

PRNC-180 PUERTO RICO NUCLEAR CENTER AERIAL INFRARED SCANNING OF DISCHARGE REGIONS OF PRESENT AND ALTERNATE POWER PLANT SITES VOLUME 1 Prepared for the Puerto Rico Water Resources Authority By the Staff of Puerto Rico Nuclear Center of the University of Puerto Rico April 1975 Meade OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT (NO. AT (4u1)1889 FOR US ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION ---Page Break--- TABLE OF CONTENTS INTRODUCTION Sites and Schedule Equipment Mounting METHODS Method A Film Record Method B Method C DATA PROCESSING TIDAL DATA POWER LEVELS OF ELECTRIC GENERATING PLANTS PLOTTED THERMOGRAPHS Part 1 Jobos Bay Palo Seco/San Juan Tortuguero Bay Punta Manati Islote Punta Higuero Cabo Mala Pascua Part 2 Jobos Bay Gabo Rojo Platform Guayanilla ---Page Break--- AERIAL INFRARED SCANNING OF DISCHARGE REGIONS OF PRESENT AND ALTERNATE POWER PLANT SITES by E.D. Wood Puerto Rico Nuclear Center Mayaguez, Puerto Rico April 1, 1975 ---Page Break--- AERIAL INFRARED SCANNING OF DISCHARGE REGIONS OF PRESENT AND ALTERNATE POWER PLANT SITES. INTRODUCTION Most power plants are only 25 to 40% efficient; therefore, tremendous amounts of energy are dissipated into the atmosphere, either directly up the stack or indirectly, first into water and from there into the atmosphere. It is important to learn the extent and the effect of thermal discharges on life in the aquatic environment. Surface temperatures of objects can be measured by directing infrared irradiation given off. Instantaneous measurement of water surface temperatures can be accomplished using an infrared scanner mounted in an aircraft which is then flown over the study region. Such flights were made over selected sites around the Island of Puerto Rico in 1973 and 1974. Measurements were taken by the Raytheon Corp. in February 1975, using a Bendix Line Scanner. The Puerto Rico Nuclear Center, using an AGA Thermovision Scanner, measured water surface temperatures quarterly from July 1973 through December 1974. ---Page Break---

Sites and Schedule 'The sites of Jobos Bay, Guayanilla and San Juan Harbor were selected for scanning because they were receiving, or were about to receive, thermal effluents. Seven other possible future power plant sites were scanned for baseline information (See Fig. 1). The Jobos Bay site was scanned on a two-week schedule of alternate morning flights plus four evening flights to cover tidal cycles and night vs. day wind conditions. The schedules for the various flights are given in Table 1. The site code key is given below: Cabo Mata Pascua PHE = Pt. Higuero CRP = Cabo Rojo Platform © PMA. = Pta. Manati cY = Guayanilla Bay PVE = Pta. Verraco Tsk = Tslote SIS = San Juan Steam Plant JB = Jobos Bay TOR = Tortuguero Bay PAS = Palo Seco ---Page Break--- Atlantic Ocean ISL PMA TOR PAS SJS PUERTO RICO PVE GY JB CMP Caribbean Sea Fig. 1. Map showing infrared scanning sites around Puerto Rico. ---Page Break--- Equipment The infrared scanning equipment was supplied by AGA Corp. An instrumentation tape recorder was acquired from Sangamo Electric Co. Brief descriptions of the major components of the system follow. Camera (-IR-): Infrared detection in the 2-5.6 μm band with various temperature ranges from 1° to 200°C adjustable between -30°C to 200°C. An indium antimonide (InSb) photovoltaic detector is cooled with liquid nitrogen. One fill lasts approximately four hours. The unit will focus from 1 m to infinity and is sensitive to 0.1°C differences in temperature through a 45°C lens (13.5 kg-30 lb). Display Unit: Picture size is 9x9 cm (3.5x5.5), showing 16 frames per second. Temperature difference (ΔT) setting is indicated on the side of the frame and a grey reference scale extends across the bottom. The display unit controls the level of temperature range selected. (25.7 kg-52 lb) Color Monitor: Signals from the display unit are fed into the color monitor where the image is reproduced. The temperature range is divided into ten arbitrary colors. Picture size is 13x18 cm (5x7 in.). (18 kg-40 lb) 0

Camera-(35 mm): Motorized Nikon F, 35 mm with a 2 frame cassette operating off 12 VDC. A special lens and attachment photographs images displayed on the color monitor ---Page Break ---
'The camera is normally shot at 1 frame per 30 seconds, but will take up to 8 frames per second. (4.4 kg-21 lb) Inverters: (Topaz) Inverts 13.2 VDC to 115 VAC to 250 VA, sine wave with less than 5% total harmonic distortion and 60.3 Hz frequency. (17.7 kg-39 lb) Instrumentation Tape Recorder: Portable Saber 111 operating on either 24 or 28 VDC. It uses a 2.54 x 35.6 cm (1 x 14 in.) reel at 120 ips. Fourteen tracks allow 4 passes of 3 tracks each, with the two edge tracks used for voice. A tape holds 12 minutes of scan data per pass. (50.0 kg-110 lb) Batteries: Lead-acid batteries power the equipment, for periods of about 2 hours, separate from the aircraft's electrical system. (82.6-182 lb) Aircraft: Four-place Cessna 182, 250 hp, constant speed propeller, equipped with camera hatch in the baggage compartment. This aircraft has a payload of over 230 kg (500 lb) in addition to the pilot, a technician, and fuel. ---Page Break ---
Mounting The infrared camera was shock mounted pointing aft in the forward area of the baggage compartment. A front-surface mirror was mounted at a 45° angle over the camera hatch in front of the camera (See Fig. 2). This caused the incident image to be reversed. The direction of flight appeared at the top of the display screen; however, left and right of the image were reversed electronically in the display units. METHOD Two methods of recording data were used, each with its own configuration of equipment other than the infrared camera. These methods are discussed below as Methods A and B. A third method (C) could also be used and is described briefly. Method A-Film Record: The equipment used was arranged as shown in Figure 3. The color monitor was connected to the control unit and its images were recorded on 35 mm Ektachrome color film. The display unit and color monitor each operated from

Separate inverters. Each inverter was supplied 14 volts from a pair of batteries (6 & 8 v) in series. The 35 mm Nikon F camera operated off 12 v. Using the film recording system, a series of overlapping pictures covering the scan path were taken. The exposed film was sent to Eastman Kodak for processing and mounting. ---Page Break---
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10 Method Bi
With the acquisition of the Saber III Instrumentation Tape Recorder, the color monitor, one inverter, and the 35 mm camera were replaced by the tape recorder and an extra battery (See Fig. 4). The signal from the IR camera then split between the control unit and the tape recorder. The recorder is capable of recording four passes of 12 minutes each on a 2.54x35.5 cm (1 14") tape reel. A site can be covered in one pass. The tape can then be played back. Method C: Data could be collected directly from the control unit using a Polaroid or 35 mm camera. The control unit displays an image in shades of grey from white (hot) to black (cold) with a graded grey scale for comparison. This method was not used by PRNC. ---Page Break---
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2 DATA PROCESSING The data recorded on slides were processed by projecting the image on a two-sided screen. A map of the area scanned, traced on a clear plexiglass sheet, was then placed on the screen side opposite the projector (See Fig. 5). The image was then fitted to the map by positioning the projector. Once aligned, the isotherms were traced onto the plexiglass with colored grease pencils. When processing data recorded on magnetic tape, isotherms were drawn directly by watching the color monitor where low temperature gradients or little detail existed. Regions of interest or high

detail were photographed with the 35 mm camera and projected on the two-sided screen. Isotherm temperatures were then assigned from temperatures measured independently at one or more

surface locations and the isotherm setting. The plexiglass drawings were then traced on paper, followed by a second tracing, using an X-Y digitizer to computerize the data. These computerized data were then used to plot out site isotherms on page-sized sheets, store data and compare scans. ---Page Break--- 13 sey yDryn a99ys, Poawajut worry susaysosy °5 "ita papis-OML .Saus 40pD9fOdd aWAhsoy 40919 wud SE ---Page Break--- (rev) 9/21 (srsopsisze (ozso)eu/zt (2250) 11/2 (sso) \$721 vive (9080) (090) (ust) (9990) (srs0) (vs90) (erso) (S290) (sso) Corso) 62/8 82/6 os/6 ton 92/6 syoi 9276 62/6 12/6 sie (ezs0) s/9 (S990) (090) (zat (0890) (800 (\$590) (2290) ¥/9 (osso) 92/2 (0040) (590) Cosco) o/s (2290) 4/9 (asso) 97/2 (sso) <79 (£890) U7 ous. ut Coos) 82/2 ELEP ON 92/2 (ozso)eis9 (s¥90) 6/¢ (zzgo)zi/9 (Esso) L/s (iso) 979 (\$580) 17s 9/9 (0290) 42/2 (1s0) 279 (0090) sz/z (£90) ze we wise ornpoyss Surtduys poxessur *1 aT6VL (\$290) 82/6 (0361) 92/6 (0x90) 02/6 (oreo) 1/e (os90) 02/6 (0s90) ¥2/6 (s190) 2/08 (\$190) 62/6 BReP ON 12/6 (oseo) 6176 ar ac saozzendysueas ---Page Break--- TIDAL DATA FOR JOBOS BAY 8 ---Page Break--- yoyo svaganan, 2 ANOYRUYS | ANN 7 opm yO | OS 08 a 2 dos Bt des 2 cs dos wows Epes ---Page Break--- : S 3 ---Page Break--- 'TIDAL DATA FOR JOBOS BAY heDeSOAY oe Faray | sxrufoar | \, -. Bg eg SUaLaNLINaD Le ° FRM 10 Mer 74 1" 16 Mar 74 =10 iat ata iat -20, ---Page Break--- ---Page Break--- POWER LEVELS OF ELECTRIC GENERATING PLANTS ---Page Break--- POWER LEVELS OF ELECTRIC GENERATING PLANTS. (SAN JUAN STEAM PLANT) HOUR LOAD (MW) IN PREVIOUS 12 HOURS (1) DATE OF LOAD FROM 1974 SAMPLE HOUR MW DATE HOUR HOUR mw 0500141 183, 197, 232, 205 228 0850 2-27 1800 0500 183, 179, 169, 148 0600147 148, 149, 148, 147 0500163 178, 167, 179, 177 6-5 0528 6-4 1800 0500175, 0600 174 151, 080093 124, 9-29 0806 9-28 2000 080094, 090096 34,

1900 259 199, 280, 251, 25° 12-3 1936 12-3 0800 1900 258, 257, 258, 252 2000 260 247, 248, 249, 259 (1) Twelve (12) consecutive hourly readings from date and hour to date and hour indicated. ---Page Break--- DATE 9-28-73 2-28-74 5-74 9-29-74 123-74 (1) Twelve (12) consecutive hour Hour of SAMPLE 1934 POWER LEVELS OF ELECTRIC GENERATING PLANTS (PALO SECO STEAM PLANT) LOAD HOUR gES E28 298 3 8] 2000 e368 265 260 245 295 245 245 FROM DATE HOUR 9-27 900 10-31 1900 227 1800 64 1800 9-28 2100 12-3 e600 LOAD (MW) IN PREVIOUS 12 HOURS (1) ro. DATE 9-28 2-28 9.29 123 Hour 1900 380, 6s, 450, 770, m5, 5, 350, 335, ws, 240, a5, 245, 15, 265, 230, 220, readings from date endhour to dote and hour indicated. 2 mw 415, 285, 450, 380, 375, 380, 330, 315, 240, 205, 245, 295, 260, 260, 200, 230, 20, 465, 485, 455, 380, 380, 380, 325, 295, 240, 250, 250, 370, 260, 250, 190, 225, 230, 310 450 460 385 375 5 34s 330 265 240 245 245 220 240 270 230 220 245 ---Page Break--- hour DATE of SAMPLE 9-20-73 aso 1or-73 ono 1-14.73 700 11-15-73 1820 116-79 0655 2-26-74 0550 ono o-t74 0622 9-26-74 0549 103-74 oss POWER LEVELS OF ELECTRIC GENERATING PLANTS 10a your mw 100558 700 580 oro ses 0200 578 orm 603 1800 19 1s00 792 0600 or6 oro 737 0500 665 0600 790 oo ase 200 a8 600 627 oro 679 asco 40 0600 640 woo 727 ooo 70 (SOUTH COAST STEAM PLANT) LOAD (MW) IN PREVIOUS 12 HOURS (1) FROM DATE HOUR s19 1900 9-30 2000 M113 1900 nas 0700 1-15-1900 2-25 1800 a8 2000 &3 1900 9-25 1800 102 1900 1 DATE 9.20 10-1 wt vets 16 226 oa 9.26 10-3 Hour 600 700 1800 0600 0500 700 0500 0600 938, wm, 704, 1002, 307, 02, 969, 666, 600, 847, 47, 607, 307, 238, 6, (1) Twelve (12) consecutive hourly readings from date and hour to date and hour indicated. 23 mw 395, Bas, 551, 592, 547, 4%, 614, 566, sar, 62, 395, 831, a, 719, 4, 390, 78, 682, 04s, 46, 792, 366, 415, 626, 242, 785, 26, 16, 38, 656, 394, 5 553, 553 555, 558 586, 578 546, 515 535, 585, 607, 577 57, \$8) 578, 571 59, 613 648, 745 827, 819 205, 798 689, 675 644, 696 1016, 1002 826, 759 678, 665 1044, 1040 814,

796 797, B54 824, 747 41, 629 en, 627 823, 839 654, 630 608, 640 294, 925, 637, 853 659, 727 ---Page Break--- Hour DATE OF 1974 SAMPLE 2-25 0600 2 0620 31 0555 330853 35 0545 37 039

39 084s 62 osi7 64 052 66 057 POWER LEVELS OF ELECTRIC GENERATING PLANTS (AGUIRRE STEAM PLANT - 1) (JB 1-7) LOAD (MW) IN PREVIOUS 12 HOURS (1) LOAD FROM (sic) Hour 0800 0500 MW 'DATE HOUR DATE HOUR mw Unit out of Service 8 Unit out of service 6-3 1800 6-4 0500 until 0100 of 64-74 we Load from 0100 to 0500 18, 19, 18, 18, 18 Unit out again at 6800 28 339, 344, 246, 295 6-5 1800 6-6 0500 292, 289, 271, 256 228 223, 29, 228, 228 (1) Twelve (12) consecutive hourly readings from date and hour to date and hour indicated. ---Page Break--- 2 os 921 9-23 9.25 om 10-41 Hour of SAMPLE 0539, POWER LEVELS OF ELECTRIC GENERATING PLANTS (AGUIRRE STEAM PLANT - Load SELLERS LRELER ERE ERE ww 185 181 156 52 204 289 249 29 260 253 270 am 258 255 zs 252 wae 145 245 245) (08 1-7) LOAD (MW) IN PREVIOUS 12 HOURS (1) Hour Date Hour 71800 91800 ent 1800 6-13 80 9-20 1800 9-22 800 0-24 1800 9-26 1900 9-28 1800 9-20 1800 9-21 9.25 927 101 500 0500 0500 0500 230, 255, 230, 245, 26, 152, 143, 142, 176, 226, 245, (1) Twelve (12) consecutive hourly readings from date and hour to date and hour indicated. mw. 2, 102, 182, 160, 184, 138, 287, 29, 285, 300, 298, 28, 266, 258, 200, 268, 26, 270, 250, 256, 256, 260, 25, 226, 153, us, M40, 194, 25, 265, 2% 1, 126, 186, 200, 17, 159, 294, 221, 282, 290, 239, 251, 269, 267, 245, 270, 269, 268, 265, 257, 250, 253, 228, 133, 40, 14, 29, 230, 240, 50 164 185 24 150 156 286 208 286 299 267 249 270 270 2460 265 273 270 282 253 258 240 27 29 a7 14 va 226 240 245 ---Page Break--- 1203 125 127 129 a4 1213 1s (1) Twelve (12) consecutive hourly readings from date and hour to date and hour i HOUR of SAMPLE 0539 0528 0513 0556 0545, POWER LEVELS OF ELECTRIC GENERATING PLANTS (AGUIRRE STEAM PLANT - 1) (JB 1-7) Load Hour Mw 500 150 ouco 138 500 196 sco 196 sco 200 20200 0500 (2) «oo 0500 (3) cco 50021 oo 227 300 © «co so 4s

oxen 145, FROM DATE HOUR 10-2 1800 2-2 1800 30100 12-4 1800 126 1800 12-8 1800 12-10 1800 12121900 1214 1800 (2) Unit out of service from 0400 hours on. 8) out of service. LOAD (MW) IN PREVIOUS 12 HOURS (1) rm DATE 10-3 125 1211 ya 1215 Hour 0500 2000 0500 0500 2400 9500 (4) No readings available for 2100, 2200, 2300 and 2400 hours on 12-2-74 6 'out of service from 0100 to 0900 hours on 12-13-74. 168, 162, 150, 233, 186, 96 242, 249, 200, 200, 207, 120, 247, 252, 27. 252, 260, 230, 197, 138, ow. 187, 150, 150, 0, 198, 28, 208, 200, 243, 206, ® ® 263, 219, 26, 262, 242, 254, 174, vas, an, 158, 150, 29, 196, 2, 204, 200, 2, 215, 258, 212, 25, 256, #7, 258, 45, 14s, 208 150 150 @ 196 245 200 200 200 220 260 221 22 262 6) 252 136 5 ---Page Break--- HOUR DATE OF 1974 SAMPLE 2-26 No Date 2-28 1800 37 tae 3101828 51955; 67 1957 69 204 én 1982 POWER LEVELS OF ELECTRIC GENERATING PLANTS (AGUIRRE STEAM PLANT 1800 1900 1800 1900 1900 2000 1900 2000 2100 1900 2000 3a 346 NM) 1) LOAD (MW!) IN PREVIOUS 12 HOURS (1) FROM DATE HOUR 6-5 0800 6-7 0800 6-7 1600 6-9 0900 6-11 0800 DATE Oo Hour 1900 1100 1900 1900 248, 359, 340, 240, a 1 153, 155, 152, 209, 315, 35, (1) Twelve (12) consecutive hourly readings from date and hour to date and hour indicated, (2) Unit out of service from 1200 to 1500 hours on 6-7-74 276, 364, 246, 310, 5 152, 150, 150, 313, 330, 316, 339, 359 349, 171 37, 44 350, 150 153, 150 150, 152 160, 200 397, 358 321, 316 297, 287 ---Page Break--- POWER LEVELS OF ELECTRIC GENERATING PLANTS. (AGUIRRE STEAM PLANT - V) (JB 1-4) HOUR LOAD (MW) IN PREVIOUS 12 HOURS (1) DATE OF Load FROM ro 1974 SAMPLE HOUR MW. DATE HOUR DATE HOUR mw 1800 250 260, 256, 259, 9-25 1045 9-25 0700 9-25 1800 246, 250, 236, 1900 250 178, 210, 230, 1900 230 220, 215, 222, 9-26 1914 9-28 0200 9-26 1900 208, 192, 192, 2000 260 190, 200, 200, 1700143 145, 143, 140, 929 178 9-29 0600 9-29 1700 136, 145, 145, 1800143 131, 144, 142, 1800176 150, 150, 150, 9-30 188) 9-30 0700 9-30 1800 190, 195, 167, 1900194 188, 167, 174, 1700249 200, 229, 222, 241748

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