

RADIOLOGICAL MONITORING IN THE PALOMARES
AREA
PERIOD: SECOND HALF OF 1988

TRANSLATION FROM SPANISH TO ENGLISH OF
"VIGILANCIA RADIOLOGICA EN LA ZONA DE PALOMARES.
PERIODO: SEGUNDO SEMESTRE DEL ANO 1988".

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PERIOD: Second Half of 1988

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RADIOLOGICAL AND ENVIRONMENTAL

CIEMAT/PRYMA/GIT/M5A01/1/89

PROTECTION INSTITUTE

Geochemistry and Transuranide

Impact Operating Unit

RADIOLOGICAL MONITORING IN THE PALOMARES ZONE

(Report for Second Half of 1988)

January 1989

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RADIOLOGICAL MONITORING IN THE PALOMARES AREA

PERIOD: Second Half of 1988

In accordance with the program established and developed by the report "Radiological Monitoring in the Palomares Zone: Program for 1988", Reference CIEMAT/PRYMA/GIT/M5A01/2/88, the activities specified below in order and by subject area were carried out.

1. MONITORING OF PERSONS

During the second half of 1988 the program of direct monitoring of persons specified in the report for the first half of 1988. As programmed, 110 persons were examined, which, together with the 40 examined in the first six-month period, constitutes the numerical group of 150 which had been planned.

These persons have been subjected to medical and dosimetric examinations during the period July 4-11 (20 persons) and October 26-December 12, 1988. Their distribution according to classification groups established and specified in the first period report was:

Group 1-A (with some positive result):	9 persons
Group 1-B (with 1 positive, and several negative readings):	1 person
Group 1-C (minors over 12 w/ no previous examination):	12 persons
Group 2-A (with evaluated doses):	19 persons
Group 2-B (under 20 yrs w/ previous negative readings):	20 persons
Group 3-A (with some positive reading in 1966, and subsequently negative):	15 persons
Companions:	34 persons

As a consequence of the examinations carried out in the two halves of 1988, data have been collected on 146 Palomares residents and 4 from Villaricos. A total of 19 persons have been seen for the first time.

Of the persons whose names appeared on the list, 37 did not

come in for a variety of reasons.

The results of the medical examinations and of the clinical and dosimetric determinations are set forth below.

1.1 MEDICAL MONITORING

1.1.2 Medical Monitoring

In the second phase of the radiological monitoring program in the Palomares Zone for 1988 (see Doc. m5A01/PI002/a/88), carried out between 7/4/88 and 12/12/88, 110 persons were examined medically, broken down as follows:

	No of persons
Group 1-A	9
Group 1-B	1
Group 1-C	12
Group 2-A	19
Group 2-B	20
Group 3-A	15
Not on the lists	34 (COMPANIONS)

The medical examinations conducted, following the instructions indicated by Safety Guide No. 7-4 "Bases for Medical Monitoring of Workers Exposed to Ionizing Radiation" and the recommendations of International Organizations, did not reveal any pathology which could be attributable to incorporation of transuranic elements coming from the zones's residual contamination.

We report below the significant findings:

Absence of alterations	32
Mild alterations	27
Presence of pathology	51

1. DISEASES OF THE ENDOCRINE GLANDS, NUTRITION AND METABOLISM AND IMMUNITY DISORDERS (240-279)*

Obesity	6
Hyperglycemia	5
Hypercholesterolemia	14

* ICD Code - 9th revision

	Hypertriglyceridemia	11
	Diabetes mellitus type II	1
	Hyperuricemia	2
	Gynecomastia	1
	Diffuse normofunctional goiter	1
2.	DISEASES OF THE BLOOD AND HEMATOPOIETIC ORGANS (280-289)	
	Iron deficiency anemia	4
	Eosinophilia	1
	Essential polyglobulia	1
3.	MENTAL DISORDERS (290-319)	
	Depressive syndrome	4
	Anxiety neurosis	2
4.	DISEASES OF THE NERVOUS SYSTEM AND SENSORY ORGANS (320-389)	
	Transient cerebral ischemia	2
	Migraine	3
	Myopia	5
	Presbycia	17
	Unilateral amblyopia	1
	Congenital cataract	1
	Cataract	2
	Allergic conjunctivitis	1
	Hearing loss	13
	Occupational deafness	1
	Otosclerosis	1
	Suppurated semi-acute otitis	1
	Meniere's disease	1
	Acufenos [?]	2
5.	DISEASES OF THE CIRCULATORY SYSTEM (390-459)	
	Peripheral arteriosclerosis	1
	Thrombophlebitis, lower extr.	1
	Varicose veins, lower extr.	13
	Orthostatic hypotension	1

6.	DISEASES OF THE RESPIRATORY SYSTEM (460-519)	
	Acute rhinopharyngitis	1
	Chronic pharyngitis	2
	Chronic asthmatic bronchitis	3
	Chronic bronchitis	1
	EPOC	1
	Polynosis	3
	Amygdalar hypertrophia	2
7.	DISEASES OF THE DIGESTIVE SYSTEM (520-579)	
	Duodenal ulcer	1
	Hiatal hernia	1
	Abdominal hernia	1
8.	DISEASES OF THE GENITOURINARY SYSTEM (580-620)	
	Renal polycystosis	1
	Kidney stones	1
	Urinary infection	3
	Prostate hypertrophia	2
	Impotence	1
	Hypermenorrhea	1
9.	DISEASES OF THE SKIN AND SUBCUTANEOUS CELLULAR TISSUE (680-709)	
	Nummular psoriasis	1
	Contact dermatitis	1
	Friction dermatitis	1
	Vitiligo	1
	Hirsutism	1
	Facial xanthelasma	1
	Pigmented nevus	1
	Stable Perthes' disease	1
	Vertebral malformation	
	w/ radicle compromise	1
	Vertebral spondylarthrosis	2
	Gonarthrosis	1
	Generalized arthrosis	1
	Arthrosis of the hands	1
	Scoliosis	5

Disseminated arthralgia	1
Cervicobrachial syndrome	1
Lumbalgia	3
Lumbosciatica	2
Assymetry of lower extremity	1

11. POORLY DEFINED SIGNS, SYMPTOMS AND UNHEALTHY CONDITIONS (780-799)

Rx. Ventriculat hypertrophia	2
Reduced vital capacity in functional respiratory tests	4
Dysphonia	1
Elevated serum transaminase	3
Microscopic leukocyturia and hematuria	4
Albuminuria	5
Hypopotassemia	1
Glucosuria	1

The findings listed correspond to the pathology which we see daily in periodic routine checkups of workers, both those exposed and not exposed to ionizing radiation, and in our judgment, there is no information which leads us to suspect any unhealthy condition specifically induced by radioactive agents.

1.2 DOSIMETRIC MONITORING

In addition to complete radiochemical analysis of urine samples accomplished in the first six-month period, during this second half, we made a determination of Pu-239 + Pu-240 and Am-241 in the urine of 75 persons. This involved the urinary testing of 40 persons in the first half, and 35 persons in the second.

Radiochemical analysis of the other 75 persons from the second six-month period is complete, but the plutonium and americium concentrations are pending measurement by alpha spectrometry of the electrodeposits already made, since, in addition to the fact that each measurement requires a continuous four-day period, the alpha spectrometry system was down for three months due to malfunctions in the data processing system.

The results of radioanalyses corresponding to the group of 75 different persons which have been completed to date, and which comprise 50% of those examined in 1988, indicate that there was no positive plutonium reading in any of these persons.

This group of 75 persons with negative values in the 1988 urine plutonium analysis comprises the following groups:

- Examined for the first time in 1988: 13 persons
- Having several negative analyses prior to 1988: 17 persons
- With only one negative analysis prior to 1988: 10 persons
- Having only one positive reading and several negative ones prior to 1988: 22 persons
- Having only one positive analysis prior to 1988: 3 persons
- Having evaluated doses: 10 persons

The 3 persons who previously presented a single positive analysis and who have now tested negatively must be examined again in 1989, so that a definite finding as to internal contamination can be made, and if positive, to estimate the dose implied.

Direct determinations of pulmonary plutonium and americium contamination, using a pulmonary radioactivity counter on the 20 persons who were examined for the first time in 1988, revealed no contamination, as the measurements showed no values in excess of the equipment's detection limit.

2. ENVIRONMENTAL MONITORING

2.1 GROUND

The below activities were conducted relative to following ground contamination.

2.1.1 Surface Am-241 Contamination of the Area

Am-241 determinations were made in the surface soil samples (5 cm thickness) during June 1988, at 29 points of the perimeter located outside the "zero line" of contamination produced by the accident in 1966, and at a distance of approximately 500 meters from it.

Figure 1 illustrates the points at which the sampling was made and Table 1 lists the results of Am-241 determinations corresponding to the 29 points selected; since duplicate sampling was employed, a total of 58 analyses are involved.

From the Table 1 readings, it is inferred that:

- The readings corresponding to Am-241 concentrations on the surface of soil not altered by farming and located outside the indicated "zero line" were below detection limits (≤ 0.007 kBq/kg) at 27 points.

- At two places, Points 1 and 21, which border on Zones 2 and 3 respectively, concentrations above the detection limit were found. The readings of these Am-241 concentrations were:

Point 1: $0.089 \pm 3\%$ kBq/kg

Point 21: $0.117 \pm 3\%$ kBq/kg

- With the exception of the two indicated points, dispersion of the Am-241 contamination outside the zone contaminated in the accident has been practically nil during the elapsed period of 22 years.

- As can be observed on Figure 1, the location of the two points where the Am-241 concentrations are greater than the detection limit seems to indicate that both might have originated at the time of the accident due to the orographic and wind characteristics of the zone.

The next sampling at both sites will permit us to gain a better understanding of the causes of these two Am-241 concentrations outside the "zero line".

2.2 AIR

2.2.1 Sampling

During this semester, continuous air sampling has been conducted at the three stations which are in operation. They are designated for reference: Station 2-1, Station 2-2 and Station P (urban zone).

During the period 8/20/88 to 9/10/88, only one air sample was collected at each of the three stations, in other words, the sampling represents three weeks rather than one. Therefore, during

this second half of the year, a total of only 75 samples were taken. The air volume was approximately 10 000 m³ for each of the weekly samples, and 30 000 m³ for each of the 3-week samples.

As already indicated in the report for the second semester of 1987, stations 2-1 and P (urban) have a sampling system which permits collection only of particles with a size of less than 10 μm, in order to be able to determine plutonium and americium concentrations in the fraction of truly inhalable aerosols.

Continuous air sampling has been made at the Santillana Reservoir, where 27 samples were taken, with a mean weekly volume of 300 m³.

2.2.2 Plutonium Concentration

In addition to the analyses carried out during the first six-month period, noted in the corresponding report, radiochemical analysis of 85 weekly air samples from Palomares has been conducted. The samples correspond to all of those collected in the second half of 1987, starting on 7/4/87 and the 4 which were still pending from the preceding quarter; each represents a volume of about 10 000 m³, as we have mentioned before.

The samples are distributed by collection point as follows:

Building 2-1: 29 samples from 1987

Building 2-2: 29 samples from 1987

Building P (urban): 27 samples from 1987

The Pu-239 + Pu-240 concentration readings corresponding to the 4 samples from the second half of 1988 are included in Table 2, and correspond to the following stations and dates:

Building 2-1: Periods 6/20/87-6/27/87 and 6/27/87-7/4/87

Building 2-2: Periods 4/25/87-5/2/87 and 6/16/87-5/23/87

The other values included in Table 2 were already given in the report for the first half of 1988, but are repeated here so as to provide a complete picture of the concentrations for that period.

The Pu-239 + Pu-240 concentration readings on the air samples from the second half of 1987 are specified in Table 3. This table shows the Station 2-1 and Station P (urban) readings which were taken, starting in 4/4/87, using the special sampling system which

permits the collection only of particles having a size of less than 10 μm . The plutonium concentrations for stations 2-1 and P (urban) are therefore representative of the inhalable fraction.

From the values specified in Table 3, we infer that:

- The mean concentrations of plutonium in the Palomares zone during the period 7/4/87 to 1/2/88 were:

Building 2-1: 9.5 $\mu\text{Bq}/\text{m}^3$

Building 2-2: 21.2 $\mu\text{Bq}/\text{m}^3$

Building P (urban): 4.4 $\mu\text{Bq}/\text{m}^3$

These mean values for the three sampling stations are lower than those corresponding to the period 3/21/87 to 7/4/87.

During the same period of time, the weekly Pu-239 + Pu-240 concentrations have been in the following ranges:

Building 2-1: between 0.2 and 108 $\mu\text{Bq}/\text{m}^3$

Building 2-2: between 1.4 and 52.2 $\mu\text{Bq}/\text{m}^3$

Building P (urban): between 0.2 and 25.9 $\mu\text{Bq}/\text{m}^3$

The most significant observations made from comparing Tables 2 and 3 are:

- At sampling stations 2-2 and P (urban), since collection of only particles < 10 μm began (second half of 1987), and contrary to what occurred in the second quarter of 1987, episodic readings far in excess of the mean have not appeared.

- At Station 2-1, where there is no system for collection exclusively of aerosol particles below 10 μm , episodic values far in excess of the mean of the other values have continued to appear, even taking into consideration the fact that the plutonium concentrations during this period were relatively low.

From the results obtained and shown here, it is inferred that during the period 7/4/87 to 1/2/88, both the mean value of the weekly concentrations and the value of the individual weekly concentrations, have remained below the limit of derived concentration in air (5 900 $\mu\text{Bq}/\text{m}^3$) for Class Y plutonium compounds, as can be derived from the value established in the Spanish legislation for the annual limit of incorporation by inhalation.

2.3 VEGETATION

The following activities in this regard have been carried out during the six-month period:

2.3.1 Plutonium Concentration

During this period, radiochemical analysis was conducted to determine Pu-239 + Pu-240 contamination in 74 vegetable farm products and one sample of wild vegetation. A total of 36 samples are from 1987 and 38 from 1988 harvests.

The specific distribution of the samples analyzed is:

1987 SAMPLES

Barley (grain)	9
Barley (spike)	9
Barley (straw)	9
Wheat (grain)	2
Wheat (spike)	2
Wheat (straw)	2
Olive (fruit)	1
Olive (leaves)	1
Wild plant	1

1988 SAMPLES

Tomatoes (fruit)	10
Tomatoes (washed fruit)	10
Tomatoes (leaves)	10
Watermelon (fruit, rind)	4
Watermelon (fruit, rest)	4

Analysis of these samples was completed up to the electrodeposit phase. However, as a consequence of the alpha spectrometry system being down for three months, and of the long time necessary to measure each of the electrodeposits (48 hours), we were unable to conduct these measurements during the six-month period, as other measurements were judged to be more important. The applicable results will be reported in the first 1989 report.

2.3.2 Americium Concentration

The determinations carried out in the first half of the year, which, involving the samples remaining from 1987 and the

1988 tomatoes, are included in the report for that first semester. In addition to those, during the period covered by this second report for 1988 we have made Am-241 contamination determinations in the remaining samples collected this year. These samples are specifically as follows:

- 1 wild plant sample
- 7 barley samples
- 3 wheat samples
- 3 alfalfa samples
- 9 watermelon samples
- 9 watermelon plant samples

Considering that the contamination was determined separately in the cereals, for grain, spike and straw, and in the watermelon, for epicarp (rind), mesocarp, endocarp and seeds, 60 samples were analyzed, which represents a total of 120 analyses. These readings are presented on Tables 4-7. It is inferred from them that:

- The barley grown in 1988 has shown Am-241 contamination above the minimum detectable limit only in the straw of two samples. One of the samples comes from Zone 2 and the other from Zone 3. The concentration measured in both cases was $0.2 \pm 4\%$ Bq/kg.

- The barley grain samples grown in 1988 showed no Am-241 concentration in excess of the detection limit of our method.

- The wheat sample collected in 1988 in Zone 2-0 showed contamination above the minimum detection limit only in the straw, with a concentration reading of $0.3 \pm 2\%$ Bq/kg. The grain was not contaminated.

- The wheat samples collected in 1988 in Zones 3 and 5 showed no Am-241 contamination above the limits detectable by our method in any of their parts.

- The alfalfa samples collected in Zones 2 and 3 during 1988 showed no Am-241 contamination above the detection limit.

- The watermelon and watermelon plant samples collected in 1988 in Zones 2,3 and 5 showed no Am-241 concentration above the detection limit, in any of their parts

- The wild plant sample collected during 1988 in Zone 2-0, and specifically at a location very near the impact point of one of the bombs, showed Am-241 contamination with a radioactivity concentration of $1.1 \pm 3\%$ Bq/kg.

The Am-241 concentration readings found in the straw samples are negligible as a practical matter from the point of view of implied risk, since the official limit of annual incorporation by ingestion for humans is 5 000 Bq and the transfer factors for ingestion in animals are below 10^{-4} .

2.3.3 Water. Americium Contamination

Analyses were made to determine if Am-241 contamination exists in the zone's water table and in the irrigation reservoir built in Palomares, which stores water delivered by pipeline from the Almanzora River Dam, located at a distance of some 20 kilometers.

The water was collected in late 1987, as was indicated in the corresponding report, and sampling of the water table was conducted in 6 of the zone's wells which have been in use all along for irrigation.

The results of the 14 determinations made, which correspond to 7 water samples, are shown on Table 8. It is inferred from these readings that there is no Am-241 contamination in any of the water samples collected, since no values in excess of the detection limits of the method used were detected.

Now then, the detection limit of the procedure is sufficient to infer that even if contamination were to exist below that value, the risk implied by ingestion of that non-potable water, as well as that derived from its use for irrigation, would be negligible as a practical matter. Even so, we are going to apply a more sensitive radioanalytical method in order to obtain readings scientifically applicable to leaching of americium into soil and its penetration power.

2.4 ANIMALS

2.4.1 Sampling

Continuing with the sampling of milk from goat No.

2, started during June, we collected two other weekly compound samples representative of the daily milking during the week.

2.4.2 Plutonium Contamination

The following activities were carried out in this regard during the second half of the year:

2.4.2.1 Animal Tissues

In addition to what was done during the first six months in this regard, during the second, we conducted radiochemical analysis and alpha spectrometry measurements on the ashes of the chickens which had been bred specifically for the purpose in a poultry yard near Parcel 2-2.

The readings from determinations carried out on 7 samples of muscular tissue (flesh), 6 samples of bony tissue and 4 samples of feathers are shown on Table 9. From these readings we draw the same conclusions expounded in our report for the first half of 1988, based on the results contained therein, to wit:

- There is no Pu 239 + Pu-240 contamination in the flesh from the extremities and body of the chickens analyzed. The measurements show no values in excess of the limits of detection.

- There is no Pu-239 + Pu-240 contamination in the bones of the chickens analyzed. The measurements showed no values in excess of the detectable limits.

- The feather samples analyzed show Pu-239 + Pu-240 contamination, with concentrations of these radionuclides in the range of 166.7 to 936.9 mBq/kg. We believe that these contaminations are external in nature, the consequence of the life style at freedom, rather than in a hen house, which they led during their breeding in a zone where the soil is contaminated in the same order as that of Parcel 2-2.

2.4.2.2 Milk

Radiochemical analyses were conducted to determine the Pu-239 + Pu-240 concentration in 6 weekly compound samples collected during the period 6/3/88 to 7/10/88 from the mentioned goat No. 2.

The values of the determinations made are shown on Table No.

10. From these values it is inferred that there is no plutonium in any of the samples collected, since the results obtained are below the minimum concentrations detectable by our method.

2.4.3 Americium Contamination

2.4.3.1 Milk

Determinations of Am-241 were made on the 7 weekly compound milk samples taken from Goat No. 2 during the period 5/25/87 to 7/12/87. The results of the determinations are shown on Table 11. From these results it is inferred that the milk from this goat presents no americium contamination in any of the samples collected.

The Pu-239 + Pu-240 concentration values in these samples were given in the report for the second semester of 1987, and were also negative.

3. COMPLEMENTARY STUDIES

3.1 PLUTONIUM AND AMERICIUM GEOCHEMISTRY IN THE SOIL

Various minerals have been separated in several soil samples of different sizes, so as to study the mechanisms which influence the distribution of plutonium and americium and determine the ways in which these transuranides are linked with each of the constituent minerals of the soil. We have still reached no firm conclusions, and therefore do not wish to speculate on the characteristics of mobility and fixation of these radionuclides in the soils of Palomares.

3.2 PLUTONIUM OXIDATION STATES IN THE SOIL

Research activities which are being conducted in cooperation with the Geological Technology Unit of CIEMAT, is permitting us to obtain some interesting data which we hope to confirm this year.

These data are the result of the speciation studies we mentioned in our report on "Radiological Monitoring in the Palomares Zone (Second Half of 1987)".

The data thus far obtained seem to indicate a significant quantitative difference between the behaviors of plutonium and americium with respect to the soil components to which they are

linked. The most significant of these differences are:

- Americium has a larger water-leachable component than Plutonium.

- The inorganically absorbed fraction is greater for americium than for plutonium.

- Organically linked fractions, such as sesquioxide and residual are less for americium than for plutonium.

- The interchangeable fraction is similar and very small for both radionuclides.

3.3 METEOROLOGY

The weather station installed in the zone, whose characteristics were described in the 1987 report, has been in continuous operation since January 1, 1987. All of the data obtained are recorded weekly, and are currently being processed. To provide an example of the weekly data recorded, we include Tables 2-5, which correspond to the data from one week of each of the four seasons (spring, summer, fall and winter). In our next report for the first half of 1989, we shall include the meteorology with annual characteristics of wind direction and speed in the zone, as well as the temperature.

3.4 DATA BANK

We have completed the transfer of medical and dosimetric data corresponding to individuals from Palomares from the conventional medical charts and from the SPERRY/1100 computer to a data base system (ORACLE) in the IBM/4381 computer.

3.5 EPIDEMIOLOGY

To date, we have no indication as to whether the Environmental Sanitation Bureau (of the Ministry of Sanitation and the Consumer) has started the epidemiological study of the population of Palomares.

3.6 CONTAMINATION OF THE MARINE ENVIRONMENT

Activities aimed at determining Pu-239 + Pu-240, Am-241 and Cs-137 concentrations in the sediments of the coastline between Cape Palos and Cape Gata have proceeded according to plan. In addition to the data furnished in the report for the second half of

1987, we can summarize the new information to be supplied as follows:

- The distribution of plutonium as a function of the depth of the sedimentation layer has been determined by radiochemical analysis of 4 cores from the talus and 2 cores from deep water. The maximum concentrations found correspond to Core 16, which at a depth of 0-1 cm, presents a value of 1.75 ± 0.04 Bq/kg.

- Americium distribution was checked in 6 cores from the continental shelf, 4 cores from the talus and 2 cores from deep water. These correspond to the same ones in which the plutonium was determined. The maximum concentration was in Core No. 31, where the plutonium maximum was also found; its value is 2 Bq/kg in the layer 4-5 cm deep.

- In addition to the largest concentrations of plutonium and americium, Core 31 was found to have two maximums, corresponding to the periods 1958-1969 and 1974-1978. The first period coincides with the time of maximum fallout in the northern hemisphere, which peaked in 1963. We believe the second peak corresponds to the sedimentation from the Almanzora River resulting from soil erosion produced by the major flood of October 1973, which inundated a portion of the lower zone of Palomares (Zone 3). This assumption is supported by the greater rate of sedimentation and particle size distribution in the sedimentation layer for the period 1974-1978, by the greater Pu and Am concentration in the surface sediments existing between the Almanzora River estuary and Core 31, and by the decreasing concentration in shelf cores southward of No. 31.

- From the total radioactivity of Pu-239 + Pu-240 and Am-241, determined from all the layers of each core, the plutonium and americium inventory for the zones to which each core corresponds has been estimated. The results obtained are shown on Table 12, including, for comparison, those which were given in the report for the second half of 1987. The location from which each core was taken is shown on Figure 6.

- As indicated in the 1987 report, these inventories are generally comparable to those found in the sediments of other

Mediterranean zones. The possible incorporation of plutonium due to erosion from the Almanzora River flood and other causes is equivalent, in one small zone, to that from radioactive fallout.

4. CONFERENCES AND PUBLICATIONS

We have participated in the following national and international conferences during 1988, in order to deliver papers relating to the research being done in the Palomares area:

- Emilio Iranzo, María Asunción Espinosa and C. Emma Iranzo: "Evaluation of Remedial Actions taken in an Agricultural Area Contaminated by Transuranides". Impact of Nuclear Origin Accidents on the Environment". Cadarache, France. March 1988.

- Lourdes Romero, Emilio Iranzo, Antonio Martínez and Catalina Gascó. "Estudio de la distribución temporal de radionucleidos de vida larga en sedimentos marinos del S.E. español", Study of the Distribution over Time of Long Lived Radionuclides in Marine Sediments of Southeastern Spain. International Conference on Environmental Radioactivity in the Mediterranean Area." Barcelona, Spain. May 1988.

- Catalina Gascó, Emilio Iranzo and Lourdes Romero. "Radionucleidos de vida larga en sedimentos marinos en el Golfo de Vera (España)", "Long Lived Radionuclides in the Marine Sediments of the Gulf of Vera (Spain)". XX Biennial Conference of the Spanish Royal Chemistry Society. Murcia, Spain. September 1988.

- Catalina Gascó, Emilio Iranzo and Lourdes Romero. "Distribution of Long Lived Radionuclides in the Marine Sediments of the Continental Shelf, Slope and Deep Sea off the Southern Coast of Spain". XXXI Plenary Session of the CIESM. Athens, Greece, October 1988.

- Emilio Iranzo, María Asunción Espinosa and C. Emma Iranzo, "Evaluation of Remedial Actions taken in an Agricultural Area Contaminated by Transuranides". Proceedings of the IV International Radioecology Symposium. "Impact des accidents d'origine nucleaire sur l'environnement". "Environmental Impact of Nuclear Origin Accidents". Vol. 2, P.1-21. Cadarache, France, 1988.

5. PARTICIPANTS

The following CIEMAT personnel have participated in the activities which have led to the obtaining of data, conclusions and specifications presented in this report:

Senior Technicians: Emilio Iranzo, Alicia Alvarez, Angel Bellido, Santiago Castaño, María Asunción Espinosa, Catalina Gascó, C. Emma Iranzo, Enrique Mingarro, Pedro Rivas and Lourdes Romero.

Technicians: Camila Blanco, Ludivina Borrego, Mariano Casado, Milagros Carmona, María Carmen Guzman, José Meral, José María Montero, Francisco Moreno and Mariano Moya.

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1. Regulations on Sanitary Protection against Ionizing Radiation. B.O.E. No. 13, Jenuary 15, 1988.

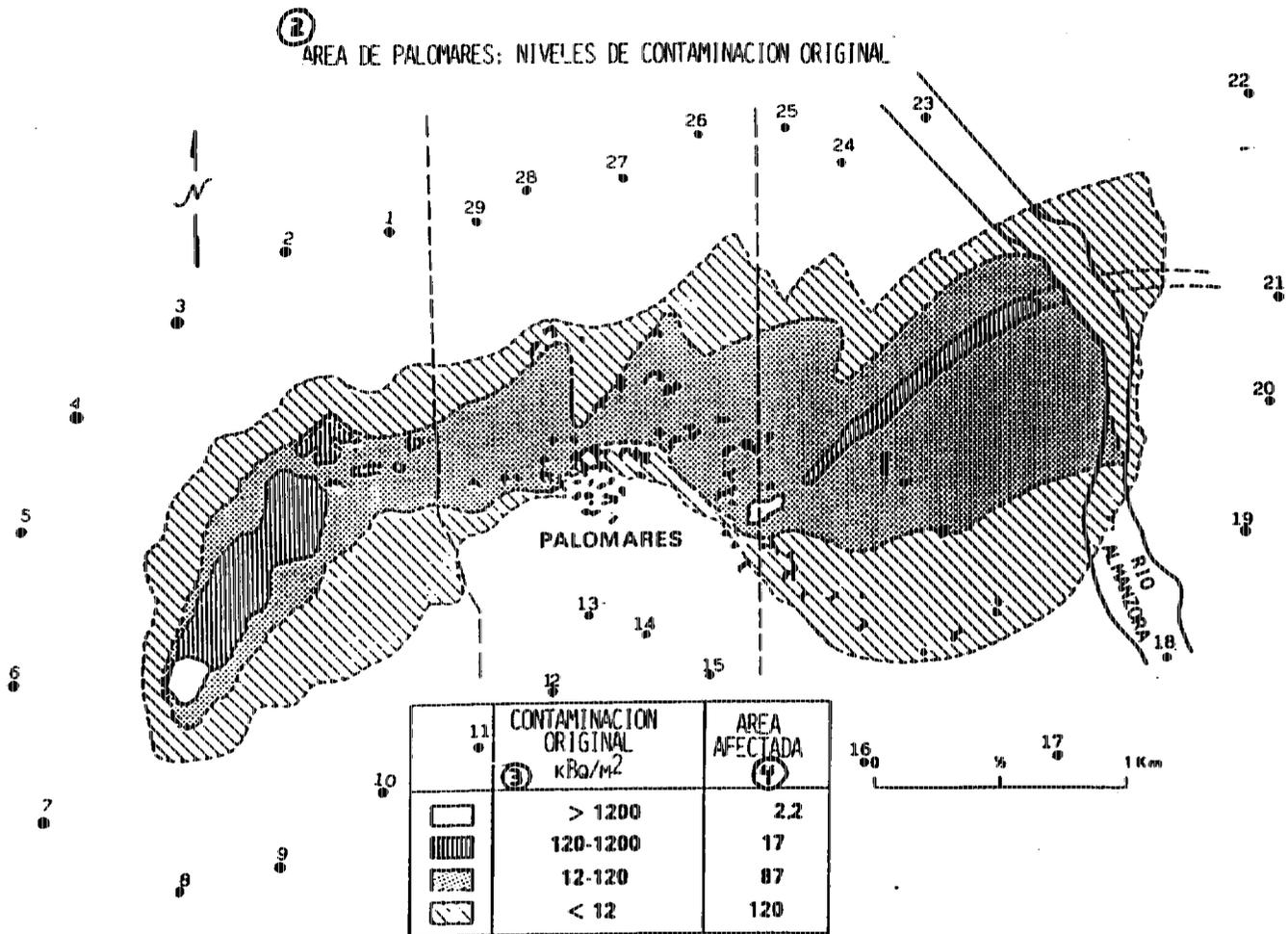


Figure 1. SOIL SURFACE LAYER (5 cm) SAMPLING SITES; JUNE 1988.

2- PALOMARES AREA: ORIGINAL CONTAMINATION AREAS

3- ORIGINAL CONTAMINATION; 4- AFFECTED AREA.

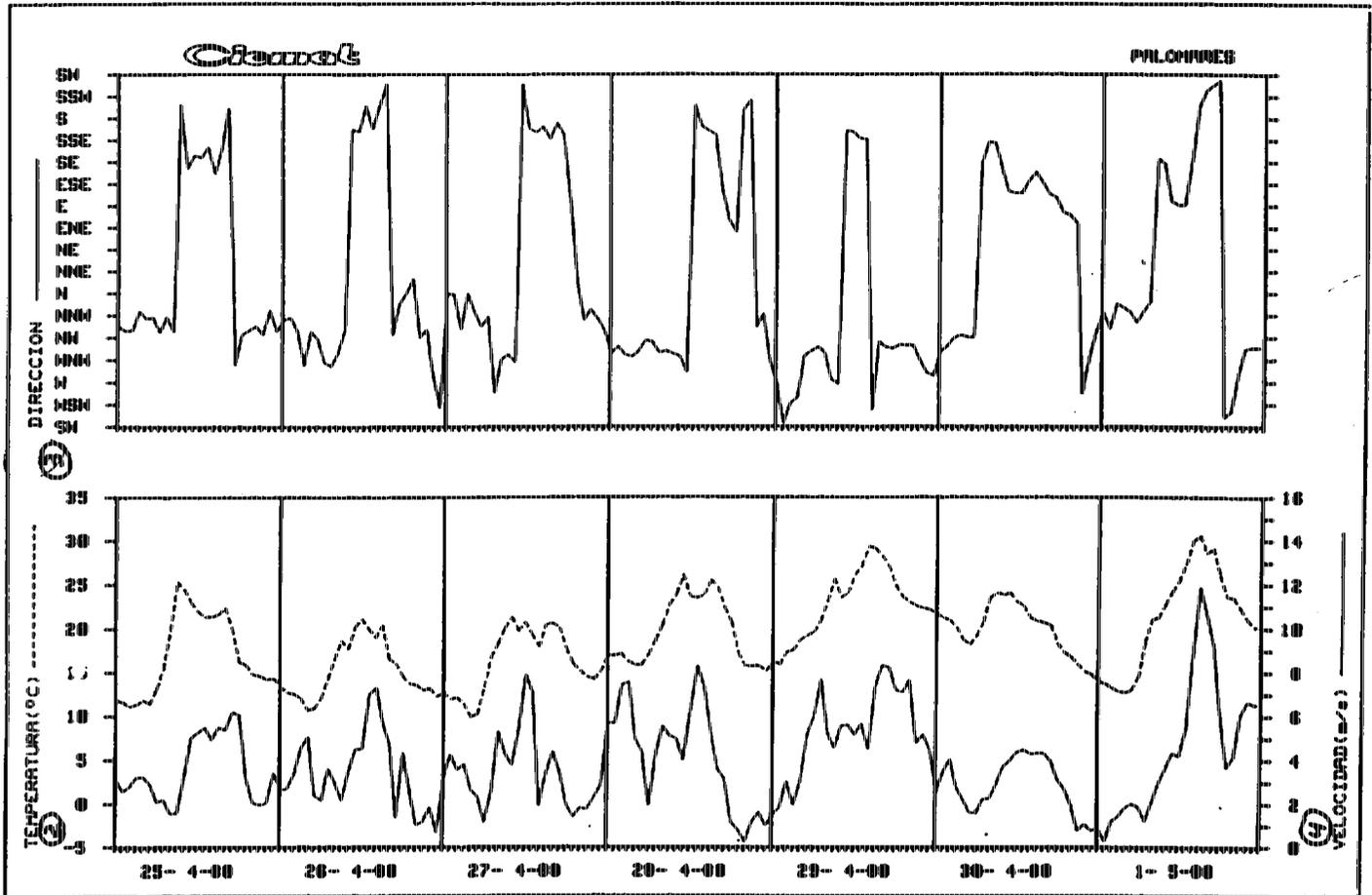


FIGURE 2 . GRAPHICAL REPRESENTATION OF THE WIND DIRRECTION AND SPEED AND TEMPERATURE AT THE PALOMARES STATION DURING THE WEEK OF - 1988.

2- TEMPERATURE, (°C); 3- DIRECTION; 4- SPEED (M/SEC)

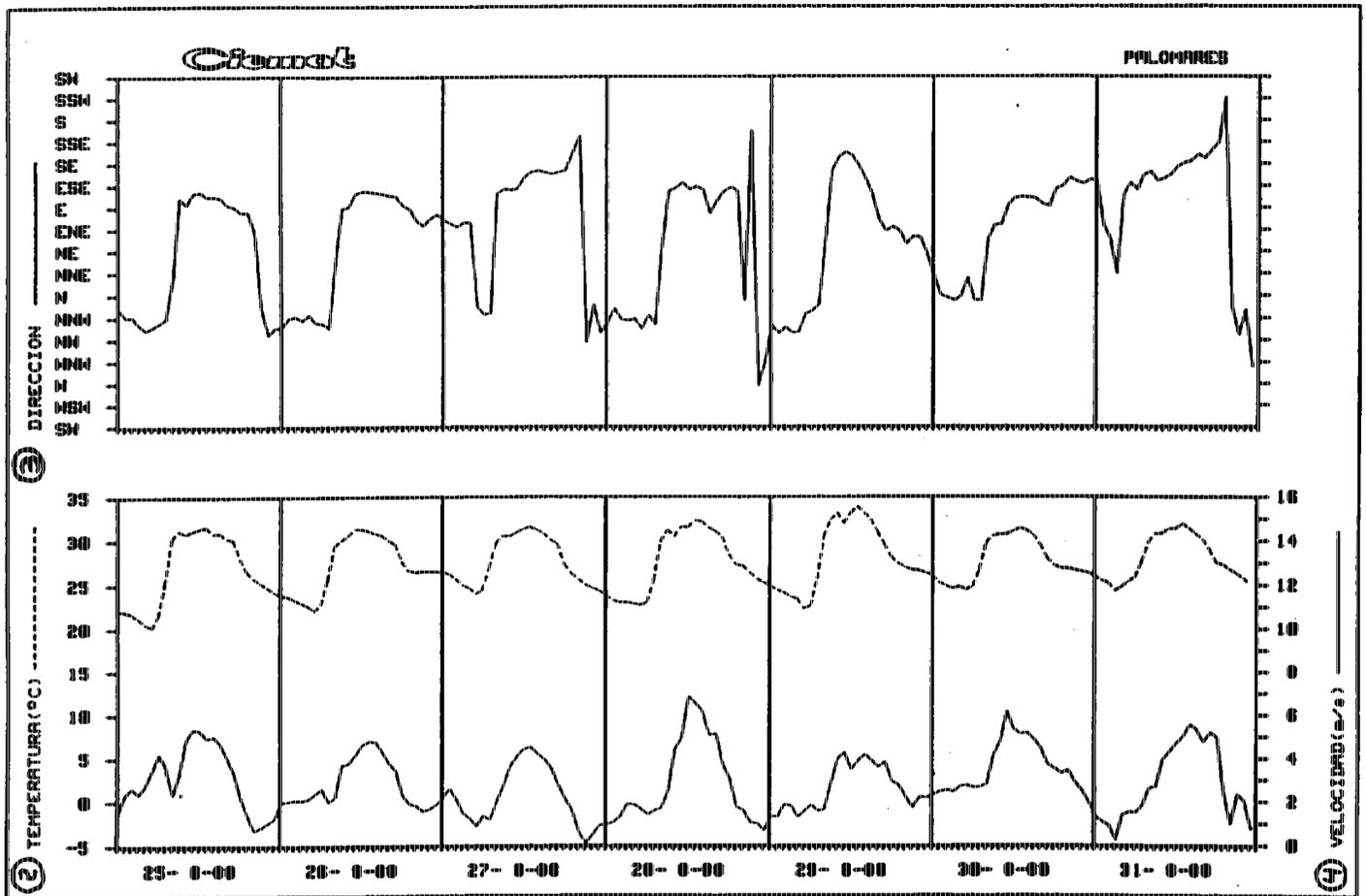


FIGURE 3 . GRAPHICAL REPRESENTATION OF THE WIND DIRRECTION AND SPEED AND TEMPERATURE AT THE PALOMARES STATION DURING THE WEEK OF 1988.

2-- TEMPERATURE, (°C); 3-- DIRECTION; 4-- SPEED (M/SEC)

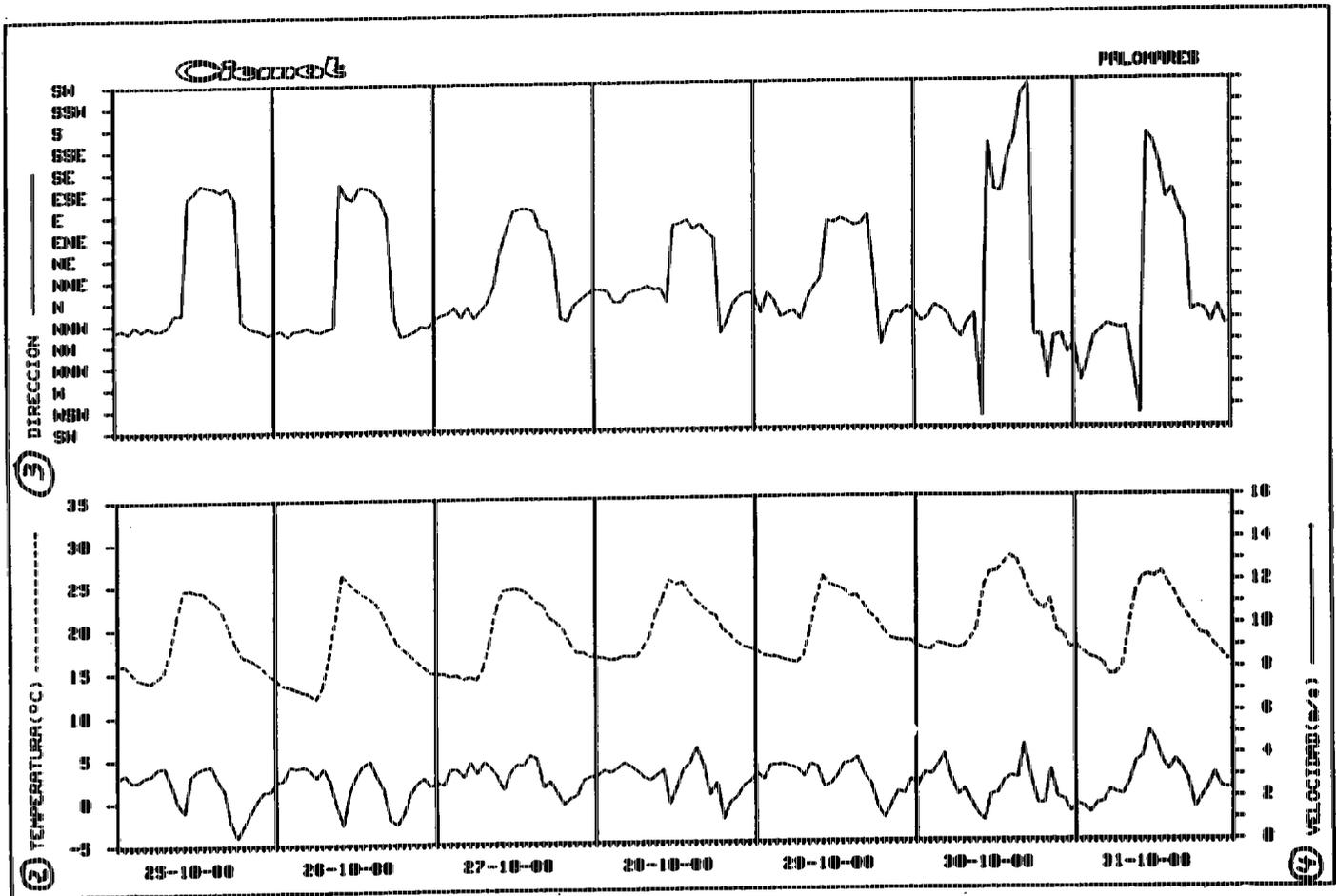


FIGURE 4 . GRAPHICAL REPRESENTATION OF THE WIND DIRRECTION AND SPEED AND TEMPERATURE AT THE PALOMARES STATION DURING THE WEEK OF 1988.

2- TEMPERATURE, (°C); 3- DIRECTION; 4- SPEED (M/SEC)

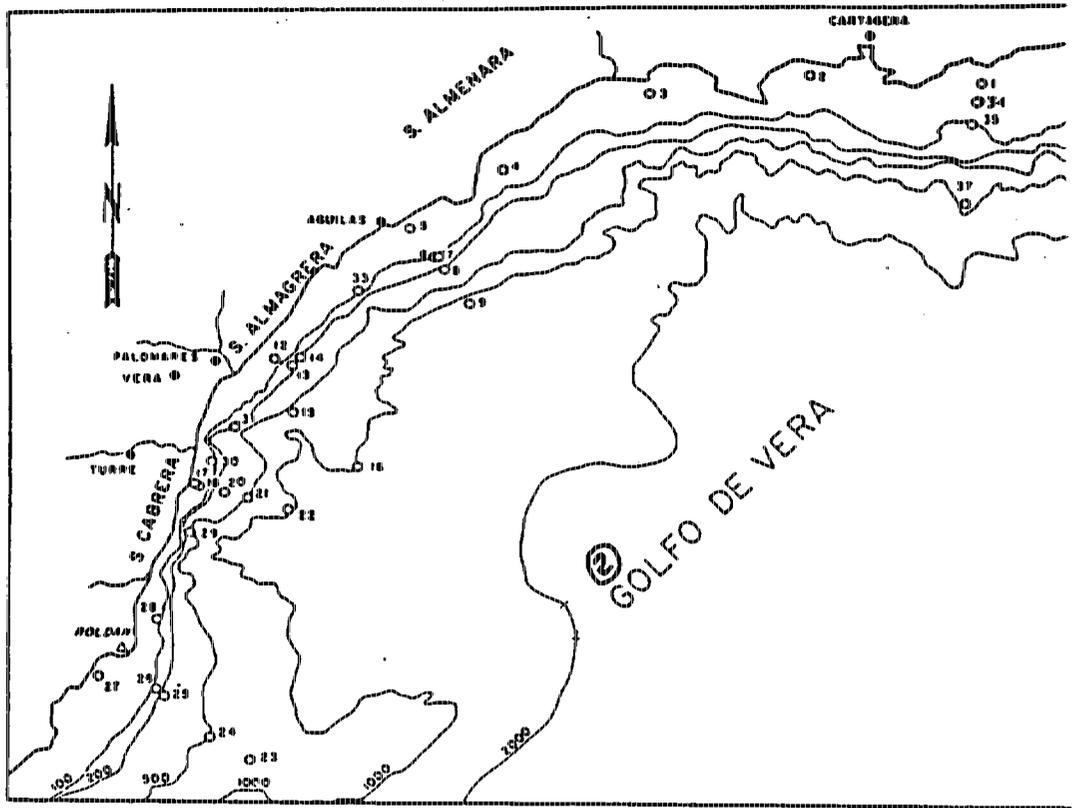


FIGURE 6. LOCATION OF SAMPLING POINTS ALONG THE SOUTHEASTERN COAST OF SPAIN

2- GULF OF VERA

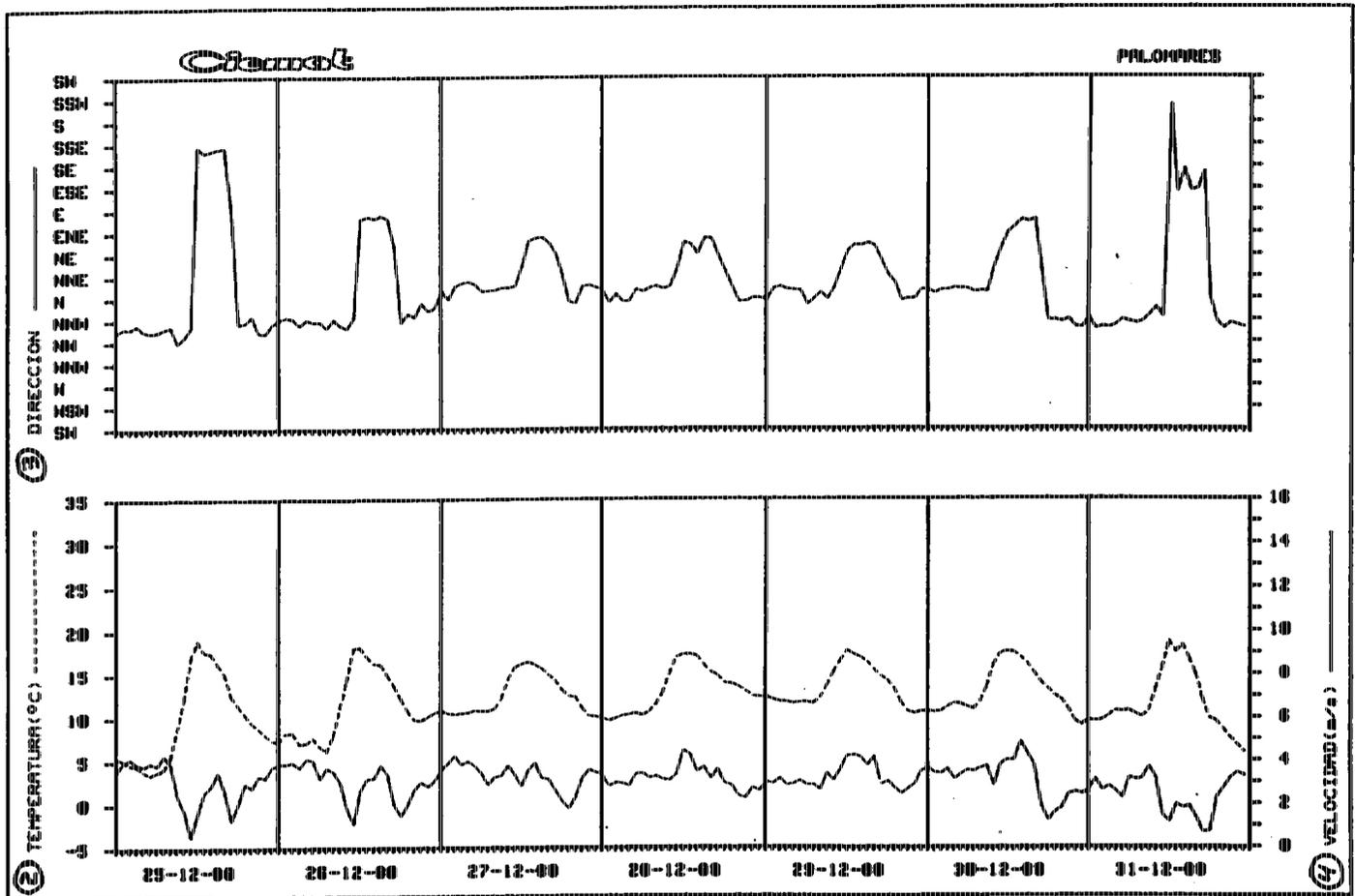


FIGURE 5 . GRAPHICAL REPRESENTATION OF THE WIND DIRRECTION AND SPEED AND TEMPERATURE AT THE PALOMARES STATION DURING THE WEEK OF 1988.

2- TEMPERATURE, (°C); 3- DIRECTION; 4- SPEED (M/SEC)

TABLE 1. AMERICIUM CONCENTRATION IN PALOMARES SURFACE SOIL SAMPLES DURING 1988

② LUGAR		③ CONCENTRACION ACTIVIDAD	
④ ZONA	⑤ PUNTO	Am-241 kBq/kg	
Limitrofe 2	1	0.089 + 3σ	
" "	2	≤0.006	
" "	3	≤0.006	
" "	4	≤0.005	
" "	5	≤0.006	
" "	6	≤0.006	
" "	7	≤0.007	
" "	8	≤0.007	
" "	9	≤0.006	
" "	10	≤0.005	
⑥ " "	11	≤0.006	
Limitrofe 5	12	≤0.005	
" "	13	≤0.006	
" "	14	≤0.006	
" "	15	≤0.007	
" "	25	≤0.006	
" "	26	≤0.006	
" "	27	≤0.007	
" "	28	≤0.006	
⑥ " "	29	≤0.007	
Limitrofe 3	16	≤0.007	
" "	17	≤0.005	
" "	18	≤0.006	
" "	19	≤0.006	
" "	20	≤0.006	
" "	21	0.117 + 3σ	
" "	22	≤0.006	
" "	23	≤0.006	
" "	24	≤0.006	

⑦ Las muestras corresponden a la capa superficial de 5 centímetros de espesor.

2- PLACE; 3- RADIOACTIVITY CONCENTRATION; 4- ZONE; 5- POINT

6- Bordering

7-

The samples correspond to the surface layer of 5 centimeters thickness.

TABLE 2 PU-239 + Pu-240 RADIOACTIVITY IN PALOMARES AIR SAMPLES

② P E R I O D O	③ CONCENTRACION DE Pu-239 + Pu-240 ($\mu\text{Bq}/\text{m}^3$)		
	④ CASETA 2-1	⑤ CASETA 2-2	⑥ CASETA P (zona urbana)
21-03-87 al 28-03-87	35.0 \pm 5.4	30.8 \pm 4.8	21 \pm 3.5
28-03-87 al 04-04-87	60.3 \pm 6.6	26.6 \pm 4.1	32.1 \pm 5.3
04-04-87 al 11-04-87	51.6 \pm 3.3	16.0 \pm 2.5	15.5 \pm 2.5
11-04-87 al 18-04-87	48.2 \pm 8.6	224 \pm 34	6.8 \pm 1.1
18-04-87 al 25-04-87	40.2 \pm 6.8	46.5 \pm 9.3	3.5 \pm 0.6
25-04-87 al 02-05-87	53.2 \pm 5.8	33.2 \pm 6.6*	224.0 \pm 39.1
02-05-87 al 09-05-87	60.1 \pm 10.2	43.4 \pm 8.4	3.5 \pm 0.6
09-05-87 al 16-05-87	3.6 \pm 0.5	676.6 \pm 102.9	0.7 \pm 0.08
16-05-87 al 23-05-87	70.6 \pm 11.3	71.0 \pm 7.6*	78.7 \pm 12.1
23-05-87 al 30-05-87	11.4 \pm 1.2	37.1 \pm 6.6	14.9 \pm 2.2
30-05-87 al 06-06-87	26.9 \pm 4.2	22.6 \pm 3.6	6.9 \pm 1.23
06-06-87 al 13-06-87	16.2 \pm 1.9	81.8 \pm 2.9	17.2 \pm 2.8
13-06-87 al 20-06-87	4491.3 \pm 46.9	442 \pm 83.8	10.6 \pm 0.2
20-06-87 al 27-06-87	4.7 \pm 0.8*	72.4 \pm 11.2	6.2 \pm 0.9
27-06-87 al 04-07-87	37.4 \pm 4.6*	35.1 \pm 5.8	2.4 \pm 0.47

⑦
* Estos valores no figuraban en la Tabla 2 del Informe del primer semestre del año 1988.

2-- PERIOD; 3- PU-239 + Pu-240 CONCENTRATION; 4-- BUILDING 2-1; 5-- BUILDING 2-2; 6--BUILDING P (urban zone)

7- * These values were not included in Table 2 of the report for the first half of 1988

TABLE 3 PU-239 + Pu-240 RADIOACTIVITY IN PALOMARES AIR SAMPLES

② PERIODO	③ CONCENTRACION DE PU-239 + PU-240 ($\mu\text{Bq}/\text{M}^3$)		
	④ CASETA 2-1	⑤ CASETA 2-2	⑥ CASETA P ZONA URBANA
27-06-87 AL 04-07-87	37.4 ± 4.6	35.1 ± 4.6	2.4 ± 0.5
04-07-87 AL 07-07-87	≤ 0.2	39.8 ± 4.6	25.9 ± 4.5
07-07-87 AL 11-07-87	≤ 0.2	30.3 ± 4.2	4.2 ± 1.1
11-07-87 AL 18-07-87	≤ 0.2	16.9 ± 2.0	1.6 ± 0.3
18-07-87 AL 25-07-87	1.4 ± 0.3	10.5 ± 1.3	0.4 ± 0.1
25-07-87 AL 01-08-87	2.2 ± 0.4	25.5 ± 3.0	7.4 ± 1.1
01-08-87 AL 08-08-87	2.8 ± 0.5	24.3 ± 3.0	5.2 ± 0.8
08-08-87 AL 15-08-87	1.8 ± 0.4	31.8 ± 3.4	2.0 ± 0.3
15-08-87 AL 22-08-87	2.8 ± 0.5	31.7 ± 3.6	3.2 ± 0.4
22-08-87 AL 29-08-87	9.1 ± 1.1	13.9 ± 1.4	3.3 ± 0.5
29-08-87 AL 05-09-87	22.6 ± 2.6	4.2 ± 0.5	≤ 0.2
05-09-87 AL 12-09-87	1.9 ± 0.3	18.3 ± 2.1	≤ 0.2
12-09-87 AL 19-09-87	6.9 ± 1.0	13.9 ± 1.6	0.9 ± 0.2
19-09-87 AL 26-09-87	108 ± 12	18.8 ± 2.1	4.4 ± 0.6
26-09-87 AL 03-10-87	9.0 ± 1.3	8.8 ± 1.1	1.7 ± 0.3
03-10-87 AL 10-10-87	7.0 ± 1.1	3.3 ± 0.5	4.0 ± 0.7
10-10-87 AL 17-10-87	5.1 ± 0.7	17.0 ± 2.4	12.4 ± 2.0
17-10-87 AL 24-10-87	5.9 ± 0.8	23.6 ± 2.7	2.8 ± 0.3
24-10-87 AL 31-10-87	41.8 ± 5.9	28.8 ± 3.2	3.2 ± 0.4
31-10-87 AL 07-11-87	2.1 ± 0.9	24.2 ± 2.9	24.0 ± 2.8
07-11-87 AL 14-11-87	2.1 ± 0.3	5.5 ± 0.7	≤ 0.2
14-11-87 AL 21-11-87	3.3 ± 1.0	15.8 ± 2.5	3.4 ± 0.4
21-11-87 AL 28-11-87	5.2 ± 0.7	29.3 ± 3.5	≤ 0.2
28-11-87 AL 05-12-87	4.6 ± 0.6	35.6 ± 4.8	2.4 ± 0.4
05-12-87 AL 12-12-87	4.8 ± 0.7	52.2 ± 5.9	1.4 ± 0.3
12-12-87 AL 19-12-87	1.1 ± 0.3	40.5 ± 4.3	≤ 0.2
19-12-87 AL 26-12-87	≤ 0.2	1.4 ± 0.3	1.8 ± 0.4
26-12-87 AL 02-01-88	3.0 ± 0.5	7.5 ± 1.0	2.6 ± 0.3

2- PERIOD; 3- PU-239 + Pu-240 CONCENTRATION; 4- BUILDING 2-1; 5- BUILDING 2-2; 6-BUILDING P (urban zone)

TABLE 6 AMERICIUM - 241 CONTENT IN THE VEGETATION OF AREA 3 DURING 1988

SAMPLING DATE	FARM	VEGETABLE		RADIOACTIVITY
		Species	Part	CONC.
16 - 5	J.N.C. (CAT.494)	barley	grain	≤ 0.007
"	"	"	spike	≤ 0.006
"	"	"	straw	≤ 0.006
"	D.S.M. (CAT.548)	"	grain	≤ 0.006
"	"	"	spike	≤ 0.005
"	"	"	straw	≤ 0.005
"	J.N.P. (CAT.778)	"	grain	≤ 0.007
"	"	"	spike	≤ 0.006
"	"	"	straw	≤ 0.007
"	J.C.G. (CAT.575)	"	grain	≤ 0.006
"	"	"	spike	≤ 0.006
"	"	"	straw	≤ 0.006
"	A.A.L. (IMPACTO N° 3) (1950-2000, 950-1000)	"	grain	≤ 0.006
"	"	"	spike	≤ 0.006
"	"	"	straw	0.2 ± 4%
"	P.S.G. (CAT.226 y 227)	wheat	grain	≤ 0.006
"	"	"	spike	≤ 0.005
"	"	"	straw	≤ 0.007

TABLE 6 AMERICIUM - 241 CONTENT IN THE VEGETATION OF AREA 3 DURING 1988

SAMPLING DATE	FARM	VEGETABLE		RADIOACTIVITY
		Species	Part	CONC.
30 - 5	D.S.C. LINDA N. P3-1	watermelon	fruit (rind)	≤ 0.007
"	"	"	fruit (rest)	≤ 0.008
"	"	"	leaves	≤ 0.005
"	J.F.G. LINDA O. P3-1	"	fruit (rind)	≤ 0.007
"	"	"	fruit (rest)	≤ 0.007
"	"	"	leaves	≤ 0.006
"	J.A.L. LINDA E. P3-2	"	fruit (rind)	≤ 0.007
"	"	"	fruit (rest)	≤ 0.008
"	"	"	leaves	≤ 0.005
"	J.A.L. LINDA O. P3-2	"	fruit (rind)	≤ 0.007
"	"	"	fruit (rest)	≤ 0.007
"	"	"	leaves	≤ 0.006
"	J.F.G. LINDA O. P3-1	ALFALFA		≤ 0.006
"	D.F.C. (CAT 489)	"		≤ 0.006

TABLE 8. AMERICIUM-241 CONTENT IN WELL WATER OF THE PALOMARES ZONE DURING 1987

WELL	RADIOACTIVITY CONCENTRATION	
	AM-241, Bq/m ³	
SAN MIGUEL	≤	52.8 Bq/m ³
VIRGEN DEL CARMEN	≤	70.0 "
ANTONIO SABIOTE GARCIA	≤	36.0 "
LOS GATOS	≤	48.0 "
LOS VELASCO	≤	21.6 "
JOSE ALARCON LATORRE	≤	52.8 "
BALSA DE LA S. DE REGANTES DE PALOMARES	≤	11.1 "

TABLE 9. PLUTONIUM CONTENT IN CHICKEN TISSUES: 1987

CONC. PU-239+PU-240

<u>SAMPLING</u>	<u>TISSUE</u>	<u>mBq/kg</u>
	MUSCLE EXTREMITIES	
21 - 10 - 87	Pollo n° 4	≤ 0.77
"	Pollo n° 6	≤ 18.6
"	Pollo n° 7	≤ 6.2
	MUSCLE BODY	
"	Pollo n° 1	≤ 3.4
"	Pollo n° 4	≤ 0.60
"	Pollo n° 6	≤ 11.4
"	Pollo n° 7	≤ 6.2
	BONES	
"	Pollo n° 1	≤ 30
"	Pollo n° 2	≤ 100
"	Pollo n° 3	≤ 50
"	Pollo n° 4	≤ 70
"	Pollo n° 5	≤ 60
"	Pollo n° 6	≤ 100
	FEATHERS	
"	Pollo n° 4	936.9
"	Pollo n° 5	166.7
"	Pollo n° 6	551.4
"	Pollo n° 7	247.1

pollo = chicken

TABLE 10 . PLUTONIUM CONTENT IN GOAT'S MILK: 1988

<u>GOAT No.</u>	<u>SAMPLING</u>	<u>CONCENTRATION PU-239+PU-240</u> <u>mBq/l</u>
2	3-6/6	≤ 6.8
"	9-12/6	≤ 4.3
"	12-19/6	≤ 10.2
"	21-21/6	≤ 12.7
"	28/6-3/7	≤ 12.1
"	6/7-10/7	≤ 6.0

TABLE 11 . PLUTONIUM CONTENT IN GOAT'S MILK: 1987

<u>GOAT No.</u>	<u>SAMPLING</u>	<u>CONCENTRATION PU-239+PU-240</u> <u>mBq/l</u>
2	25-31/5	≤ 63
"	1-7/6	≤ 60
"	8-14/6	≤ 62
"	15-21-/6	≤ 58
"	22-28/6	≤ 60
"	29/6-5/7	≤ 60
"	6-12/7	≤ 52

TABLE 12. LUTONIUM AND AMERICIUM INVENTORIES IN THE SEDIMENTS OF THE SOUTHEASTERN COAST OF SPAIN

<u>RADIONUCLIDE</u>	<u>SHELF</u>		<u>TALUS</u>		<u>DEEP WATER</u>	
	<u>core</u>	<u>Bq/m²</u>	<u>core</u>	<u>Bq/m²</u>	<u>core</u>	<u>Bq/m²</u>
Plutonium	34	177	08	52	16	43
	12	128	15	≤0.5		
	31	529				
	30	327				
	18	254	20	78	22	18
	29	252	24	3		
Americium	34	55	08	28	16	25
	12	60	15	12		
	31	160				
	30	80				
	18	30	20	45	22	24
	29	58	24	13		