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ENV ENG DIV

March 3, 1997

Mr. Winston Martinez, Land Use
Environmental Engineering Div
Department of the Navy
U.S. Naval Station Roosevelt
Box 3021
FPO AA 34051-3001

FAX TRANSMITTAL form with handwritten details: To Mr. John Van NAME, From Don Counter, Phone # 787 865 4429, Fax # 787 865 4967. Includes stamp 'John, As Discussed' and '8' in a circle.

Dear Mr. Martinez:

Please find enclosed the final report from Quanterra Environmental Services for the ground-water samples taken during the rehabilitation of the U.S. Navy wells located in the Naval Ammunition Support Department (NASD), Vieques, Puerto Rico. Also enclosed, I have included tables and figures which summarize the findings from the initial survey conducted by the U.S. Geological Survey (USGS) in October and the subsequent sampling in November, 1996. The purpose of the October visit was to rehabilitate the existing wells using compressed air and chemical treatment to enhance ground-water flow into the casing.

A total of fourteen wells were inventoried in the NASD area by USGS personnel. The depth and depth to water were measured and the coordinates obtained through use of Global Positioning System (GPS) equipment. The findings were compared to existing data from previous studies in the USGS Ground-water Site Inventory (GWSI) database. Eight wells were matched based upon available information with the remaining wells to be added to the database. All wells were assigned a number according to the sequence of well rehabilitation or proximity of nearby wells. Four wells were found to be plugged with soil or debris, one destroyed, one with a bent casing, and another was plugged with a beehive inside the casing (see table 1).

A total of six wells were rehabilitated using compressed air to remove accumulated sediments and chemically treated (sulfamic acid) to dissolve mineral buildup in well screens. The treated wells are identified in table 1 with the USGS well rehab designation. Sulfamic acid was added to remove any calcium carbonate encrustation in the well screens at least 12 hours prior to development with air. The air development was conducted for a minimum of three hours and generally produced 1 to 4 gallons per minute from each well. After the redevelopment was completed, concentrated chlorine was added as a disinfectant.

Ground-water sampling of five wells located within the NASD, Vieques, Puerto Rico (figure 1) was conducted on November 19 and 20, 1996, with each well pumped for a period of time prior to sampling to acquire a representative ground water from the aquifer. Analytical results given in table 2. General sampling protocol requires extracting a minimum of 3 well volumes from each well to be sampled. Due to the chlorination process used following well redevelopment, a minimum of 4.7 (U.S. Navy 11) and maximum of 87 (U.S. Navy 17) well volumes were pumped from the respective wells. Samples were processed and preserved in the field using standard USGS water-quality techniques and sent to Quanterra Environmental Services at Arvada, Colorado, for analyses. The specific conductance and pH were monitored during the pumping of each well. Dissolved solids and the Sodium Adsorption Ratio (SAR) were calculated from the laboratory results. The calculated dissolved solids in the water samples range from about 450 to about 730 mg/L. The calculated Sodium Adsorption Ratios (SAR) values were used to classify the ground water for agricultural use by comparing the SAR values with the specific conductance of each well. All except the well U.S. Navy 10 has an SAR considered to have hazard levels high in salinity and low in sodium (alkali) in use as an irrigation water source (see diagram). The value for well U.S. Navy 10 fell into the range for medium sodium hazard.

All the wells sampled showed high concentrations of iron and manganese which exceeded the secondary drinking water maximum contaminant level (SMCL) established by the Environmental Protection Agency (EPA). The concentrations of iron ranged from 0.8 to 6.1 mg/L, which exceeds the established SMCL for iron of 0.3 mg/L. The concentrations of manganese ranged from 0.18 to 0.54 mg/L, which exceeds the established SMCL for manganese of 0.05 mg/L. A detailed description of the geology of Vieques by Meyerhoff in 1927 eludes to the granitoid intrusives exposed over the western half of the island. Volcanic rocks are a common source for iron and manganese. A report published in 1996 on the Yabucoa valley by Troester attributes high dissolved iron and manganese found in numerous wells to the volcanic source material within the drainage basin.

The three wells sampled for Volatile Organic Compounds (VOCs) indicated the presence of chloroform in the range of 0.74 to 6.2 µg/L. The Maximum Contaminant Level (MCL) set by EPA for the combination of trihalomethanes (chloroform, bromoform, bromodichloromethane, dibromochloromethane) is 100 µg/L. The trihalomethanes are usually present as a byproduct of direct chlorination or disinfection, thus it cannot be inferred that these contaminants are present in ground water at the site since chlorine disinfection was conducted at the well.

The analyses for organochlorine pesticides and PCBs tentatively identified heptachlor epoxide (0.38 µg/L) in well U.S. Navy 17. This compound was not confirmed in the second column analysis therefore, it was not reported as present. Siloxane was also detected in the range of 1.1 to 1.9 µg/L in wells U.S. Navy 17 and Well rehab 2. The laboratory reports that siloxanes are common laboratory and field artifacts but may also be present in silicone or lubricating oils with siloxane additives.

A total of 6 wells were surveyed for elevation using the benchmark on the south side of highway 994, 0.4 mile east of Laguna Kiani, as the starting point. A reference mark near the entrance road to the Navy Facility was used to survey the elevation for the well U.S. Navy 17. The elevations of reference marks (RM's) established at the surveyed wells within the Resolución valley ranged from 26.4 to 48.5 feet above mean sea level and well U.S. Navy 17 near the Navy Facility, was surveyed at 57.4 feet above mean sea level. The water levels taken in the wells located in the Resolución valley indicate the altitude of the water table ranges from 0.57 feet (U.S. Navy - USGS Well Rehab 2), nearest the shoreline to 2.62 feet above mean sea level (U.S. Navy - USGS 3B) inland-most wells. Two wells surveyed and subsequent water levels indicate the altitude of the water table is below mean sea level in the area of U.S. Navy 10 and 11 wells.

The preliminary findings of this study indicate that previous estimates for the aquifer ground-water development potential in the Resolución valley could be high. It is highly recommended that aquifer tests be conducted to delineate the transmissivity, specific yield, and the potential for saltwater encroachment into the well fields. This work was included in our original proposal for the second year: We are willing to meet with you at your convenience to discuss this possibility. If you have any questions regarding the results, feel free to call Gregory S. Cherry at (787) 749-4346.

Sincerely,



Rafael W. Rodríguez
District Chief

Enclosures

Table 1. Description of wells located on NASD, Vieques Island, Puerto Rico
 [--, indicates data not available; MSL, mean sea level]

Well number on figure 2	Well name	USGS Site ID	Lat/Long GPS unit	Year constructed	Measured depth of well (feet)	Casing diameter (inches)	Type of well finish and finish interval (feet)	Land surface altitude of well (feet)	Depth to water below land surface datum (feet)	Water level altitude, in ft above MSL	Date water level measured (month-day-year)
1	U.S. Navy (USGS Well Rehab 2)	180658065325900	180658 655259	--	75.0	10	--	26.37 Surveyed	25.80	0.57	11-21-96
2	U.S. Navy 8 (USGS 2A)	180659065325900	180658 653259	--	46.3	8	--	23 Topo map	25.00	--	10-30-96
3	U.S. Navy 7 (USGS 2B)	180657065325700	180657 653259	1941	Destroyed	8	--	--	--	--	--
4	U.S. Navy 6 (USGS Well Rehab 3)	180654065325900	180651 653256	--	60.0	21	--	36.65 Surveyed	36.10	0.55	11-21-96
5	U.S. Navy 5 (USGS 3A)	180644065325400	180647 653254	--	16.5	6	--	33 Topo map	Plugged		
6	U.S. Navy (USGS 3B)	--	180640 653254	--	58.1	6	--	48.53 Surveyed	45.91	2.62	11-21-96
7	U.S. Navy 10 (USGS Well Rehab 4)	180637065331000	180639 653311	--	58.0	6	--	33.77 Surveyed	34.35	-0.58	11-21-96
8	U.S. Navy 9 (USGS 4B)	180640065330700	180639 653309	--	35.0	8	--	33 Topo map	Plugged		
9	U.S. Navy 11 (USGS Well Rehab 5)	180637065330700	180638 653308	1941	48.5	18	0-65 Perforated	35.74 Surveyed	36.08	-0.34	11-21-96
10	U.S. Navy (USGS 6)	--	180637 653254	--	28.0	6	--	49	Plugged		
11	U.S. Navy 17 (USGS Well Rehab 1)	180727065312600	180728 653128	--	69.0	8	--	57.41 Surveyed	53.46	3.95	11-21-96
12	U.S. Navy (USGS 3C)	--	180647 653254	--	45.5	6	--	40.19 Surveyed	38.95	1.24	10-31-96
13	U.S. Navy (USGS 3D)	--	180644 653255	--	42.7	6	--	--	Plugged		
14	U.S. Navy (USGS 4C)	--	180637 653308	--	Well casing plugged with beehive						

Table 2.--Summary of Physical and chemical characteristics of ground water at selected wells within the Resolución alluvial aquifer, Isla de Vieques, Puerto Rico.

[---, indicates data not available; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; SAR, sodium adsorption ratio; ND, not detected]

Well number and name	well number on figure	Date of Sample	Time of pump-age (min.)	Pump rate (gal per min)	Total draw-down in feet	Specific conductance ($\mu\text{S}/\text{cm}$) (Field)	pH (stand-ard units) (Field)	Nitrate as N dissolved (mg/L as N)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
1 U.S. Navy 17	11	11-19-96	175	20	2.66	1,275	---	1.2	64	45	168
2 Well Rehab 2	1	11-19-96	122	22	15.16	950	---	1.4	47	30	147
3 U.S. Navy 11	9	11-19-96	40	18-22	4.31	1,300	---	1.4	23	18	139
4 U.S. Navy 6	4	11-20-96	134	21	12.55	900	6.6	1.6	46	23	133
5 U.S. Navy 10	7	11-20-96	60	22	3.94	750	6.6	1.7	14	12	156

Well number and name	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Zinc dissolved (mg/L)	Iron dissolved (mg/L)	Manganese dissolved (mg/L)	Alkalinity (mg/L as CaCO_3) (Lab)	Sodium Adsorption Ratio (SAR)
1 U.S. Navy 17	38	178	< 1.0	< 0.01	0.8	0.21	369	3.9
2 Well Rehab 2	26	104	< 1.0	0.02	1.9	0.18	348	4.1
3 U.S. Navy 11	17	79	< 1.0	< 0.01	6.1	0.39	254	5.3
4 U.S. Navy 6	19	90	< 1.0	0.01	5.0	0.54	309	4.0
5 U.S. Navy 10	15	76	< 1.0	0.03	2.0	0.33	261	7.4

Summary of detected Volatile Organic Compounds (VOCs) and Organochlorine Pesticides

Well number and name	Chloroform ($\mu\text{g}/\text{L}$)	Siloxane ($\mu\text{g}/\text{L}$)	Heptachlor epoxide ($\mu\text{g}/\text{L}$)
1 U.S. Navy 17	0.74	1.1	ND
2 Well Rehab 2	1.1	1.9	ND
3 U.S. Navy 11	6.2	ND	ND

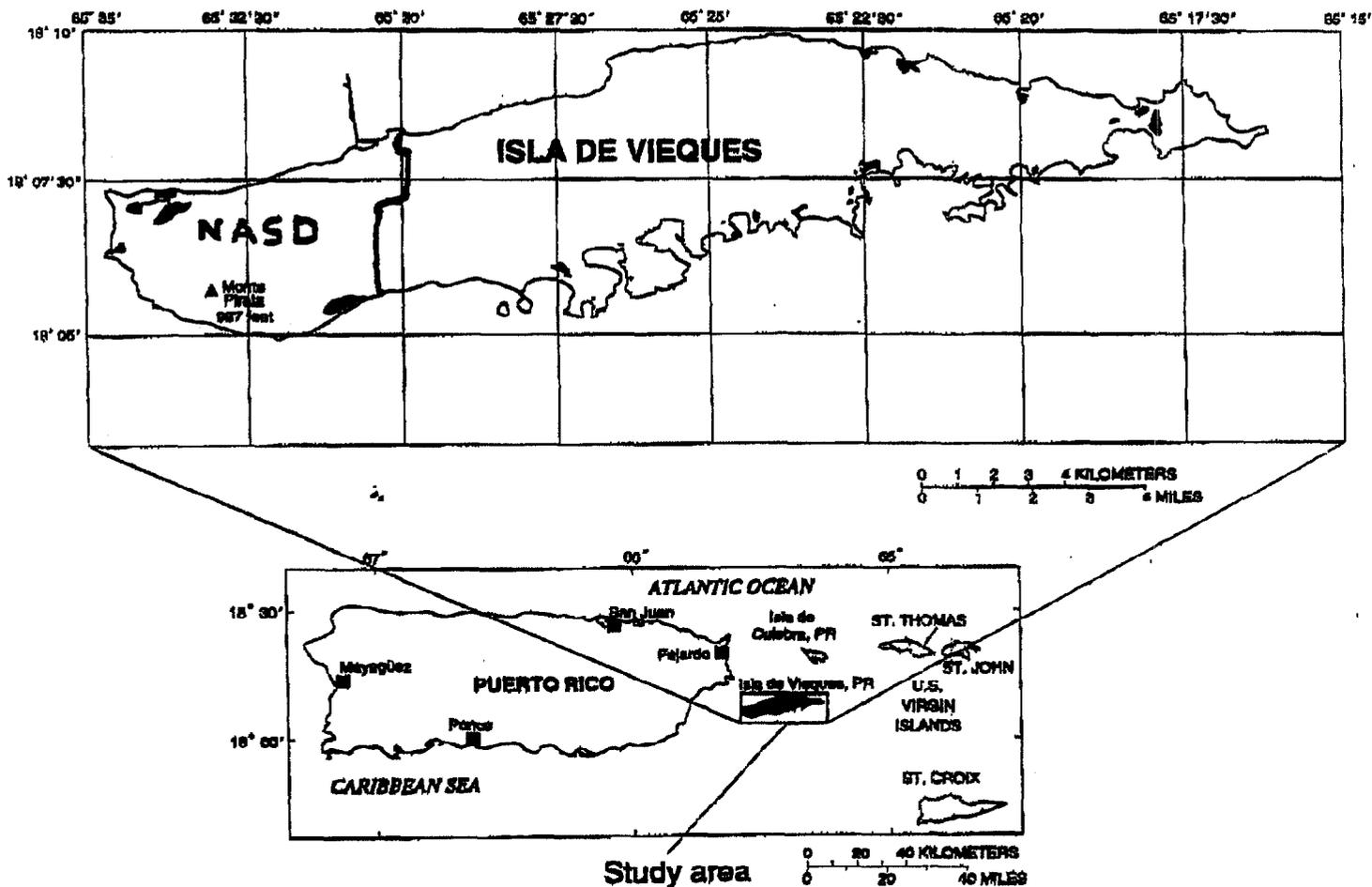
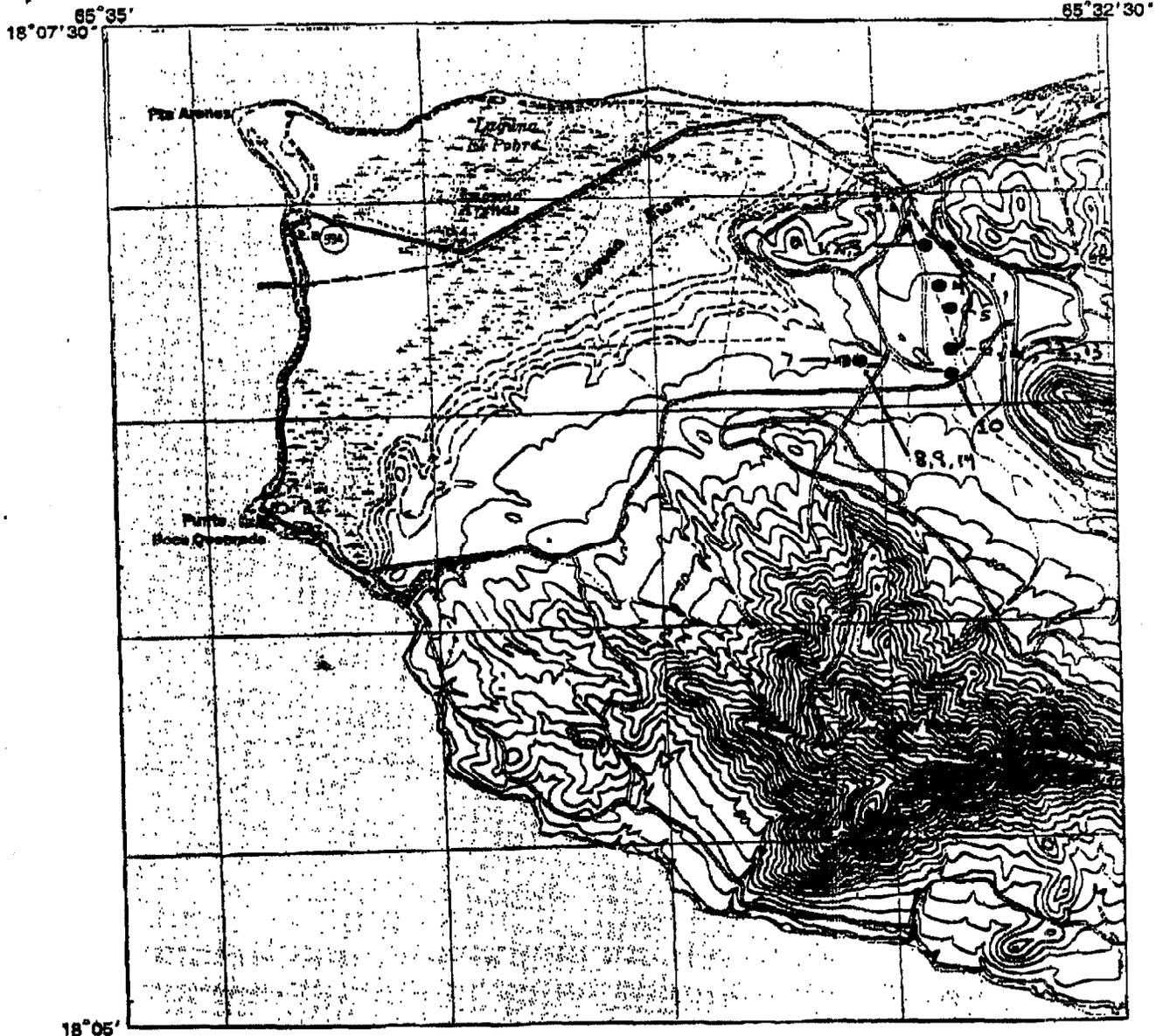


Figure 1. Location of Isla de Vieques, Puerto Rico, and Naval Ammunition Support Department (NASD).



Base from U.S. Geological Survey, 1951
 Isla de Vieques P.R. Guayama
 scale 1:20,000, Photorevised 1982

EXPLANATION

- WELL LOCATION AND NUMBER-See table 1

0 0.5 1 KILOMETER
 0 0.5 1 MILE
 CONTOUR INTERVAL 10 METERS
 DASHED LINES INDICATE 1 METER CONTOURS
 NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure 2a Location of reconnaissance study area, Isla de Vieques, Puerto Rico.

18°07'30" 65°32'30"

65°30'



Base from U.S. Geological Survey, 1951
 Isla de Vieques P.R. Quadrangle
 scale 1:50,000, Photorevised 1962

EXPLANATION
 ● WELL LOCATION AND
 NUMBER-See table 1

0 0.5 1 KILOMETER
 0 0.5 1 MILE
 CONTOUR INTERVAL 10 METERS
 DASHED LINES INDICATE 1 METER CONTOURS
 NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure 2 b Location of reconnaissance study area, Isla de Vieques, Puerto Rico.