

# PRNC180

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)

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Jobos Bay

Palo Seco/San Juan

Tortuguero Bay

Punta Manati

Islote

Punta Higuero

Cabo Mala Pascua

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Jobos Bay

Gabo Rojo Platform

Guayanilla

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Ab

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

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## AERIAL INFRARED SCANNING OF DISCHARGE REGIONS OF PRESENT AND ALTERNATE POWER PLANT SITES.

### INTRODUCTION

Most power plants are only 25 to 40% efficient, there-

fore, tre

ndous 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.

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#### 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 possi-

ble future power plant sites were scanned for base line

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?

owe Cabo Mata Pascua PHE =~ Pt. Higuero

CRP - Cabo Rojo Platform © PMA. -?s~Pta. Manati

cY = Guayanitia 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 um band

with various temperature ranges from 1° to 200°C adjustable

between -30°C to 200°C, An indium antimonide (InSb) photo-

voltaic 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 1b).

Display Unit: Picture size is 9x9 cm (3.5x5.5), showing,

16 frames per second. Temperature difference (4,) 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-S2 1b)

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 1b)

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 1b)

Inverters: (Topaz) Inverts 13 $\phi$ 2 VDC to 11546 VAC

© to 250 VA, sine wave with less than St total harmonic dis-

tortion and 60 $\pm$ .3 Hz frequency. (17.7 kg-39 1b)

Instrumentation Tape Recorder: Portable Saber 111

operating on either 24 or 28 VDC. It uses @ 2.54x35.6 em

(1x14 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 1b)

Batteries: Lead-acid batteries power the equipment,

for periods of about 2 hours, separate from the aircraft's

electrical system. (82.6-182 1b)

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 mn 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 over-lapping pictures covering the scan path were taken. The exposed film was sent to Eastman Kodak for processing and mounting.

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Method Bi With the acquisition of the Saber III

Instrumentation Tape Recorder, the color monitor, one in-  
verter, 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 ii

ge in shades of grey from white (hot) to black (cold) with a graded grey scale for comparison.

This method was not used by PRNC.

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## 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 gr

se 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.

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TIDAL DATA

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POWER LEVELS OF ELECTRIC GENERATING PLANTS

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POWER LEVELS OF ELECTRIC GENERATING PLANTS.

(SAN JUAN STEAM PLANT)

HOUR LOAD (MY) 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---

nour

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) INV PREVIOUS 12 HOURS (1)

FIOM

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 ossa

39 084s

62 osi7

64 052

66 057

## POWER LEVELS OF ELECTRIC GENERATING PLANTS

Fa

(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

oste

osze

0539,

POWER LEVELS OF ELECTRIC GENERATING PLANTS

(AGUIRRE STEAM PLANT ~

Loap

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)

Hom

Dare Hour

71800

91800

ent 1800

6-13 80

9-20 1800

9-22 800

o-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)

LoD

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 fom 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,

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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 BLECTRIC 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 reading 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 Loan 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 124 0600 124 1700245, 250, 248,  
1800242 247, 245, 253,  
1800 220 260, 270, 263,  
26 1016 12-6 0700 12-6 1800-274, 279, 273,  
1900243 268, 261, 255,  
1800 247 68, 102, 118,  
1210 1829 12-10 0700 12-10 1800 190, 200, 200,  
1900 263, 200, 210, 240,  
1800 190 0700 1200 @), 14, 60,  
12131847 v3 rata M5, (9), 62,  
1900 200 1500 1800120, 190!

(1) Twelve (12) consecutive hourly readings from date and hour to date and hour Indicated

(@) Unit out of service until 0900 hours on 12-13-74

(G) Unit out of service from 1300 to 1400 hours on 12-19-74.

265

220

250

216

190

230

v3

5

3

170

73

1%

250

245

243

270

270

220

m2

200

247

35

?

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PLOTTED ISOTHERMS

Part 1

Jobos Bay

Palo Seco/San Juan

Tortuguero Bay

Punta Manati

Islote

Punta Higuero

Cabo Mala Pascua

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