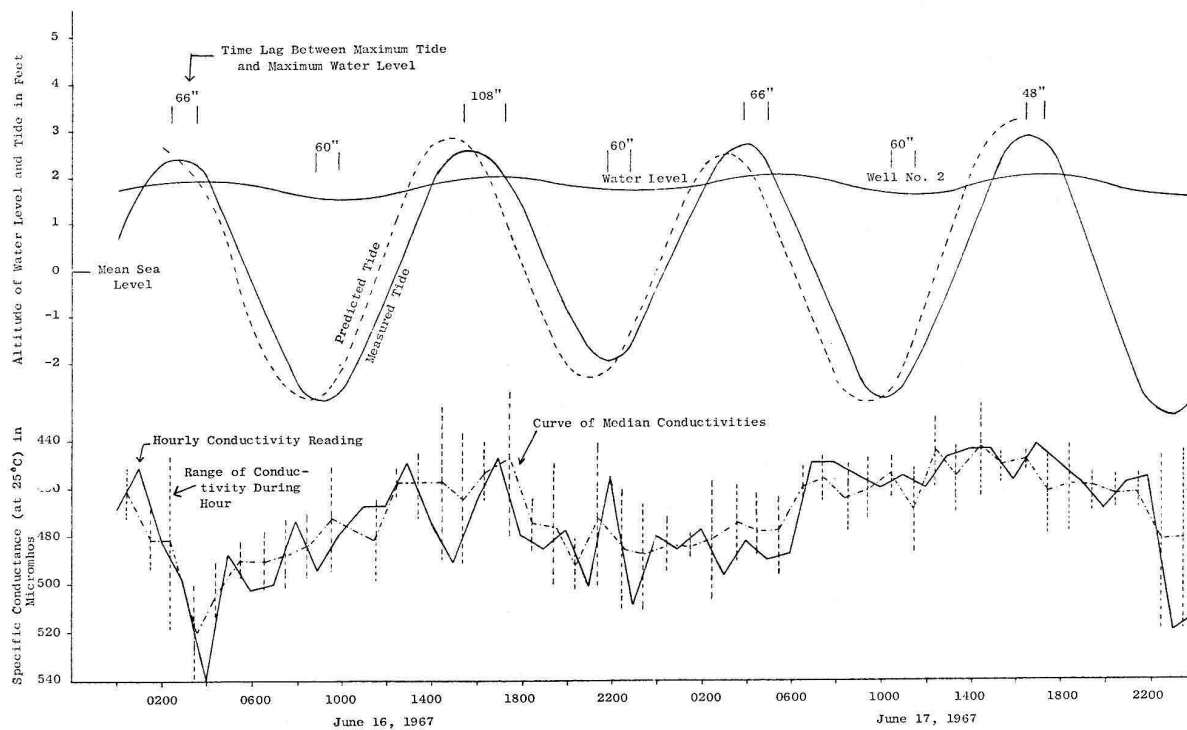


Figure 3. Relative stages of predicted (USC&GS) tide, observed tide, and water level fluctuations in observation well No. 2, compared with measured conductivities in well No. 3, Fort Sumter, S.C.

measuring from zero to as much as three-fourths of a foot higher than water table elevation during a period of $1\frac{1}{2}$ hours preceeding and following the high tide, and a nebulous or inconclusive relation between tidal stage and the conductivity of the shallow ground-water.

Pumping Tests

With the instrumentation indicated above, we proceeded to make a number of pumping tests -- most of which however were run before all the instrumentation was available and none of which to date were conducted during periods when all instruments were functioning properly or simultaneously. These factors, along with a number of smaller difficulties, all contributed to the fact that an entirely adequate or definitive test is yet to be obtained. A sub-surface condition of heterogeneity was assumed at the beginning of the project but we seem to be continuously discovering additional factors which indicate even lesser homogeneity, as for example when well No. 4 was installed, the driller reported that during the process of drilling he realized that the well was situated between two buried concrete structures in a space not much larger than the well diameter. Neither of these structures were previously known to exist beneath that part of the parade ground.

Table 1 summarizes the detailed data obtained during a series of pumping tests conducted between February 8 and September 1, 1967. As

Table 1. Summary of Ft. Sumter pumping test data, 1967

Date test began	Pumped well number	Pumping rate (gpm)	Duration of test	Total gallons pumped	Recharge during test	Chloride concentration and related factors			
						Con- centra- tion of Cl (ppm)	Well sam- pled	Time since pump- ing began	Tidal stage
2/8/67	3	4 - 2½	2 hr 26 min	542	None	260	3	5 min	falling
						210	3	2¼ hr	low
5/3/67	4	2	4 hr	500	(R)	b/	4		
5/4/67	4	3	3 hr	540	(R)+.06(P)	b/	4		
	4	1	1¼ hr	75	(R)+.20(P)	2,600	4	None	low
						2,800	4	1¼ hr	rising
	5	1	a/ 92 hr	5,490	.03(P)	358	5	None	high
						54	3	30 min	high
						54	3	18½ hr	low
						54	3	a/ 92 hr	low
5/10/67	5	1	26 hr	1,560	None	190	5	22½ hr	falling
						190	5	25 hr 20 min	falling
5/11/67	5	.36	a/ 240 hr	5,141	.86(P)	54	3	22 hr	falling
						600+	5	a/ 240 hr	low
	4	1	50 min	50	None	3,300	4	None	falling
						2,100	4	50 min	falling
5/30/67	5	2.77	26 hr 40 min	4,432	(R)	685	5	26 hr 10 min	high
						380	5	26 hr 40 min	high
6/2/67	5	1	a/ 237 hr	14,220	.88(P)	390	5	1 hr 40 min	rising
						420	4	1 hr 10 min	rising
						700	5	172 hr 45 min	rising
						54	3	20 hr	low
						54	3	48 hr	low
7/10/67	5	2.5	a/ 47¼ hr	7,200	None	600+	5	47¼ hr	low
						45	3	37¼ hr	low
9/1/67	5	1	a/ 172 hr 48 min	10,368	.14(P)	130	5	1 hr 37 min	rising
						30	3	100 hr	low
						25	3	150 hr	rising
						600+	5	a/ 172 hr 48 min	low

a/ Approximate time

b/ Driller says water brackish

(R) Water spillage on parade ground or ground water used in drilling -- amounts indeterminate.

(P) Precipitation at Customs House, Charleston, S.C. (in inches).

shown by the table, the known ^{1/} rate of pumpage ranged from about one-third of a gallon per minute to about 4 gallons per minute. The pumping period ranged from 50 minutes to 10 days. The total number of gallons pumped during any one test ranged from 50 to about 14,200.

It became obvious during the drilling of well No. 4 that even small quantities of water pumped from this well resulted in a rapid increase in chloride content (3,300 ppm ^{2/} after 50 minutes pumping at a rate of 1 gallon per minute). Water from this well contained the highest chloride content of any of the 5 wells during all the tests made at the site. Water from well No. 1 contains the next highest concentration of chloride, which although not shown in the table, was analyzed at about 1,900 ppm on December 1, 1966.

Water from well No. 2 consistently contained less than 20 ppm of chloride, making it the freshest water in any well. The chloride concentration of well No. 3 was derived from the values obtained by use of the conductivity sensor installed in this well. Mechanical and/or electronic difficulties currently being experienced with this instrument

^{1/} The pumping rate as set at the beginning of a test was not always constant during the course of several tests. On a number of occasions a check of the discharge rate indicated that the control valve on the pump had probably been tampered with inasmuch as the pumping rate differed considerably from its original setting.

^{2/} The table heading for chloride concentration was prepared using the units formally used by the U.S. Geological Survey to report ionic concentration of water analyses in ppm. The policy of the Survey, as of October 1, 1967, is to report these concentrations in mg/l.

may indicate that the reported chloride concentrations are subject to some adjustment, although probably not by significant amounts. Analyses of water pumped from the discharge well (No. 5) indicated chloride concentrations ranging from 130 to 700 ppm. The maximum chloride concentration for water from this well was determined by Park Service personnel using a small portable chloride analysis kit. Although this method is not very accurate, the results obtained indicate that it can still be used with confidence as a rough index of the concentration. Thus some values reported in the table as 600+ ppm indicate that the pump was operating longer than the time the last sample was analyzed and that the chlorides at that time were in the general order of 600 ppm.

Not very definite conclusions can be made as a result of these first series of tests, except for the more obvious one that a continuous pumping rate of 1 gpm will, within about 4 days time, produce water from well No. 3 with a chloride concentration of about 600 ppm. The pumping test of June 2, 1967 would appear to show that this amount of chloride in the discharge water might even be reached within a slightly shorter time.

For reasons unknown at the present time, pumping from wells 1, 4 or 5 appear to have no effect on the chloride concentration in well No. 2. This rather anomalous condition is reflected also when well No. 1 is pumped for a short period of time and yields water with nearly 2,000 ppm of chloride, whereas the chloride content of water in well No. 2 remains less than 20 ppm. Possible explanations include the recharge of well

No. 2 by fresh water coming in from beneath Battery Huger, the "coning up" or vertical encroachment of salt water beneath the pumped well, rather than a lateral encroachment of the salt water - fresh water interface, or a complete discontinuity or barrier between the wells.

The pumping test starting on May 11, 1967 represented the longest period of continuous pumping (10 days) although the total volume of water pumped (5,141 gallons) was less than half that pumped in the seven-day test started on September 1, 1967 (10,368 gallons) and slight more than a third that pumped during the test starting on June 2, 1967 (14,220 gallons). Rainfall reported by the U.S. Weather Bureau at the downtown Charleston station occurred during the course of these three tests. During the May 11 test, 0.86 inch was reported in the early morning of May 13. During the June 2 test, 0.10 inch was measured between 5 and 6 p.m. of June 3 and 0.78 inch between midnight and 6 a.m. on June 5. If this much rain fell at Fort Sumter, and it is likely that it did, then this rainfall may have helped to maintain fresh water in the aquifer for the duration of the test but the test of July 2, 1967, with no rainfall occurring, pumped 7,200 gallons from the aquifer with lower resultant chlorides.

Tentative Conclusions

The data obtained to date from pumping tests on the present wells at Fort Sumter are not adequate to define either aquifer constants or any measure of safe yield from the shallow sands beneath the parade ground. The heterogeneity of the subsurface material and the structures buried therein make it very unlikely that a precise hydraulic evaluation can ever be obtained. However, a refinement of the gross quantities or magnitudes of water available, including the probable rainfall, and evaluation of empirical results obtained by sustained pumping and monitoring of the salinity range of ground water obtained thereby, can probably be made when more definitive data are obtained from the existing wells or one or two additional wells.

As indicated previously, we are of the opinion that a potential supply of fresh water should be available in the sand-fill beneath the grass plot east of Battery Huger and originally requested a test well be installed there. To date no driller has been willing to bid on such a well so it appears that we will be unable to assess the potentialities of this supply. However, if as some of the data suggest, well No. 2 is being recharged by water coming from this elevated area of the fort, then another shallow well located about 65 to 70 feet north of well No. 2 and about the same distance away from the concrete wall of Battery Huger would appear to provide not only a suitable test well, but if

the well contains fresh water sustained by recharge then it could also be used as a discharge well if the shallow aquifer is later utilized as a water supply.

Our present plans involve the continuation of monitoring under the present instrumental arrangement; also a shifting or alternation of monitors and pump on other well combinations to test well yield vs resultant chloride distribution; to obtain pumping test data under more favorable conditions of control and possibly try some well injection tests rather than those of water withdrawal. This effort would be enhanced by the additional test well suggested and/or the pumping of the old well in Battery Huger. The over-all evaluation would be enhanced by the installation of water meters as suggested previously to monitor the quantities of water actually now being used and by the installation and maintenance of a rain gage at the fort.

It seems also evident on the basis of what is known that greater utilization of available rainfall on the fort proper will be advantageous either by catchment and diversion to cisterns or by diversion as recharge to the shallow sand aquifer. The latter can be accomplished by a variety of methods including injection wells, spreading, or through a system of feeder lines.

Activities Under Phase II

Phase II of the project involves the evaluation of the intermediate limestone and sand aquifer of Tertiary age (Eocene to Paleocene) underlying the Charleston and Fort Sumter areas at depths of from about 400 to 600 feet. Many industrial and some irrigation and municipal wells tap this aquifer in the greater Charleston area. Because of heavy pumping from wells in this aquifer, principally by industries in the North Charleston area, the piezometric level of the aquifer has dropped several tens of feet in the last decade.

Our efforts during the period have been directed towards obtaining additional well data from drillers and owners of wells which utilize this aquifer. We have located two wells which we planned to use as monitoring wells, one owned by the Standard Oil Company and one by the Jenkins Orphanage. The drop pipe in the latter well was still in place, although the pump had been removed when the orphanage was served by city water. We contracted with Mr. Frank Taylor to remove this pipe and the check valve so we could install our monitoring instruments. He has experienced considerable difficulty in getting this well in condition to use. Its strategic location makes it preferable to the well at Standard Oil but if it can not be cleared for use, we might have to use a substitute well.

We have also made arrangements to make some geophysical logs of representative wells in this aquifer, one of which would be a fluid resistivity log. This type of log is generally useful in determining points or zones of salt water encroachment and thus we hope to obtain this type of information as it pertains to the aquifer in the area surrounding Fort Sumter.

We arranged to have an overflight made of Fort Sumter to obtain infrared imagery of this area for the purpose of determining whether criteria of this nature could be discerned as having some relation to the parameters of fresh water discharge or the fresh-water - salt-water interface. So far the results of these tests have been inconclusive, although we have enlargements of the imagery on order and possibly the increased detail of these might reveal some significant information.

November 16, 1967

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Associate District Chief

